The postgraduate diploma course in bioinformatics
(this course, also used as set of modular training programs, **has been DICONTINUED**)

It was a full time course and students were selected via a nation-wide entrance test and interviews, just like the current MSc program. About 40 students were admitted per batch, from all over India. The course intended to provide competence in computational biology/bioinformatics by training students in the areas of cell/ molecular biology, computer science, statistics, chemistry and drug design. Related topics like IPR, entrepreneurship, clinical trials were also taught. The course received a good support from many other organizations and individuals in and outside Bengaluru.

The course was very successful and achieved about 95% placement. Many students went on do PhD (mostly abroad).

The batch-wise details of students and placements can be found 'here'.

Who WAS eligible? *Graduates/ Postgraduates from Engineering, Computer Science, Statistics, Mathematics, Physics, Chemistry, Pharmacy, Medicine, Agriculture, Veterinary and Life Science.*

Duration: *18 months*

Course curriculum - *for first 12 months*
(last six months of the program were used for internship at various organizations where students were placed by IBAB)

Various modules involved lectures, lab/practical classes, assignments, oral discussions, quizzes and tests. Each credit corresponded to about 4-5 hours of application per week. In addition there were invited lectures on recent exciting new developments in biology/ bioinformatics, as well as on social and ethical issues related to biotechnological developments.

The syllabus listed is only a guideline and may be subject to some modification by the concerned faculties, who will also identify the appropriate course material/format.

Foundation course in cell and molecular biology

Objectives:
Introduce life as a cellular and molecular process and provide an understanding of the workings of a living cell.

Provide an introduction to the basic structure and function of biomolecules, study the in depth structure of the cell and the function of its organelles.

Examine the central dogma of molecular biology, followed by elucidation of principles of gene regulation in differentiation and development, post-translational modifications and protein trafficking within cells, transport of molecules across cell membranes, processes of cellular metabolism, cell division and reproduction, and cellular signaling - signal transduction. Concepts of genetics and the use of genetic analysis in cell biology will also be covered.

An overview of Biology
- Life as a Cellular and Molecular process and a continuum
- Biological information and bioinformatics

Cell Structure
- General Structure of the cell
- Prokaryotes vs. eukaryotes; relevant theories of evolution; diversity of life-forms and broad classification of organisms
- Viruses
- Eukaryotic cell structure and function of organelles (including differences between plant and animal cells)

Introduction to Structure and Function of Bio-molecules
- Basic chemistry of biological molecules; structure and function of nucleic acids, proteins, carbohydrates and lipids

Central Dogma of Molecular Biology
- Replication
- Transcription
- Translation

Intracellular Processing and Transport
- Post translational protein processing in ER and Golgi. Protein sorting and secretion.
- Transport across cell membranes – diffusion, active transport, co-transport.
- Protein trafficking between cellular compartments, endocytosis, exocytosis.

Cell Division and Differentiation
- Reproduction and Development
- Cell Cycle and Cell Division
- Regulation of Cell Cycle

- Gene Regulation and Differentiation
- DNA-Protein interactions
- Inter-cellular connections
- Cell interactions in Development

Cell signaling and signal transduction

- Introduction to endocrinology
- Mechanisms of hormone actions

Bioenergetics

Genetics

- Basics
- Genetic analysis and techniques
- Population genetics in the context of bioinformatics

Immunology

- Basics
- Antigen antibody interaction, use of bioinformatics in designing of Mimotopes

Cell signaling and signal transduction

- General principals of cell – cell communication
- G-Protein coupled signaling
- Enzyme-linked receptor signaling
- Computational cell signaling

Cancer

- Basics
- Advanced talks

Neurobiology

- How neurons transmit signals – action potentials
- Structure of synapses
- Receptors and ion channels
- Examples of neuronal signaling

Biotechnology Laboratory course

Objectives:
Provide hands-on laboratory the basic experimental techniques used in modern biology, which generate the real data, requiring bioinformatics tools for analysis.
Basic laboratory equipment and procedures(performance):

- Instruments used
- Gram staining
- Microscopy
- Preparing solutions and calculations involved
- pH adjustments

Bacterial culture

- Plating and primary culturing- Performance

Protein handling

- Protein estimation - Performance

Bacterial culture

- Colony selections
- Preserving cultures
- Culture growth phases - demonstration

Protein handling

- PAGE, Protein purification - demonstration

DNA handling

- AGE – performance
- Extraction, sequencing, PCR, RD, ligation, transformation for rDNA demonstration
- Chromosome handling
- Mammalian cell culturing

Computational methods for sequence analysis

Objectives:
The purpose is to understand the information contained in the sequences. An important question in sequence analysis is to understand the structural and functional properties through computational insight. If the characters of a sequence aligns within a statistical limit with a known sequence whose structural properties are understood, this information can be transferred to the unknown sequence. Therefore, it is necessary to develop efficient algorithms for sequence alignment. Hidden Markov Model is used to understand the evolutionary origin of sequences and their alignment. Stochastic methods, such as genetic algorithm, are more useful to analyse very long sequences. Phylogenetic analysis is needed to comprehend evolutionary divergence of a set of sequences and their similarities. Data-mining tools are used to find gene interactions in multifactorial diseases.

Modelling in Bioinformatics
Theory

- Introduction to sequence analysis
- Substitution matrix, dot matrix method
- Sequence alignment (global and local),
- Dynamic programming, Needleman-Wunsch Algorithm
- Evolutionary computation (genetic algorithm)
- Multiple sequence alignment
- Phylogenetic analysis, binary tree
- Maximum parsimony
- Probabilistic approach to phylogeny
- Rates of amino acid substitutions, molecular clock
- Jukes-Cantor model for nucleotide substitutions
- Hidden Markov Model (HMM) and sequence analysis
- Examples of hidden Markov process
- Likelihood algorithm for a set of sequences
- Pair-wise alignment in HMM
- Viterbi algorithm for pair HMM
- Entropy and sequence alignment, information content, relative entropy, mutual information
- Quantitative genetics, Hardy-Weinberg genotypic equilibrium, simple models of selection
- Neutral theory of molecular evolution, genetic drift
- Quantitative traits
- Data-mining tool to find gene interactions in multifactorial diseases
- Gene-environment interactions

Lab

- Introduction to Pubmed
- Biological databases:
  - Nucleotide sequence databases
  - Protein sequence databases
  - Protein structure database
  - Protein secondary databases of (domains)
  - Structural Classification of proteins
- Searching biological databases using Entrez
- Usage of GCG sequence analysis package:
  - Seqlab- Interface, Editor, Main list,
- Start up preferences
  - Running programs, translate and back translate
- Database searching:
- Searching databases for sequences
- Searching for sequences similar to the query sequence
  - Comparison: Compare two sequences
  - Mapping - Display restriction digests
- Motif searching
  - Pattern recognition - Gene finding
  - Multiple sequence alignment
  - Protein secondary structure prediction
  - Primer selection
- Other programs
  - draw plasmid maps,
  - find repeats, composition

Data bases and data mining

- Design of biological databases
  - relational data models
  - semi-structured data models
  - text databases
  - sequence databases
  - pattern databases
- Database design principles
  - brief mention of normalization theory
  - query paradigms
  - query languages (SQL)
  - similarity searches
  - approximate retrieval integrated data analysis and applications
  - VIEWs across databases
  - pathway modeling
  - network queries
- Practical and deployed database designs

- examples from Nucleic Acids issues
- experiences from VT Stress Signals project
- other applications

- Data mining
  - general paradigms: clustering, classification, biclustering
  - structure discovery in biosequences
  - rule finding
  - probabilistic graphical models
  - techniques for particular datasets
  - gene expression assays
  - transcription factor data
  - protein-protein interactions
  - regulatory networks
  - signaling pathways
  - biomedical natural language processing
  - cross-genomic modeling

Gene Prediction

- Introduction *to gene prediction*
- Homology based gene prediction methods
- HMM based gene prediction methods
- Neural network based gene prediction methods

Computational structural biology

Objectives:
To acquire knowledge of macromolecular conformation, to understand structure-function relationships involved and to apply physical and chemical principles in order to develop appreciation of biological activity at the atomic structural level.

During this process, the students are expected to attain familiarity with different application softwares, to be able to use mathematical and programming tools and where possible develop their own, to appreciate the correlations that exist among sequence, structure and function
Theory

- Foundations of Physics – Units and Dimensions, Measurement and errors, Kinematics, Coordinate frames, Transformations, Electrostatics
- Protein Structure-component amino acid residues
- Conformation-Internal parameters; Search space
- Hierarchy in protein structure- Primary, secondary, tertiary and quaternary
- Ramachandran Plot, Contact criteria
- 3D structural databases
- Protein classification
- Structure prediction – secondary structure
- Structure of Nucleic acids
- Structure of Carbohydrates
- Molecular Graphics – available 3D display tools
- Molecular modelling concepts
- Structure and Dynamics in Genomic context
- Biomolecular interactions & thermodynamics
- Protein-Ligand interactions using biomolecular NMR spectroscopy as means to 'rational' drug design
- Comparative modelling
- Threading methods
- Force field philosophy
- Parametrization
- Docking strategies
- Energy minimization methods
- Simulation protocols – Molecular Dynamics, Simulated annealing
- Experimental structural determinations; X-ray crystallography

Lab

- Familiarising with *SGI/Accelrys* environment
- Model building using Biopolymer module

- Analysing 3D structures of proteins
- Measurement of conformational parameters
- Transformations, conformational grid search
- Contact map examination
- Rendering of protein properties; photorealistic graphical images
- Homology Modelling
- Creating molecular topology files under Discover and AMBER environments
- Energy minimization protocols
- MD simulations on Peptides/Proteins

Introduction to computers and programming languages

Objectives:
Ability to write short programs and understand compilation and installation of bioinformatics software, parsing and manipulation of bioinformatics outputs
Operating Systems (DOS & Windows)

- Introduction
- Entering DOS
- Files and Directories
- Types of files and file attributes
- Windows

Linux

- Getting started
- Using Linux
- Working with files and directories
- File permissions and file utilities
- Basics of editing with vi
- Advanced text editing with vi
- Filters
- Regular expressions and grep
- Process management
- Communication utilities
- The Linux file system
- Input/Output redirection in detail
- The Linux environment
- A quick tour of X-Windows

C Programming

- Introduction
- Data types
- Expressions
- Input and Output
- Decisions
- Loops
- Functions
- Arrays
- Pointers
- Files

Internet and WWW

Objectives:
Develop basic computer skills and IT skills specifically with relation to the distributed resources on a variety of topics, including the human genome, that are available on the Internet. To access, manipulate, download and analyse selected Internet resources. Do a project to investigate an aspect of the human genome project relating to the genetics of disease (example). Write a report in a computer-based format and install on the www to present the work.
Internet

- Basic network concepts
- Network components
- Types of networks
- Protocols
- Network topologies
- Services provided on the Internet
- WWW
- Browsers
- Web servers
- HTTP

HTML

- Introduction
- Types of elements
- Syntax
- Tags, elements, layouts, formatting, hyperlinks, images, tables, frames, forms

CSS

- Introduction
- Advantages
- Rules
- Tree structure
- Adding style to documents
- Loops
- Functions, arrays, pointers
- Files

PERL

- Introduction
- Scripting vs compiled languages

- Data types, numerical and string operators
- Conditional statements and loops
- Lists, arrays, array functions
- Built in functions, subroutines, functions
- File handling, command line arguments
- Built in modules

CGI

- Web server
- How CGI works
- Configuration of web server
- Integration of HTML and PERL
- Request and response read
- Read, write and modify data files using web interface

Mathematics & Statistics in bioinformatics

Mathematics

- Introduction an recap
- Logarithms
- Functions and limits
- Coordinate system
- Coordinate geometry
- Linear algebra
- Basic calculus
- Numerical methods
- Optimization techniques
- Fourier series and transforms

Statistics

- Basic statistics
- Probability theory
- Distributions: Normal, Poisson, Binomial
- Central limit theorem
- Bayesian statistics
- Significance test
- Correlation and Multiple regression
- Hypothesis testing
- ANOVA and Markov chains
- Hidden Markov models
- Multivariate analysis
- Principal component analysis

Guest lectures

- Hypothesis testing
- How to write a protocol

Basic biochemistry and chemistry

Biochemistry

- *Metabolic pathways*
- *Metabolic pathways: Examples*
- *Thermodynamics and enzyme kinetics*

Organic chemistry

Objectives:

Property is a function of the molecular structure.Organic compounds are to be portrayed in stereochemical form with associated functional group(s). Reactions are changes introduced in the functional groups and stereochemistry. Traversing through a stereochemical transition state along (some now defined) dynamic stereochemical paths (organic or enzymatic have similar route). The change occurs at a targetted site with bonds involvement, at the reaction centre. They must visualize the synthetic and retrosynthetic steps in the molecular change stereochemically and enantioselectively. The application of [Property (P) as f (structure (S) is brought to reality by(say) 6 drug development programmes; with stress on the dynamical nature of effecting the change in P and S.

Several examples and problems, (with ohps to exemplify not as text; standard texts go too deep into chemistry of the issues hence the selective collection) are taken to ***emphasise each step*** *in the entire process –functional group (XII class review) – skeletons (stereochemistry) – reaction mechanism (stereochemical).*

- of the families as per XII class texts as alkanes, alkenes, aromatics, alkyl halides, alcohols, aldehydes, ketones, acids, acid derivatives, aminoacids & amides, carbohydrates –mono & disacchaarides.

Stereochemistry

- Enantiomerism,nomenclature, diastereoisomers;enantiotopism, nomenclature, stereospecific addition to double bonds, acetone (etc) and LiAlH4, Grignard, NADD
- Conformational analysis – ethane, butane,cyclohexane,decalin, hydrindane, steroidal systems (mainly A/B, B/C, C/D - trans junctions), -- structures of, ideas of relative stability, some reactions and their stereocontrol.
- EZ-isomerism, nomenclature, mechanism of addition reactions
- Ideas and examples of Atropisomerism, (planar) cis-trans isomers (Racemisation, separation, characterisation, complex cases have been generally omitted)

Reactions

- Bonds, general ideas of strength, length, fission , dipoles...; reagent

types, the reaction coordinate-- eenthalpy diagram aand thee explanation of varioous terms, nature of transition state, intermediates, Hammetts sigma meaning, (very superficial determining methods, as and when they appear in below). types of reactions

- The mechanism of the simple reactions of addition, substitution... a couple of cases as they come in general chemistry above.
- Synthesis—Mechanism & stereochemical aspects as they occur in 1 and 2 and 3 above.
- Protection, Assymetry in synthesis sugars and steroids used as bases.
- Similarity of Mechanisms of Organic and Enzyme Reactions

Elementary notions of the modification in drug molecules

- for improvements.e.g pK and sulphonamides, beta-lactamase and penicillins, isosterism and morphine, acetylcholine... more specific examples and details of this as "chemistry in drugs" could be suggested. Above is a "foundation in organic chemistry" course

Physical chemistry

Objectives:
At the end of the physical chemistry module they should be able to wotrk the energetics of a transformation could be biological/chemical. To be able to understand the rate of reactions. The reasons for some reactions to be fast and some to be slow. To understand the concepts of acids and bases and why controlling the pH in certain situations is so important. The role of buffers in any biological processes should be clear to them. Analysis and characterisation of compound by anlytical and spctroscopic tools. This will help them to charecterise unknown compounds and their identification.

- Experimental quantities
- Acids and bases, buffers
- Error analysis
- Energetics of a chemical reaction
- Rate of a chemical reaction
- Oxidation/reduction processes

Special lectures

- Chemical elements in living systems
- Chemistry in everyday life

Fundamentals in Microbiology

Microbiology
Objectives:
Microorganisms in general and prokaryotic bacteria and lower eukaryotes in particular play key roles in biotechnology. A basic knowledge of these organisms with respect to their evolution, identification, growth, structure-functions, biochemical pathways unique to them, their pathogenicity, and susceptibility to chemotherapeutics and antibiotics is quite essential in understanding the multiple roles they play in health,agriculture and creation of wealth. These aspects are the subject matter of the first half of the lectures.

The topics covered in the 2nd half are at an advanced level. They include: the role of genetically engineered organisms in biotechnology; changing patterns of infectious diseases; molecular mechanisms of antibiotic action and resistance, and genomics of selected organisms pathogenic to humans and plants.

- Introduction
- Cell structure and diversity: Phylogeny, Systematics (brief), Metabolic diversity among microorganisms
- Methods in microbiology
- Microbial diseases
- Antimicrobial drugs, mechanism of action and resistance
- Industrial applications: An overview

Biotechnology: Research and methodology

Objectives:
The majority of the industrially produced biotechnology products use microorganisms , plant or animal cells and manipulate them in suitable production equipment.

This course will aim to give the student an overview of the technologies involved in the industrial production these products - the practical applications of biotechnology in Industry.

- Biological research in general: An introduction in the context of bioinformatics
- Methodologies: An introduction
- Electrophoresis
- Nucleic acid hybridization based techniques
- Recombinant DNA technology
    - Transgenic and knockout models
    - Introduction
    - Advanced

- Electrophoresis
- Nucleic acid hybridization based techniques
- FISH, Western, ELISA, Immuno-histo-chemistry EMSA, SWA etc
- Protein purification – an overview
- Applied biotechnology
- Other aspects: Cloning animals, gene therapy, and stem cell research. Techniques used in forensic sciences

Intellectual Property

Objectives:

Raise awareness of the principal concepts of intellectual property and its importance as spur to human creativity in the advancement of economic and social development, and in the facilitation of international trade through the treaties offering multi-lateral protection.
Explain what constitutes protection of IP.
Introduce the treaties that govern IP.
Understand some of the IP issues in Biotechnology and Bioinformatics.

- Introduction to Intellectual Property
- Copyright & Related Rights; Trademarks; Geographical Indications
- Patents
- Searching Patent Information
- Major Treaties
- Issues in Biotechnology & Bioinformatics.
- Discussions

Bioinformatics in Drug Design and Discovery

Objectives:

Introduce students to the entire gamut of methods and principles used in the drug discovery process in the post genomic era, with particular reference to bioinformatics tools.

- use of genomics and proteomics for understanding diseases at the molecular level
- strategies for target identification and lead design
- molecular modeling
- protein-ligand interaction
- brief introduction to pharmacology, pharmacogenomics,
- chem-biology & chemoinformatics
- protein/DNA - ligand docking methods

Computational analysis of cellular signalling.

Objectives:

Basics of cellular signalling
Databases of cellular signalling
Computer modelling of cellular signaling.

- Introduction: Signalling as information flow and computation.
- Review of cellular signalling 1
- Review of cellular signalling 2
- Signalling, genes, and cell biology
- Cellular signalling databases: Design issues and sites.
- Cellular signalling as chemistry
- Modelling cellular signalling
- Experiments, literature, model building, and databases for signalling