M.Sc. Biotechnology Syllabus (2008-2009)-(Credit System)

COURSE STRUCTURE FORMAT

Theory & Practical

Semester I	Course name	No. of credits
Theory		
BT 11*	Biological Chemistry	4
BT 12*	Cell Biology	4
BT 13	Quantitative Methods	4
Practical		
BT 14	Biological Chemistry	6
BT 15	Cell Biology	3
BT 16	Quantitative Methods	3
Semester II		
Theory		
BT 21*	Molecular Biology	4
BT 22	Genetics	2
BT 23a	Microbial Technology	3
BT 23b	Virology	2
BT 24	Immunology	2
BT 25	Bioinformatics	2
Practical		
BT 26	Molecular Biology	4
BT 27	Genetics	2
BT 28	Microbiology, Virology & Immunology	3
BT 29	Bioinformatics	2
Semester III		
Theory		
BT 31*	Tissue Culture (Plant & Animal)	4
BT 32*	Fundamentals of Genetic Engineering	2
BT 33*	Advanced Techniques in Biological Chemistry & Molecular Biology	2
BT 34*	Biochemical Engineering	2
BT 35*	Pleuripotent Cell Technologies and Reproduction	2
Practical		
BT 36	Tissue Culture (Plant & Animal)	4
BT 37	Genetic Engineering	4
BT 38	Advanced Techniques in Biological Chemistry & Biochemical Engineering	4
Semester IV All theory courses are optional		
Theory		
BT 41*	Structural Biology	2
BT 42*	Industrial Biotechnology	2
BT 43*	Applications of Genetic Engineering	2
BT 44	Plant Biotechnology	2
BT 45	Chemical Synthesis & Screening in Biotechnology	2
BT 46*	Genomics & Proteomics	2
BT 47*	Molecular Immunology & Immunotechnology	2
BT 48	Molecular Approaches to Drug Discovery	2
BT 49	Nanobiotechnology	2
BT 50	Intellectual Property Rights (IPR) & Patents	1
Practical		
BT 51	Seminar	4
BT 52	Project	10

***** All courses have been identified in terms of the prerequisites and lateral integration. All practical courses have lateral integration with theory.

COURSE STRUCTURE FORMAT WITH MODULES, 2008-09

THEORY

Course No.	Subjects	Theory 4C X 15 L=60 L
Semester I		
BT 11	**Biological Chemistry**	
BT 11.1	Biochemistry of macromolecules and building Blocks	12 L
BT 11.2	Organic reactions and stereochemistry	8 L
BT 11.3	Introduction to enzymology, metabolism and Bioenergetics	20 L
BT 11.4	Basic Biochemical techniques	20 L
BT 12	**Cell Biology**	
BT 12.1	Cell structure and methods in cell biology	15 L
BT 12.2	Biomembranes and transmembrane signalling	15 L
BT 12.3	Cell dynamics, cell differentiation, cell death and transformation	15 L
BT 12.4	The plant cell	15 L
BT 13	**Quantitative Methods**	
BT 13.1	Biostatistics	15 L
BT 13.2	Biomathematics	15 L
BT 13.3	Basic Concepts in Computing & Networking	15 L
BT 13.4	Introduction to Programming	15 L
Semester II		
BT 21	**Molecular Biology**	
BT 21.1	Genome Structure & Organization	15 L
BT 21.2	DNA replication and DNA repair	15 L
BT 21.3	Gene Expression in Prokaryotes & Eukaryotes	15L
BT 21.4	Protein Synthesis, modifications and transport	15L
BT 22	**Genetics**	
BT 22.1	Basic Concepts in Genetics	15 L
BT 22.2	Microbial Genetics 15 L	
BT 23a	**Microbial Technology**	
BT 23a.1	Microbial Characteristics	20 L
BT 23a.2	Applied Microbiology	10 L
BT 23a.3	Fungal Biotechnology	15 L
BT 23b	Virology	
BT 23b.1	General Virology	15L
BT 23b.2	Applied Virology and Diagnostics	15L
BT 24	**Immunology**	
BT 24.1	Immunology I	15 L
BT 24.2	Immunology II	15L
BT 25	**Bioinformatics**	30 L
BT 25.1	Biological Data Bases	15L
BT 25.2	Applications of Bioinformatics	15L
Semester III		
BT 31*	**Tissue Culture (Plant & Animal)**	
BT 31.1	Introduction to tissue culture techniques	15 L
BT 31.2	Animal cell and organ culture	15 L
BT 31.3	Plant cell, tissue and organ culture	15 L
BT 31.4	Applications of tissue culture	15 L
BT 32*	**Fundamentals of Genetic Engineering**	
BT 32.1	Basics of genetic Eng.& Cloning Strategies	15 L
BT 32.2	Detection & Characterization of Transformants	10 L
BT 32.3	Expression systems	15 L
BT 33	**Advanced Techniques in Biological Chemistry & Molecular Biology**	
BT 33.1	Techniques in Biological Chemistry and Molecular Biology	15 L
BT 33.2	Techniques in Macromolecular Structure	15 L
BT 34*	**Biochemical Engineering**	
BT 34.1	Theory and design of bioreactors	15 L
BT 34.2	Transport and process control	15 L
BT 35*	**Pleuripotent Cell Technologies and Reproduction**	
BT 35.1	Cells of Reproduction and Early	15 L

	Development	
BT 35.2	Stem Cell Concepts & Technologies	15 L

Semester IV

All theory courses are optional

BT 41*	**Structural Biology**	
BT 41.1	Protein crystallography and NMR Spectroscopy	15 L
BT 41.2	Organization & function of Protein Structure	15 L
BT 42*	**Industrial Biotechnology**	
BT 42.1	Enzyme and bioprocess technology	20 L
BT 42.2	Biotechnological approach for improving the	10 L
BT 43*	**Applications of Genetic Engineering**	
BT 43.1	Applications	20 L
BT 43.2	Bioinformatics in gene and protein analysis, IPR	10 L
BT 44	**Plant Biotechnology**	
BT 44.1	Appl. of Plant Cell & Tissue Culture in Industry	10 L
BT 44.2	Transgenic Plants	20 L
BT 45	**Chemical Synthesis and Screening in Biotechnology**	
BT 45.1	Synthesis and interaction of biological Macromolecules	15 L
BT 45.2	Combinatorial Chemistry & High throughput Screening	15 L
BT 46*	**Genomics and Proteomics**	
BT 46.1	Genomics	15 L
BT 46.2	Proteomics	15 L
BT 47	**Molecular Immunology & Immunotechnology**	
BT 47.1	Molecular Immunology	15 L
BT 47.2	Immunotechnology	15 L
BT 48	**Molecular approaches to Drug Discovery**	
BT 48.1	Basic Concepts in Drug Discovery	15 L
BT 48.2	Functional Assays & Toxicity Evaluation	15L
BT49	**Nanobiotechnology**	
BT49.1	Production and Characterization of Nanoparticles	15L
BT49.2	Applications of Nanoparticles	15L
BT50	**Intellectual Property Rights (IPR) & Patents**	**15L**

CREDIT COURSE STRUCTURE FORMAT, 2008-09

PRACTICAL

Course No.	Subjects	Practical
Semester I		
BT 14	Biological Chemistry	6C = 6x15=90h
BT 15	Cell Biology	4C = 4x15=60h
BT 16	Quantitative Methods	2C = 2x15=30h
Semester II		
BT 26	Molecular Biology	4C = 4x15=60h
BT 27	Genetics	2C = 2x15=30h
BT 28	Microbiology, Virology & Immunology	3C = 3x15=45h
BT 29	Bioinformatics	2C = 3x15=30h
Semester III		
BT 36	Tissue culture (Plant & Animal)	4C = 4x15=60h
BT 37	Genetic Engineering	4C = 4x15=60h
BT 38	Advanced Techniques in Biological Chemistry & Biochemical Engineering	4C = 4x15=60h
Semester IV		
BT 51	Seminar	4C = 4x15=60h
BT 52	Project	10C 10C = 10x15 =150h

Detailed Syllabus of M.Sc. Biotechnology, 2008-09

THEORY

SEMESTER I

BT 11 BIOLOGICAL CHEMISTRY

BT 11.1: Biochemistry of Macromolecules and Building Blocks (12L)

Macromolecules (Nucleic acids, proteins, carbohydrates and lipids) and their building blocks: amino acids, purine and pyrimidine bases, fatty acids and sugars.
Small molecules of biological importance: vitamins and minerals.

BT 11.2: Organic Reactions and Stereochemistry (8L)

Basic reactions in organic chemistry: Oxidations, reductions, substitutions, molecular rearrangements
Stereochemistry: Stereoisomers, resolution, cyclohexanes, asymmetric synthesis.

BT 11.3: Introduction to Enzymology, Metabolism and Bioenergetics (20L)

Enzymes: classification, catalysis, kinetics, regulation (fine, coarse and metabolic control). Coenzymes and cofactors, and their relevant reactions. Allostery.
Metabolic pathways: glycolysis, Krebs cycle, pentose phosphate pathways, glycogen metabolism, oxidative phosphorylation, fatty acid biosynthesis and oxidation and photosynthesis.
Bioenergetics
Thermodynamics in biological systems.

BT 11.4: Basic Biochemical Techniques (20 L)

Spectroscopy, UV – VS, Fluorescence, pH and Conductivity.
TLC, Concepts in a) Chromatography b) Radioactivity.
Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis.

BT 12 CELL BIOLOGY

BT 12.1: Cell Structure and Methods in Cell Biology (15L)

Cell: structural and functional organization.
Cell motility.
Ultrastructure and Electron microscopy.
Fractionation of subcellular organelles.
Microscopy, Morphometry, Cell counting.

BT 12.2: Biomembranes and Trans-Membrane Signaling (15L)

Biomembranes: structure-function relationship.
Cell signaling: Cell surface, Hormone, receptors and signal transduction and second messengers.

BT 12.3: Cell Dynamics, Cell Differentiation, Cell death, and Transformation (15L)

Cell dynamics, cytoskeleton and cell surface.
Extracellular matrix.
Cell-cell interactions and cell matrix interaction.
Cell lineages and the context of Developmental biology
Cell differentiation, hormones and growth factors.
Apoptosis.
The transformed cell
Oncogenes, protooncogenes and etiology of cancer

BT 12.4: The Plant Cell (15L)

Structure of Plant Cell, Plant cell wall - primary and secondary, role in growth and development, Plamodesmata, their role in virus transfer etc.
Plastids - biogenesis, structure and types, chloroplast-Nucleus interaction, Rubisco, photosynthesis.
Growth and development of plants
Programmed Cell Death

BT 13 QUANTITATIVE METHODS

BT 13.1: Biostatistics (15L)

Statistical population, sample from population, random sample.
Tabular and graphical presentation.
Mean and standard deviation of group and ungrouped data.
Probability, relative frequency, probability distribution.
Binomial, poisson and normal distribution.
Test of significance, test for proportion, means and standard deviations, F and t test, chisquare test for goodness of fit.
Theory of errors, errors and residuals, precision, measure of precision, probable error of function, rejection of observation.
Methods of averages and least squares.
Correlation and linear regression, associated test of significance.
Analysis of variance for one and two way classification.
Design of experiments, randomization, replication, local control, completely randomized and randomized block design.

Nonparametric tests.

BT 13.2: Biomathematics (15L)

Differential and integral calculus.
Derivative and its physical significance, basic rules for differentiation (without derivation) maxim and minima, their applications in chemistry, exact and inexact differentiation with specific emphasis on thermodynamic properties, partial differentiation.
Curve sketching.
Basic rules for integration (without derivations), definite and indefinite integrals, geometric meaning of integration, applications in the biology and chemistry.
Solutions to quadratic and cubic equations.
Differential equations.
Separable variable, homogeneous, exact and linear equation, equations of second order Applications of differential equations in chemistry.
Determinants evaluations of 3 x 3 determinants, matrices manipulations, simultaneous equations and inversion.
Interpolation and polynomial fitting.
Trigonometry: Trigonometric functions, identities and inverse functions
Complex numbers: Representation, complex algebra, complex conjugate, roots
Matrices: Definitions and types of matrices, Matrix algebra and matrix multiplication, Special square matrices, Determinant of a square matrix, Inverse of a matrix, rank of a matrix, Eigen vectors and eigen values, diagonalization.
Vectors: Vector algebra, coordinate systems, Basic vectors and components, Scalar and vector multiplications, Reciprocal vectors, coordinate transformations.
Fourier transform and inverse Fourier transform.
Logarithmic and exponential functrions

BT 13.3: Basic Concepts in Computing and Networking (15L)

a) Overview and functions of a computer system, devices, memory -
Types of processing: Batch, Real-Time, Online, Offline
Types of modern computers: The work station, the minicoputer, mainframe computers, parallel processing computer, the super computer etc
a) Introduction to operating systems: Windows / Unix / Linux
b) The internet and its resources, World Wide Web (www): associated tools, services, resources and various terminologies
c) Computer Networking, Network and Data security:
i) OSI reference model, TCP/IP, topologies and protocols, designing networks
ii) Networking gadgets(router, switch, etc); Data Communication (ISDN, VPN, DSL, cable modem, cellular modem, etc); Communication links (wire pairs, coaxial cables, fibre optics, microwave, satellite, etc)
iii) Network security fundamentals: types of attacks, firewall, packet filtering, classification of data security threats, protection mechanism (authentication, access control, access rules)
iv) Encryption / Decryption techniques
v) An overview of computer viruses: How do they get transmitted? What are the dangers? General precautions to be taken.
vi) Current & future technologies (grid computing, VPN, wireless, mobile computing, biometrics etc)

BT 13.4: Introduction to programming (15L)

C programming
C++

SEMESTER II

BT 21 MOLECULAR BIOLOGY

BT 21.1: Genome Structure & Organization (15L)

Organization of viral, prokaryotic and eukaryotic genomes: DNA reassociation kinetics (Cot curve analysis), repetitive and unique sequences, kinetics and sequence complexities, satellite DNA, DNA melting and buoyant density.
Gene families, clusters, packaging of chromatins and evolutionary advantage Organelle genomes.
Rearrangement and amplification of DNA in the genome.
Genomics and proteomics.

BT 21.2: DNA Replication and DNA Repair (15L)

DNA polymerases, mechanisms of DNA replication in prokaryotes and eukaryotes DNA replication models
DNA damage, DNA repair and recombination.

BT21.3: Gene Expression in Prokaryotes & Eukaryotes (15L)

Chromatin structure and remodeling in relation to gene expression, DNase hypersensitivity, DNA methylation.
Transcription: Basic mechanism in prokaryotes and eukaryotes. RNA polymerase, Reverse transcriptase, and regulation of transcrption including transcription factors.

Post-transcriptional processing and transport of RNA. Non coding RNAs
Organization and structure-function of ribonucleoproteins.

BT 21.4 Protein Synthesis, Modifications and Transport (15 L)

Components of protein synthesis
Mechanism of protein synthesis
Genetic code
Regulation of protein synthesis
Post translational modifications
Transport of proteins
Protein turnover and degradation

BT 22: GENETICS

BT 22.1: Basic Concepts in Genetics (15L)

a) Science of genetics
b) Animal models (*Drosophila, Caenorhabditis*) in the study of Genetics
c) Mendelian principles, Concept of Dominance, multiple allelic systems, sex-linked inheritance, Epistasis, Pleiotropy, Penetrance,
d) Mutation, Chromosomal aberrations. Linkage studies, genetic maps.
e) Sex determination and dosage compensation
f) Genotoxicity: detection and assays.
g) Population genetics: Hardy-Weinberg law.
h) Quantitative genetics and applications
i) Plant genetics: Inbreeding and heterosis, and plant improvement.

BT 22.2: Microbial Genetics (15L)

a) Mutagenesis: mutagenic agents, mechanisms of mutagenesis
b) Expression of mutations- gene mutation.
c) Point mutations, isolation of auxotrophs, conditional lethals and suppressor mutations
d) Gene mapping in phages, bacteria.
e) Control of gene expression in bacteria. Operon concept- lactose, arabinose and tryptophane operons.
f) Transposons in prokaryotes and eukaryotes.
g) Lambda genetic control

BT 23a MICROBIAL TECHNOLOGY

BT 23a.1: Microbial Characteristics (20L)

Microbial life: Prokaryotes, Eukaryotes, Archeas & Protozoa
Structure of microbial cell : Spore, cell wall, flagella, cell membrane, capsule, pilli.
Characteristics of aerobes, anaerobes, cyanobacteria, actinomycestes.
Nutrition, Metabolism, Growth media, propagation, Cell counting, Growth kinetics, Yield constants, Growth Synchronous growth.
Handling pathogens, Sterilization, Safety in microbiology laboratory.
Microscopic identifications, immuno probe tests, PCR application in diagnostic microbiology.
Action of antibiotics and multi drug resistance

BT 23a.2: Applied Microbiology (10L)

Microbiology for public health: Mycobacteria, Enterobacteria, and Protozoa.
Microbiology for agriculture : Agrobacterium, Nitrogen fixation.
Extremophiles,
Industrially important microbes, secondary metabolites

BT 23a.3 : Fungal Biotechnology (15 L)

Fungi, a unique kingdom – Conventional and Molecular taxonomy, Evolution
Fungal interactions – with fungus, plant, animal and insects
Architecture of fungal cell : cell wall, membranes and cytoskeleton
Growth and differentiation of fungi – dimorphism, sexual and asexual sporulation
Metabolism, Biochemical and molecular basis of development, apoptosis and autolysis
Mycotoxins, strain improvement
Uses of fungi in industry including food industry, biosensors, fuel cells, coal sulubilization, cancer therapy etc
Uses of fungi in agriculture and environment: Biofertilizer and Bioremediation, Biological control
Medical Mycology

BT 23b VIROLOGY

BT 23b.1: General Virology (15L)

Classification of viruses.
Propagation of animal viruses.
Propagation of plant viruses & bacteriophages.
Morphology and ultrastructure of viruses.
Steps involved in virus replication.
Replication of viruses:
RNA viruses: polio and measles (+ve strand)

RNA viruses: VSV and influenza (-ve strand)
DNA viruses: pox, adeno, herpes
Retro viruses.
Replication of Bacteriophages.
Replication of Plant viruses.

BT 23b.2: Applied Virology and Diagnostics (15L)

Antivirals.
Anti-retrovirals.
si RNAs.
Viral diagnostics: Immuno diagnosis, molecular diagnosis.
Laboratory tests in viral diagnosis.
Viral vaccines (conventional).
New vaccine candidates: proteins and peptides, DNA.
Viral vectors.
Vaccine trials.
Antiviral Drug designing

BT 24 IMMUNOLOGY

BT 24.1: Immunology - I (15L)

Introduction, History, Phylogeny.
Immune system overview, innate and acquired immune system.
Components of immune system.
Structure and function of antibody.
Inflammation, opsonization.
Primary and secondary lymphoid organs.
Complement.
B cell, T cell ontogeny.
Characteristics of antigen, T cell dependent and independent antigens.
Hypersensitivity.
Primary and Secondary immune responses.
Techniques in humoral immunology.

BT 24.2: Immunology - II (15L)

BCR and TCR structure, gdTCR.
Generation of diversity.
MHC I and II gene, polymorphism.
Generation of immune response.
T helper, T cytotoxic cells.
MHC peptide interaction.
Antigen presentation, secondary signaling.
Immunological disorders and autoimmune diseases.
Lymphocyte traffic.
Techniques in cellular immunology.
Immune response to viral and bacterial lymphatic infection.

BT 25 BIOINFORMATICS (30 L)

BT 25.1 Biological Data Bases

The need for computation in Biology: An introduction to Bioinformatics, Historical overview, the principles involved, development of tools, internet based access
Introduction to Biological Databases, Database Browsing and Data Retrieval
- Sequence databases
- Genome Databases

BT 25.2 Applications of Bioinformatics

Application of Bioinformatics Approaches for analysis and interpretation of Sequence Data and using : Homology Searches, Sequence Alignments, Pattern Searching
Application of Bioinformatics Approaches for analysis and interpretation of Genome data such as - Gene prediction, Full Genome comparison etc.
Introduction to computational structural biology: Protein structure prediction using computational methods, Structure analysis, Classification of Proteins etc.

SEMESTER III

BT 31 TISSUE CULTURE (PLANT & ANIMAL)

BT 31.1: Introduction to Tissue Culture Techniques (15L)

Introduction to tissue culture: Definition, principle and significance of tissue culture.
Animal tissue culture.
Maintenance of sterility and use of antibiotics, Mycoplasma and viral contaminants.
Various systems of tissue culture - their distinguishing features advantages and limitations.
Culture medium: Logic of formulation (natural media, synthetic media, and sera).
Methodology: i. Primary culture: Behaviour of cells, properties, utility.
ii Explant culture. iii. Suspension culture.

History & Development of plant tissue culture.
Nutrient media: obligatory and optional constituents.
Plant Growth Regulators: mode and mechanism of action.
Incubation systems: static & agitated culture systems.
Maintenance of *in vitro* cultures.

BT 31.2: Animal Cell Organ Culture (15L)

Cell lines: Definition, development, maintenance and management and Cell adaptation.
Established cell lines: Their characteristic features and utility, Cross contamination hazards.
Characteristics of cells in culture.
Contact inhibition, anchorage (in) dependence, cell-cell communication etc, Cell senescence.
Cell and tissue response to tropic factors, Culturing of different cells.
Designing of an experiment in tissue culture and response assessment. Significance of various controls.
Growth studies: Cell proliferation, cell cycle, mitosis in growing cells.
Organ culture: Methods, behaviour of organ explant, and utility of organ culture.
Organ transplants. Freeze storing of cells and transport of cultures.
Mass production of biologically important compound.
Harvesting of products, purification and assays.
Propagation of viruses (viral sensitivity of cell lines).
Cell cloning and cell synchronization.
Separation of cell types: Various methods: advantages and limitations; Flow cytometry.
Nuclear transplantation, Cell hybridization, Transfection studies.

BT 31.3: Plant Cell, Tissue and Organ Culture (15L)

Growth and development of plant cells and tissues *in vitro*.
· Callus culture
· Cell suspension culture
· Organ culture
· Protoplast culture
· Organogenesis
· Embryogenesis
In vitro culture: physical, genetic, chemical and genotypic factors.
Assessment of growth and development *in vitro.*
Problems in plant tissue culture (Recalcitrance, Contamination, Phenolic Browning, Seasonal Variation)

BT 31.4: Applications of Tissue Culture (15L)

Commercial applications of animal tissue culture: Tissue culture as a screening system.
Cytotoxicity and diagnostic tests.
Development and preparation of vaccines against infecting organisms, mammalian cloning.
Establishment of cell lines from tissues of genetic diseases.
Applications of Genetic manipulations.
Commercial applications of plant tissue culture for clonally identical plants: Mass propagation by organogenesis and embryogenesis, Synthetic Seeds, Use in multiplication of specific genotypes, rare and/or improved varieties, endangered species, disease elimination.
Workings of a commercial laboratory (Design, aseptic techniques and control of contamination, quarantine, pathological indexing, packaging, cost analysis, marketing).

BT 32 FUNDAMENTALS OF GENETIC ENGINEERING

BT 32.1: Basics of Genetic Engineering & Cloning Strategies (15L)

General introduction and concept.
Biosafety guidelines and containment strategies
DNA modifying enzymes and restriction enzymes
Cloning strategies: Genomic libraries, cDNA libraries, single gene cloning.
Vectors in gene cloning: Types of vectors and choice of vectors- Plasmids, cosmids, lamda phage vectors, shuttle vectors, BACs and YACs
Choice of hosts, Methods for transferring recombinant DNA to host cells (Transformation and Transfection)

BT 32.2: Detection and Characterization of Transformants (10 L)

Screening and selection for transformants: Hybridizations- colony, Southern, Northern, Western, Detection (radioactive and non-radioactive procedures).
DNA sequencing techniques including automated DNA sequencing.
Site-directed mutagenesis.

BT 32.3: Expression Systems (05L)

Various expression vectors in bacteria and eukaryotes.
Choice of appropriate hosts, Induced expression.
Chimeric constructs, Expression of industrially important products.

BT 33: ADVANCED TECHNIQUES IN BIOLOGICAL CHEMISTRY & MOLECULAR BIOLOGY

BT33.1:Techniques in Biological Chemistry & Molecular Biology (15L)

Chromatography: gel permeation, adsorption (ion exchange, affinity), partition, HPLC, protein purification.
2-D analysis and Maldi-Tof in Proteomics
Centrifugation techniques.
Nucleic acids techniques: Agarose gel electrophoresis, various blotting techniques, PFGE, RNA intereference and gene silencing (si-RNA, mi-RNA) technology, Microarray analysis.
Radioactivity: Applications of radioisotopes for analysis of biological samples: General principles of using radiotracers, Detection and measurement of radioactivity Neutron Activation Analysis, Isotope dilution analysis, Radio-immunoassay. Interaction of radiation with matter: Interaction of charge particles and gamma rays, interaction with biological cells. Somatic and genetic effects of radiations.

BT 33.2: Techniques for Macromolecular Structure (15L)

Techniques: IR, NMR, CD, Fluorescence, STM, MALDI-TOF, Small angle scattering, Crystallization of biomolecules, Introduction to X-ray crystallography.
Sequencing of proteins and nucleic acids.
Structure of Biomolecules: Proteins, nucleic acids, carbohydrates, lipids, structural organization of proteins, Amino acids, Conformational angles, Ramachandran plot, Primary, secondary, tertiary and quaternary structures.

BT 34 BIOCHEMICAL ENGINEERING

BT 34.1: Theory and Design of Bioreactiors (15L)

Concepts of basic modes of fermentation – Batch, Fed batch and Continuous Types of Bioreactors
Mathematical aspects of enzyme reactions and bio-reactors.
Simulation of reaction kinetics and reactors.
Construction and design of bioreactors.
Scaling up of processes.

BT 34.2: Transport and Process Control (15L)

Transport phenomena in biochemical engineering: mass transfer, heat transfer, mixing, rheology

BT 35 PLEURIPOTENT CELL TECHNOLOGIES AND REPRODUCTION

BT 35.1: Cells of reproduction and early development (15L)

Gamets and fertilization
Early development: Metabolic activation, cytoplasmic rearrangement, embryonic induction, cell lineages, pattern formation.
Molecular basis of development in animal and plants : a) homeobox gene expression and pattern formation b) DNA methylation and epigenetic gene regulation

BT 35.2: Stem cell concept and technologies

Committed cells and late development **(15L)**
Stem cells, Embryonic stem cells, differentiation.
ES cell technologies, Transgenics and knock outs.
Concept of Cell replacement therapy and regenerative medicine
Human cloning and Bioethics.

SEMESTER IV

BT 41 STRUCTURAL BIOLOGY (30L)

Biomolecules: (Introduction, Structure & Function)

Biomolecular conformation

- Nucleic acids
  * Conformational features (Twist, Roll, propeller twist etc.), different forms of DNA (A, B, Z etc.), Supercoiling
- Proteins and polymers
  * Conformational features of polypeptides, Torsion angle, Ramachandran Map
  * Primary, secondary, tertiary and quaternary structures
  * RMSD, DALI, SCOP, CATH, Superfamily

Biomolecular interactions

- Electrostatic and van der Waals' interactions, Hydrogen bonding, interactions with the Solvent, Entropy.

Biophysical techniques

- X-ray crystallography
  * Introduction, Symmetry, Diffraction principle, Phase problem, Refinement, Validation
- NMR

* Introduction, 2D NMR (NOESY,COSY), peak Assignment, Structure determination and Dynamics

- Cryo-EM

* Introduction, Sample preparation, Negative staining, Phase contrast, 3D reconstruction

- Circular Dichroism (CD) / Fluorescence spectroscopy

* Applications of CD and Fluorescence spectroscopy to solve structural problems

Computational techniques

- Structure visualization
- Structure prediction through Homology-modelling, Threading
- Force fields, Energy minimization

Understanding biological function from structures

- Enzymes- proteases
- Haemoglobin/Myoglobin, Co-operativity
- Protein-nucleic acid interactions
- Ribosomes, tRNA, tRNA synthatase
- RNA polymerase, Transcription
- Membrane proteins

BT 42 INDUSTRIAL BIOTECHNOLOGY

BT 42.1: Enzyme and Bioprocess Technology (20L)

Applications of enzymes, immobilization of enzymes, in vitro-stability of enzymes.
Bioprocess Technology: Upstream, Fermentation (including SSF) and Down Stream Processing
Significance of R&D, Large Scale Production,
Microbial processes : production, optimization, screening, strain improvement
Production of antibiotics, Ethanol, Organic acids,
Production of food, feed and therapeutics
Production of rDNA products including DNA vaccines, Taq polymerase
Costing and economics, Break even point

BT 42.2: Biotechnological Approach for Improving the Environment (10L)

Characteristics of industrial effluents,
Conventional treatments, Bioremediation,
Kinetics of biodegradation of waste,
Advances in aerobic and anaerobic treatments
Genetically modified organisms for improving the environment
Techno-economic feasibility of conversion of waste into energy

BT 43 APPLICATIONS OF GENETIC ENGINEERING

BT 43.1: Applications to Medicine and Agriculture (20L)

Concepts,
Pharmaceutical products: Human protein replacement, Human therapeutics, and vaccines.
Human diagnostics: Methods of linkage analysis and mutation detection, Diagnostics for infectious agents: methods with examples
Gene therapy: types, vectors, methods, safety and advances.
Agriculture: Transgenic plants – enhancing resistance to pests, nutritional value, modification of ornamental plants, bioengineered food, vegetable vaccines, plantibodies, biopharming.
DNA marker technology in plants
DNA fingerprinting and forensic applications

BT 43.2: Bioinformatics in Gene and Protein Analysis, IPR and Patents (10L)

Human genome sequences and gene annotation technology.
General concept of patenting, International and Indian Scenario, WTO.
Evolution of patenting system.

BT 44 PLANT BIOTECHNOLOGY

BT 44.1: Applications of Plant Cell &Tissue Culture in Breeding and Industry (10L)

Somaclonal & Gametoclonal Variation: applications and limitations. (Exploitation for selecting superior phenotypes - disease resistant, stress tolerant, high secondary metabolite producing), Screening procedures.
Haploid production (Anther, Ovule, Pollen cultures).
Cryopreservation and *ex situ* conservation of germplasm.
In vitro pollination and fertilization, embryo rescue, embryo culture, endosperm culture and production of seedless plants.
Somatic hybridization (Symmetric, Asymmetric, Cybrids)

Commercial production of secondary metabolites - Use of bioreactors, immobilized cells, biotransformations, elicitors. Applications and limitations.
Metabolic Engineering for secondary metabolite production.

BT 44.2: Transgenic Plants (20L)

Ti- & Ri- plasmid based vectors, Selectable markers, Reporter genes, promoters, SARs.
Applications of transformed plants (Disease/Pest/Herbicide tolerance, Improvement of crop quality, Abiotic stress tolerance, Molecular Pharming).
Other nuclear transformation methods (Virus-mediated, Direct gene transfer through protoplasts, Particle bombardment).
Chloroplast transformation.
Transgene stability, gene silencing, removal of marker genes.
Management of transgenic plants, consumer issues, IPRs.

BT 45 CHEMICAL SYNTHESIS AND SCREENING IN BIOTECHNOLOGY

BT 45.1: Synthesis and Interaction of Biological Macromolecules (15L)

Synthesis of oligonucleotides and their uses in diagnostics.
Synthesis of oligopeptides.
Synthesis of polysaccharides: principles and applications.

BT45.2:Combinatorial Chemistry & High Throughput Screening (15L)

Various methods for library generation
Target oriented synthesis
Diversity oriented synthesis

BT 46 GENOMICS AND PROTEOMICS

BT 46.1: Genomics (15L)

Introduction to Genomics and Proteomics
sequencing strategies for whole genome analysis, sequence data analysis.
Comparative Genomics: Protein evolution from exon shuffling, Protein structural genomics, Gene function by sequence comparison
Global expression profiling : whole genome analysis of mRNA and protein expression, microarray analysis, types of microarrays and their applications
Functional genomics.
Toxicogenomics.
Pharmacogenomics
Metagenomics, Metabolic engineering

BT 46.2: Proteomics (15L)

Importance of Proteomics
Strategies in Proteomics: 2 D PAGE, Mass spectrometry.
Databases and search engines in proteomics
Mapping of protein interactions: Two hybrid, phage display etc
Proteomics applications: Understanding the mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins.

BT 47 MOLECULAR IMMUNOLOGY & IMMUNOTECHNOLOGY

BT 47.1: Molecular Immunology (15L)

Cytokines.
T cell education, Affinity maturation.
Immunological Memory.
Cell-cell interaction, signal transduction.
Development of tolerance.
Characteristics of T helper and Tc TL and B cell peptide.
Transplant immunology.
Bone marrow chimera.
Auto immunity, molecular mimicry, Therapy.
Monoclonal antibody.
Techniques in molecular immunology.
Network theory.

BT 47.2: Immunotechnology (15L)

Animal models and transgenic animals and their use in immunology.
Experimental immunology.
Vaccine development.
Stem cell technology.
Molecular modeling and Bioinformatics.
Chimeric antibodies, phage display, antibody engineering.
Large scale manufacture of antibodies.
Manufacturing of immuno diagnostics.
Recombinant vaccines, combined vaccines, polyvalent vaccines.

BT 48 MOLECULAR APPROACHES TO DRUG DISCOVERY

BT 48.1 : Basic Concepts in Drug discovery (15L)

(a) Introduction to drug discovery

(b) Steps in drug discovery: (i)Target identification and validation (ii) Hit identification (iii) Lead generation and optimization (iv) Pre-clinical studies (v) Clinical trials
(c) Types of targets and their role in physiology and disease : (i) GPCRs (ii) Nuclear
(d) receptors (iii) Enzymes (Proteases, kinases and phosphateases) (iv) ion channeles (calcium, sodium, potassium)
(e) In vitro screening methods for common targets: (i) Principles of absorbance (ii) Fluorescence, Luminance and radioactivity measurements and their use in drug discovery (iii) Receptor binding assays (iv) enzyme assays

BT 48.2 : Functional Assays and Toxicity Evaluation (15L)

(a) Functional assays: (i) GPCR functional assays (intracellular calcium and camp measurements) (ii) Gene reporter assays (iii) Functional assays for enzymes (iv) Gene expression tools
(b) In vitro absorption and metabolism: (i) Introduction to ADME (adsorption, distribution, metabolism and excretion) (ii) In vitro metabolism assays (iii) In vitro absorption assays (iv) In vitro CYP- 450 induction and inhibition assays
(c) In vitro toxicity assays: (i) AMEs test (ii) Mouse lymphoma (iii) mouse micronucleus test

BT 49 NANOBIOTECHNOLOGY

BT 49.1: Production and Characterization of Nanoparticles (15 L)

Introduction to Nanoscience
Techniques used in Nanobiotechnology : Optical Microscopy, Atomic Force Microscopy, SEM etc
Production of nanoparticles: Collision / Coalescence mechanism of primary particle formation, nanoparticles agglomerates & aerogels
Biological production of nanoparticles: fungi, bacteria, yeast and actinomycetes

BT 49.2: Applications of Nanoparticles (15 L)

Use of nanoparticles as molecular imaging probes
Use of optical microscopy to study the dynamic events in cells
Nanobiotechnology for human health : nanoparticles for drug delivery, gene delivery, understanding the mechanism of macromolecular interactions etc
Use of nanoparticles as sensors
Nanoparticles for cleaning environment particularly heavy metal bioremediation

BT 50 INTELLECTUAL PROPERTY RIGHTS (IPR) & PATENTS (15 L)

What is Intellectual Property?
Importance of protecting scientific discoveries
IPR policy of Government of India
Qualification for a Patent – Novel, Commercial & Non-obvious
Jurisdictionn of Patent laws, Indian & International Patent laws
How is the patent filed and granted

BT 51 SEMINAR

BT 52 PROJECT

DETAILED SYLLABUS OF M.Sc. BIOTECHNOLOGY, 2008-09 (PRACTICALS)

SEMESTER I:

BT 14 BIOLOGICAL CHEMISTRY

1. Introduction to measurements: balances and pipetting. Preparation of solutions of given normality and its standardisation.
2. pH meter: buffering capacity of a buffer, Indicators. To determine the pKa value and hence the dissociation constant of a given acid by using pH meter. Determination of the amount of a a-amino nitrogen by formal titration method
3. Colorimetry: To determine the dissociation constant of a given indicator colorimetrically and to prepare the buffer solutions in the pH range of 2.2 to 8.0
4. Potentiometry: Redox potential of Fe +2 and Fe+3
5. Conductivity meter: To determine the cell constant of 0.1 M KCl and perform the titration of strong acid vs strong base and to find out equivalent conductance of the salt formed.
6. Quality of water.
7. Viscometry: a) Radius determination: Glycerol molecule b) Molecular weight determination - Proteins and DNA.
8. Radioactivity: To determine the half life, average life and decay constant of a given radioactive isotope.
9. Thin layer chromatography : lipids, mixture of dyes.
10. Spectrophotometry: Double beam and recording spectrophotometry, Derivatives and difference spectra: Indicators, cytochromes , haemoglobin.

11. ELISA Reader and spectrophotometer: Estimation of protein by Lowry, Biuret and Bradford methods, Analysis of Standard curves, linear regression and assessment of ranges and reliability.
12. Spectrophotometry: To find out absorption spectrum of a given chromophore and/or oxidised and reduced forms (sodium nitrite and borohydrate). a) Haemoglobin and Methaemoglobin b) NAD and NADH.
13. Enzyme assays b-galactosidase, time, temperature, protein concentration and cofactors.
14. LDH : Km and Vmax, Various kinetic plots.
15. Use of computer packages for parametric and non-parametric methods and non-linear regression.
16. Liposome : Preparation of Uni and multilamellar vesicles, use of sonication. Light scatter and Turbidity correction of multi and unilamellar vesicles.
17. Introduction to centrifugation.
18. Use of computer for data analysis and spectral changes, difference and derivative spectra.
19. Polyacrylamide gel electrophoresis : Native gel.
20. Isozymes and activity staining.
21. SDS-PAGE of proteins.

BT 15 CELL BIOLOGY

1. Microscopy: a) simple, b) compound c) phase contrast microscopes.
2. Cell Division: Mitosis and Meiosis.
3. Permanent Slides: Polytene chromosomes, grass hopper spermatids and chromosomes.
4. Cell motility and flagellar staining, Photography and videotaping (motility, morphometry).
5. Micrometry: Calibration of stage and ocular micrometer and measurement of the given biological sample Haemocytometer: calibration and measurement of biological samples.
6. Electron microscopy : Demonstration and good photographs for interpretation.
7. Blood cells: WBC: types of polymorphs.
8. Demonstration of animal handling for experimental purposes: cervical dislocation, dissection of rat: cardiac puncture, blood sample preparation and its handling, Osmotic fragility of RBC's.
9. Density gradient: sucrose/percoll.
10. Embryo development: permanent mounts.
11. Developmental studies: chick: developmental stages and Gastrulation.
12. Programmed cell death during embryonic development.
13. Cell types of plants - maceration of various tissue explants and identification of xylem vessels, trachieds, stomata, root hair etc.
14. Isolation of chloroplast.
15. Chlorophyll estimation: spectrum and light scatter turbidity correction in chloroplasts.

BT 16 QUANTITATIVE METHODS

BT 16.1 BIOSTATISTICS

1. Descriptive statistics: systematic tabular summarisation of data (before analysis), measures of central tendency, measures of dispersion, measures of skewness (using calculators).
2. Correlations (product-moment coefficient, Spearman's rank coefficient) and regression (linear regression, curve fitting).
3. Data presentation (tables/figures): 1-D and 2-D bar charts, pie diagrams, graphs (using computer software packages).
4. Statistical distributions: fitting discrete uniform, binomial, Poisson and normal probability distributions to given data.
5. Testing of hypotheses: Tests of significance (mean, Standard Deviation, Correlation coefficient).
6. Chi-squared test for goodness-of-fit, test for independence of attributes, non parametric tests (run test) using calculators and printed tables and computers.
7. Sampling (drawing random samples using random number, tables, chits).
8. Computer programs for random number generation), Design of experiments, ANOVA (one-way and two-way).

BT 16.2 BIOMATHEMATICS

1. Ratio and proportion.
2. Factorial notation, permutation and combination.
3. System of algebric equations (verification of consistency and finding solutions).
4. Round-off error and how to minimise it while evaluating algebraic expression (can be included in computer course).
5. Functions and their graphs, Concept of limit of function.
6. Computing area under a curve of regular/arbitrary shape.
7. Trigonometry.

8. Calculus: i) Differentiation and higher order differentials ii) Application of derivatives iii) Integration: definite and indefinite iv) Differential equations v) Application of integration.

BT 16.3 COMPUTER

1. Introduction computers and its peripherals.
2. Maintenance of computers using antivirus programs, formatting computers.
3. Handling of computers files and folders, Use of Dos commands.
4. Introduction to various packages and softwares.
5. Use of MS Dos commands , Windows: Word and Excel.
6. Introduction to programming languages.
7. Basic C programming.
8. Advanced C programming.

SEMESTER II:

BT 26 MOLECULAR BIOLOGY

1. Isolation of chromatin: Determination of mononucleosomal size.
2. Chromatin gel electrophoresis.
3. Endonuclease digestion of nuclei.
4. Analysis of DNA fragments by agarose electrophoresis.
5. Thermal melting of DNA.
6. Isolation and analysis of nuclear DNA.
7. Restriction endonuclease digestions of nuclear DNA.
8. Isolation of mitochondrial DNA, agarose gel electrophoresis and detection of modifications.
9. Restriction endonuclease digestion and separation of fragment by gel chromatography, density gradient centrifugation and base composition analysis of DNA.
10. Isolation plant genomic DNA, agarose gel electrophoresis and detection of plant DNA.
11. Restriction endonuclease digestions of plant genomic DNA.
12. Isolation of bacterial DNA.
13. Agarose gel electrophoresis and detection of bacterial DNA.
14. Restriction endonuclease digestions of bacterial DNA.
15. Transformation.
16. Preparation of beads and column packing for cationic exchange chromatography.
17. To find out the capacity and nature of the cationic exchange resin.
18. Preparation of beads and column packing for anionic exchange chromatography.
19. To find out the capacity and nature of the anionic exchange resin.
20. Gel filtration chromatography: Sephadex, Sepharose.

BT 27 GENETICS

1. Mutants of Drosophila, mono and dihybrid crosses in Drosophila - Mendel's laws of genetics Sex linkage in Drosophila.
2. Sex linked lethals in Drosophila.
3. Dominant lethals in Drosophila.
4. Sister chromatid exchange in CHO cell line : Control and EMS treated.
5. Use of Drosophila as a model system in genetics: morphology, life history, mutants, culture, sexing pupae for setting up crosses etc.
6. Study of autosomal gene heritance, Study of sex linked gene inheritance.
7. Estimating gene frequencies in human population, estimation of heterozygotes frequencies, Pedegree analysis, analysis of human karyotes, chromosomal aberrations.
8. Isolation/identification of auxotroph mutants in bacteria, Recombination in Bacteria.
9. Micronucleus test for detecting genotoxins, study of sister chromatid exchange for genotoxicity study.
10. AME's test for screening genotoxins.

BT 28 MICROBIOLOGY, VIROLOGY & IMMUNOLOGY

BT 28.1 MICROBIOLOGY

1. Cleanliness, media preparation, sterilisation, culturing methods, dilution technique, and isolation of pure culture- techniques.
2. Staining techniques in microbiology i) simple staining ii) negative staining iii) positive staining iv) spore staining v) capsule staining and identification.
3. Culture characteristics of microbes, identification of unknown bacteria by biochemical tests.
4. Bacterial growth curve - serial dilution plating and turbidity measurement.
5. Competent cell preparation , replica plating.
6. Extracellular enzymatic activities of microbes, immobilization of *Saccharomyces cerevisiae* and alcohol.
7. Standard qualitative analysis of water.
8. Antibiotic sensitivity test, LD50, Potency of drug/antibiotics and biotransformations.

BT 28.2 VIROLOGY

1. Electron microscopic observations of ultrastrucutre of animal viruses.
2. Propagation of viruses in animals/tissue culture/embryonated eggs and preparation of virus.
3. Plaque/Focus formation assay of animal viruses and/or Animal cell transfection by viruses.
4. Microtitration - Haemagglutination technique, Immunodiffusion, immunoelectrophoresis, radioimmunoassay and ELISA.

BT 28.3 IMMUNOLOGY

1. Immunodiffusion.
2. Rocket immunoelectrophoresis.
3. Immunoelectrophoresis.
4. Western blotting.
5. Interferon induction in cells - isolation and assay.
6. Development of monoclonal antibodies by hybridoma technology.
7. Production of polyclonal antibodies and testing-immunodiffusion, immunoelectrophoresis.
8. Crossed antigen-antibody electrophoresis.
9. Radioimmunoassay.
10. Immunofluorescence.
11. Agglutination, rosette-formation, complement fixation.
12. Antigen-induced T cell proliferation, Generation of cytotoxic T lymphocytes.

BT 29 BIOINFORMATICS

1. A guided tour of NCBI/EBI : Data acess – standard search engines : data retrievals tools – Entrez, DBGET and SRS (sequence retrieval systems); software for data building; submission of new revised data.
2. Sequence homology as product of molecular evolution, sequence similarity searches, sequence alignment-global, local, end free-space; measurement of sequence similarity, similarity and homology.
3. Multiple sequence alignment
4. Phylogeny reconstruction, PHYLIP package

SEMESTER III:

BT 36 TISSUE CULTURE (ANIMAL & PLANT)

BT 36.1: Tissue Culture Techniques

1. Acquaintance with tissue culture laboratory, Culture place: culture cubicals P1 to P4; Laminar flowsystem.
2. Preparatory techniques: Washing of glassware, dry and steam sterilisation. Maintenance of aseptic conditions, Sterilisation techniques, Preparation of culture media, Media preparation: Filter sterilisation, Sterility tests, and media storage. Serum inactivation.
3. Short term cultures. a. Primary culture of cells b. Organ culture.
4. Staining of cell cultures and observations under microscope.

BT 36.2: Animal Tissue Culture Techniques

1. Growth studies. Cell count, protein estimation, mitotic index.
2. Development and maintenance of a cell line.
3. Karyotyping.
4. Virus propogation in cells, cytopathogenic response of cells to viruses.
5. In vitro assay of drugs, predictive test for anticancer drugs.
6. Staining and screening of cells /sera for mycoplasma, viruses.
7. Cell cloning by single cell dilution method, Freeze storing and revival of cultured cells.
8. Clonogenic assay, Cell-cell interaction: Co-culture of normal and mutant cells, cell cloning by single cell dilution method.
9. Cell synchronization (determination of mitotic index and cell cycle time), LDH isozyme analysis of the given cell lines.
10. Purification of a product secreted by a functional cell line, Estimation of hormones secreted by a hormone - secreting cell line.
11. Cell hybridization.
12. Immunohistochemical staining (oncogene expression).
13. Transplantations: tumors, organs, cells.

BT 36.3: Plant Tissue Culture Techniques

1. Introduction to plant tissue culture techniques: Surface sterilisation techniques, media preparation.
2. Role of additives on various explant cultures.
3. Effect of plant growth regulators on various explants for callus induction, cell suspension culture, growth analysis, cell plating efficiency.
4. Organogenesis and Somatic embryogenesis.
5. Shoot tip and nodal sector culture.

6. Anther culture.
7. Embryo culture.
8. Endosperm culture.

BT 37 GENETIC ENGINEERING

1. Isolation of plasmid DNA- i) minipreparation ii) large scale isolation.
2. *In vitro* DNA ligation, transformation of *E.coli*.
3. Characterisation of transformants: DNA gel electrophoresis, Restriction map analysis.
4. Southern blot analysis.
5. Isolation of cytoplasmic RNA.
6. Separation of poly A+ RNA on oligo-dT column**.**
7. Electrophoresis of RNA on denaturing gels.
8. Northern and dot blotting technique.
9. cDNA synthesis and cloning.
10. *In situ* detection of RNA in embryos/tissue.
11. PCR/ RT-PCR technique.
12. Sequencing and computer analysis.
13. *In vitro* translation.

BT 38 ADVANCED TECHNIQUES IN BIOLOGICAL CHEMISTRY AND BIOCHEMICAL ENGINEERING

BT 38.1: Chromatographic Separation of Proteins

1. Preparation of beads and column packing for ion exchange chromatography.
2. To find out the capacity and nature of the ion exchange matrix exchange resin.
3. Separation of proteins on ion exchange column.
4. Separation of glycoproteins on Con A Sepharose.
5. Gel filtration chromatography: Sephadex, Sepharose.
6. Preparation of dye affinity matrix.

BT 38.2: Proteomic profiling of Cellular proteins

7. 2D PAGE of complex nature of proteins
8. Identification and characterization of proteins resolved on 2D PAGE

BT 38.3: Biochemical Engineering

9. Immobilization of yeast on calcium alginate
10. Conversion of starch into glucose by yeast invertase
11. To determine the efficiency of membrane filtration
12. Down stream processing: Extraction and purification of enzyme from natural source.

SEMESTER IV:

BT 51 SEMINAR

Each student will have to give 4 seminars on important recent scientific discovery published in prestigious scientific journals.

BT 52 PROJECT

Each student will have to do an extensive project on a topic of their choice. Attempts willbe made to absorb maximum student in the Department itself.