Syllabus Frame work- Implemented from July 2018

Department: Institute of Bioinformatics and Biotechnology (Jointly merged with Department of Biotechnology)

Course: Five years integrated M.Sc. Biotechnology **Duration: Five years**

Semester I		
Core Courses		
Subject Code	**Subject Title**	**Number of Credits**
IBT-101T	Fundamentals of Physics I	3
IBT-102T	Fundamentals of Chemistry I	3
IBT-103T	Mathematics I	2
IBT-104T	Plant, Animal and Microbial World	3
IBT-121P	Laboratory Exercises in Physics I	2
IBT-122P	Laboratory Exercises in Chemistry I	2
IBT-123P	Laboratory Exercises in Biology I	2

Total Number of Credits: 17 (Core)

Semester II		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-201T	Applied Physics (Fundamentals of Electronics & Instrumentation)	2
IBT-202T	Applied Chemistry	2
IBT-108T+P	Introduction to Computer Science & Programming Languages	2
IBT-206T	Biomolecules	2
IBT-207T	Statistics I	2
IBT 212T	Introduction to Microbiology and Genetics	2
IBT-221P	Laboratory Exercises in Applied Physics II	2
IBT-222P	Laboratory Exercises in Applied Chemistry II	2
IBT-223P	Laboratory Exercises in Biology & Microbial Genetics	2
IBT 225 P	Practicals in Statistics I	1

Elective Courses		
IBT-EL1T+P	Introduction to Laboratory Instrumentation and Safety (T+P)	2
IBT-EL2T+P	Introduction to Ecosystems and Ethology (T+P)	2

Total Number of Credits = 21 (19 core + 2 elective)

Semester III		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-208T+P	Advances in Computational Programming	2
IBT-209T	Principles and Advances in Molecular Biology	2
IBT-305T	Biomathematics & Biostatistics	2
IBT-306T	Microbial, Plant and Animal Biodiversity	2
IBT-321T+P	Stereochemistry	2
IBT-322P	Laboratory Exercises in Molecular Biology	2
IBT-323P	Laboratory Exercises in Biodiversity	2
Elective Courses		
IBT-EL3T	Advanced Biostatistics	3
IBT-EL4T+P	Introduction to Analytical Techniques and Applications	3
IBT-EL5T	Practices and Ethics in Science	3

Total Number of Credits = 20 (14 core + 6 elective)

Semester IV		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-204T	English	2
IBT-205T	Cellular Basis of Structure and Function in Biology	2
IBT-307T	Biochemical and Biophysical Techniques	2
IBT-401T	Modern Physics	2
IBT-403T	Spectroscopy of Biomolecules	2
IBT-405T	Plant and Animal Physiology	2

IBT-324 P	Practical Applications of Biochemical and Biophysical Techniques	2
IBT-328 P	Laboratory Exercises in Cell Biology and Physiology	2
IBT-421 P	Laboratory Techniques in Molecular Biology	2
Elective Courses		
IBT-EL6T+P	Biophysics	3
IBT-EL7T+P	Host-Pathogen Interaction	3
IBT-EL8T	Advanced Biomathematics	3

Total Number of Credits: 24 (18 core + 6 elective)

Semester V		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-314T	Developmental Biology of Higher organisms	2
IBT-406T	Microbial Biotechnology I & II	2
IBT-404T	Genetics of Higher Organisms	2
IBT-107T	Seminars	1
IBT-422P	Laboratory Exercises in Microbial Biotechnology	2
IBT-329P	Laboratory Exercises in Developmental Biology	1
IBT-513T+P	Basic Separation Techniques in Biology & Biophysics	3
IBT-325P	Introduction to Computational Biology	2
Elective Courses		
IBT-EL9T+P	Elective I Histochemistry and cytochemistry	3
IBT-EL10T+P	Elective II Heterocyclic chemistry	3
IBT-EL11T+P	Elective III Basics of model systems in Biology	3

Total Number of Credits: 21 (15 core + 6 elective)

Semester VI		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-210T	Immunology I	2
IBT-309T	Bioinformatics I	2

IBT-409T+P	Plant Tissue Culture	2
IBT-326 P	Lab Exercises in Bioinformatics	2
IBT-213T+P	Project + Project Seminar	4
IBT-224 P	Techniques in Immunology I	2
IBT-423T+P	Animal Cell Culture I	2
Elective Courses		
IBT-EL12T+P	Elective I Food biotechnology	3
IBT-EL13T+P	Elective II High-end instrumentation in Biology	3
IBT-EL14T+P	Elective III Nanotechnology and Biomaterial	3

Total Number of Credits: 22 (16 core + 6 elective)

Semester VII		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-602T	Advances in Molecular Biology	2
IBT-603T	Enzyme Technology	3
IBT-310T	Immunology II	2
IBT-311T+P	Animal cell culture II	2
IBT-411T+P	Bioinformatics II	3
IBT-621P	Lab Exercises in Enzymology	2
Elective Courses		
IBT-EL15T+P	Nucleic acid Protein chemistry	3
IBT-EL16 T+P	Model systems to study Human biology	3
IBT-EL17T+P	Natural Product and Medicinal Chemistry	3

Total Number of Credits: 20 (14 core + 6 elective)

Semester VIII		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-501T+P	Introduction to Omics I	3

IBT-601T	Introduction to Genetic Engineering	2
IBT-407T	Metabolic Pathways	3
IBT-604T+P	Applications of Plant Tissue culture	2
IBT-622P	Laboratory Exercises in RDT	3
IBT-623T+P	Advances in Cell Biology (GT/TD)	2
Elective Courses		
IBT-EL18T+P	Structural Biology & Protein Engineering	3
IBT-EL19T+P	Applications of Biotech in Environment	3
IBT-EL20T+P	High End Instrumentation II	3

Total Number of Credits: 21 (15 core + 6 elective)

Semester IX		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-502T+P	Omics II	2
IBT-503T	Review writing	1
IBT-701T	Fermentation Technology and Downstream Processing	3
IBT-702T+P	Plant Biotechnology	3
IBT-703T	Seminars in Advanced Genetic Engineering	2
IBT-721P	Laboratory Exercises in Fermentation Technology and Downstream Processing	3

Total Number of Credits: 14 (core)

Semester X		
Core Courses		
Subject Code	**Subject Title**	**No. of Credits**
IBT-723P	Project	20

Total Number of Credits: 20

UGC recommended courses (Additional 10 credits)		
Subject Code	**Subject Title**	**No. of Credits**
	Cyber security/Information security	4C
	Skill based credits	4C

	Human rights education	2C
	Introduction to Constitution (From Batch 2020)	2C

Semester wise detail Syllabus-Implemented from July 2018

SEMESTER I (17 credits)

IBT 101T Fundamentals of Physics 3 credits

Work and Energy,Potential and Kinetic energy, conservation laws of momentum and energy, non-conservative forces.

Rotational motion – rotational variables, kinetic energy of rotation, rotational inertia, torque, Newton's second law of angular motion, and conservation of angular momentum. Rigid body, its Kinetic energy, angular momentum conservation, precession of top (elementary). Law of gravitation, Concept of temperature and its measurement, heat and work, First law of thermodynamics, Second law of thermodynamics Carnot engine and cycle, isothermal and adiabatic processes, enthalpy and concept of entropy.

Fluids at rest, pressures within fluids, upthrust, Archimedes' principle, Surface phenomena. Fluid dynamics, streamlines,Bernoulli's equation and its applications. Viscosity, Reynold's number, Turbulence.

Revision of electrostatics, Applications of Gauss law, electric potential equipotential surfaces, dipole, potential calculation in simple cases. Ampere's law and its applications, Lorentz force, cyclotron motion, magnetic force on a current carrying wire, Torque on a current.

Faradays law of induction, Lenz's law, induction and induced electric field, Alternating current induction (self and mutual), L-R, C-R and L-C-R circuits, resonance energy stored in inductance and capacitance. Maxwell's modification of Ampere's law, displacement current, qualitative discussion of traveling electromagnetic waves, energy transport, Poynting vector, radiation pressure and polarization.

References:

1. University Physics by F W Sears
2. Fundamentals of physics by Haliday, Resnick and Walke
3. Lecture series by Feynman.
4. Physics by Catnell and Johnson
5. Principles of Physics: H.C. Verma

IBT 102T Fundamentals of Chemistry 3 credits

1. **Atomic structure** – Bohr theory, de Broglie hypothesis, Heisenberg's uncertainty principle, atomic spectra, wavefunction and its interpretation, Formulation of Schrodinger equation, particle in a box, polar coordinates, hydrogen like atoms-spherical harmonics, polar plots, hydrogenic orbitals, many electron atoms, LS coupling **15 L**

2. **Molecules**: Born Oppenheimer approximation, PE curve, Hydrogen molecule, valence bond theory, hybridization, hybrid orbitals, LCAO, homo- and hetero- nuclear molecules, bond order, bond dissociation energies, MO diagram of simple polyatomic molecules **15L**

3.**Coordination chemistry** –Werner theory, EAN rule-valence bond theory, structure and magnetic properties, inner and outer sphere complexes-crystal field theory- splitting of d orbitals in ligand environments (octahedral, tetrahedral, square planar, trigonal bipyramidal, square pyramidal, cubic etc.)-tetrahedral distortion, spectrochemical series, Jahn Teller distortion-CFSE-isomerism in coordination compounds, IUPAC nomenclature of coordination compounds.

15L

References:

1. Physical Chemistry-A molecular approach by Mcquairee and Simon
2. Physical Chemistry by G M Barrow
3. Concise Inorganic Chemistry by J D Lee

4. Inorganic Chemistry by Shriven and Atkin

IBT 103T

Mathematics I (30L) 2 credits

Refreshing course on Sets & symbolic logic, Power functions & polynomials, integration & differentiation, periodic functions and conversion of different co-ordinate system.

Matrices and determinants: addition of matrices, multiplication of scalars, transpose of a matrix, system of linear equations, inverse of a matrix. Eigen values and eigen vectors.

Vector differential calculus: curves, arc length, tangent, curvature, velocity & deceleration, directional derivative, transformation of coordinate systems and vector components, divergence and curl of vector field.

Relations & Functions: Linear, periodic, logarithmic, exponential, Quadratic functions. Mapping & Cartesian product. Their application in Biology.

Partial differential equations: Introduction to partial derivatives & Ordinary Differential Equation of the first order.

Graphical representations: Linear scales, nonlinear scales, Semilogarithmic, triangular, nomography, pictoral presentations

IBT 104-T Plant Animal and microbial world 3 Credits

General – **5L**

Origin of life: primordial soup, bioelements, biomolecules, importance of water, Cell as the unit of life, development of cell theory, cell types: prokaryotes vs. eukaryotes; from single cell to multi-cellular organism, concept of multi-cellularity, cell-cell interactions- at tissue level, cell organization,

Animal World- 10L

Level and organization in animal kingdom: Major animal groups and their salient features: (at Phylum level for non-chordates to chordates at class level).

Animal adaptation and trends in animal evolution.

Plant World- 10L

Plant forms and classification- Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms

-Plant forms and anatomy

-Plant reproduction: asexual and sexual, life cycles, and alterations of generation

-Plant evolution (Evolutionary trends like –increase in complexity of sporophyte and reductions in gametophytes, seed development, conducting elements etc.)

Microbial World-

Definition, scope, impact and future of microbiology, beneficial and harmful microbes – food industry, agriculture, medical field 1L

History of Microbiology –Major discoveries and contributions of different scientists (Leewenhoek, Joseph Lister, Robert Koch, Louis Pasteur etc.) 2L

Nutritional classification of microorganisms on the basis of carbon, light: (Photoautotrops, Photoorganotrops, Chemolithotrops (sulfur, hydrogen, iron oxidizers), chemoorganotrophs, nitrogen: (nitrifying, nitrogen fixing, denitrifying microorganisms), oxygen (aerobes, facultative anaerobes, microaerophiles, aerotolerant anaerobes, anaerobes) 3L

Physical factors influencing growth –Temperature (hyperthermophiles, thermophiles, mesophiles, psychotrophs, psychrophiles), pH (acidophiles, neutrophiles, alkaliphiles) Osmotic pressure (extreme, moderate, mild halophiles, osmophiles, xerophiles) 2L

Techniques in microbiology: staining (monochrome, negative, Gram, capsule, endospore, acid fast), media preparation, cultivation, isolation, preservation 3L

Ultrastructure of prokaryotes, flagella, pili, capsules, cell wall, cell membrane, genomes, plasmids, cytoplasmic inclusions, endospores, magnetosomes, carboxysomes, chlorosomes, gas vesicles, Volutin granules. 3L

Introduction to viruses (bacteriophages, plant, animal), Archea (thermophiles, halophiles, methanogens) Fungi, algae, protozoa 1L

IBT-123P Laboratory Exercises in Biology I (Minimally Any 10 practical) 2 credit

General:

1. Microscopy –simple, compound, dark field, phase contrast and florescence
2. Methods for washing glassware and plastic wares and laboratory safety practices
3. Study of Instruments – Autoclave, hot air oven, Laminar air flow, incubator, mBOD, incubator, centrifuge, pH meter, membrane filter and colorimeter, spectrophotometer, balance

Microbiology:

1. Concept of sterility, existence of microorganisms and their control
2. Media preparation: Liquid, semi-solid, slants, butts, plates, dehydrated, selective, differential
3. Enumeration of cell: use of haemocytometer
4. Simple staining: Monochrome, negative
5. Differential staining: Gram, Capsule and Endospore staining
6. Motility Demonstration: Hanging drop preparation, wet mount, dark field microscopy

Plants:

1. Plant morphology and anatomy of major plant groups namely Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms
2. Field Trip
3. Cell types of plants: Maceration of various tissue explants, Identification of xylem vessels, trachieds, stomata, root hairs etc.

Animals:

1. Membrane permeability
2. Osmosis
3. Pinoocytosis

IBT 121P Laboratory Exercises in Physics I 2 Credits

1. Moment of inertia of disc – torsional pendul
2. 'g' by resonance pendulum
3. Velocity of sound by resonance tube
4. Thermal conductivity of insulator – Lee's method
5. 'γ' and 'η' by flat spring spiral
6. Total energy conservation (Kinetic Energy + Potential Energy = Constant)

IBT 122 P Laboratory Exercises in Chemistry 2 credits

(Minimally Any 10 practical)

1. Standardization of NaOH with primary standard KHP.
2. Determine redox potential of Fe+2/ Fe3+ systems by titrating it with standard K2Cr2O7
3. To determine hydrolysis constant of aniline hydrochloride by pH measurements.
4. Determine pKa of glycine by pH measurements
5. Determine the concentration of KCl solution by titrating with standard AgNO3 conductometrically
6. Investigate the conductometric titration of strong acid and strong base
7. Determination of Jobs method (Ferro salicylate)
8. Synthesis of chloro, nitro, nitito pentamino cobalt (III) complexes
9. Techniques such as TLC, crystallization, distillation etc.
10. Synthesis of potassium tri-oxalate ferrate.

SEMESTER II (21 Credits)

IBT- 201T Applied Physics (Fundamentals of Electronics and Instrumentation)2 Credits

Electronics

Analog Electronics

1. **Basic electricity and Network Theorems-** Kirchoff's voltage law, Kirchoff's current law, voltage divider formula, superposition theorem and examples, Thevenin's theorem, Norton's theorem and examples, Maximum power transfer theorem and examples.**(5L)**

2. **Electronic components –**Active, passive, resistor, thermister, LDR, capacitor, Inductor, transformer, switches, relay types, symbols, applications, working of each. **(1L)**

3. **Semiconductor devices –**single stage amplifier, i/p, o/p impedence, impedence matching, freq. Response, bandwidth, fidelity, power amplifiers **(2L)**
4. **Power supplies –** AC to DC conversion, rectifiers, filters, designing, highpass, low pass, regulator series (block dia.), shunt zener working, zener breakdown, avalanche reakdown. **(3L)**
5. **OPAMP-** Differential amplifiers, Inv., Ninv.inputs, opamp characteristics, application-adder, subtractor, integrator, differentiator. **(3L)**

Digital Electronics

1. Number systems- decimal no. System, binary no system, hexadecimal, octal, inter-conversions, binary codes, binary addition, subtraction. **(4L)**
2. Logic gates-basic gates, derived gates, universal building blocks, Boolean algebra, truth tables, proving logical equations, examples, De Morgan's theorem, Half adder, Full adder, Binary adder, subtractor, **(5L)**
3. Combinational logic- **(1L)**
4. Counters- multivibrators, RS flip-flop, JK flip-flop, T flip-flop, 4-bit binary counter, decade counter, up-down counter, shift registers and applications. **(2L)**

Instrumentation (15)

1. **Transducers -** primary & secondary transducers, temperature, pressure, displacement, velocity transducers. (3)
2. **ADCs and DACs -** Digital to analog convertors, analog to digital convertors , examples (3)
3. **Instrumentation systems –**data acquisition systems (3)

Reference Books:

1. Electronic Principles by Malvino, Bates
2. Digital principles and Applications by Leach, Malvina, Saha

References:

1. University Physics by F W Sears
2. Fundamentals of physics by Haliday, Resnick and Walke
3. Lecture series by Feynman.
4. Physics by Catnell and Johnson
5. Principles of Physics : H.C. Verma

IBT 202T Applied Chemistry 2credits

1. Adsorption, chemisorption, adsorption isotherms

2. Thermodynamics – second law of thermodynamics, entropy, spontaneous change, free energy, enthalpy, adiabatic demagnetization, reactions at equilibrium, interpretation of equilibrium constants, acid and bases, solubility equilibria, biological activity, thermodynamics of ATP

3. Electrochemistry – electrochemical cells, half cell reactions, reduction potentials, the electrochemical series, thermodynamic functions from cell potential measurements, liquid junction potentials, Debye Huckel Theory, over voltage

References:

1. Physical Chemistry by P W Atkins

2. Physical Chemistry by Venullapalli
3 Physical Chemistry for life sciences and biosciences by R Chang
4. Organic Chemistry by R T Morrison and R N Boyd (2006)
5. Organic Chemistry by P Y Bruice (2006)

IBT 207 T-Statistics (30L) 2 credits

Frequency distribution and associated measures

Probability Theory, Sample mean, Sample variance, mean and variance of a distribution, random numbers, random sampling.

Probability Distributions: Applications of probability and standard distributions, estimation, standard error and confidence interval, t-tests, F-test, single tail & double tail.

Confidence intervals,goodness of fit, pairs of measurements, fitting straight lines, curves, polynomials etc. Test of hypothesis associated with correlation and regression.

References:

1. Biostsistics:: A foundation for analysis in Health Science. 7 th Edition Wayne Daniel
2. Fundamental and University Mathematics by Colin McGregor
3. Statistical methods in Biology by Norman Bailey
4. Biostatistics by Striecke
5. Mathematical models in biology by Allama
6. Engineering Mathematics- M-1, M-2, M-3
7.Advanced Engineering Mathematics : Kreyzig
8.Introduction to Mathematics for Life Scientists by Edward Batschalet, Springer
9. Mathematics for the Biological Sciences by J.C. Acharya and R. Lardner, Prentice Hall

IBT 108 T+P Introduction to Computer Science & Programming Languages 2 credits

Theory (1 credit)

Introduction (2L)
History and generation of computers (2L)
Structure of a computer (2L)
Computer operation: keyboard, mouse, screen, printer, and other I/O devices (2L)
Operating systems: introduction e.g., Linux, Windows (2L)
System handling, system commands, introduction to computer languages and utilities (6L)
File formats and directory structure (2L)
Data organization on a computer (2L)
Connecting and Communicating Online: The Internet, Websites, and Media (3L)
Programs and Apps: Productivity, Graphics, Security and Work (2L)
Digital Security, Ethics, and Privacy: Threats, Issues, and Defenses (3L)
Glossary of important terms (2L)

Practical (1 credit)

Hands-On experience and regular usage: Tutorials (Typing, Windows 98/XP, Internet, Unix (LINUX), applications and utilities of Windows 98/XP, Browsers (I.E., Netscape) (1P)
Internet, Search Engines, using E-Mail/Web mail, ftp (1P)
Basic Unix commands (1P)
Word Processing (Microsoft Word): Creating, Saving & Opening a document, Editing, Inserting, Deleting, Formatting, Moving & Copying Text, Find & Replace, Spell Checker & Grammar Checker (Thesaurus), Document Enhancement (Borders, Shading, Header, Footer), Printing document (Page layout, Margins), Introduction to the use of Wizards & Templates, Working with Graphics (Word Art) (1P)
Working with Tables & Charts, Inserting Files (Pictures, Databases, Spreadsheets)
Spreadsheet Applications (Microsoft Excel): Worksheet Basics (Entering information in a worksheet, Saving & Opening a worksheet, Editing, Copying & Moving data, Inserting, Deleting & Moving Columns & Rows, Clearing Cells & Formatting cells), Working with workbooks, Working with formulae and functions, Printing worksheets, An introduction
to the use of advanced spreadsheet concepts, Database Management (Sorting records, Finding records, Adding & Deleting records, Filtering records in a worksheet), Working with Macros, Creating and using multiple worksheets (1P)

Creation of Computer Presentations with graphics (Microsoft Power Point): Creation of slides, Rapid Presentation design using wizards, Inserting graphs & charts Action buttons, Transitions, Build and Animation effects (1P)

References:

1. Introduction to Computers by A. Leon and M. Leon, Vikas Publishing House.
2. Fundamentals of Computers by Rajaraman V., PHI.
3. Computers Today by Sanders D. H., McGraw Hill.
4. Computer Architecture and Organizations by J. P. Hayes, Mc Graw Hill.
5. Modern Digital Electronics by R. P. Jain, Tata Mc Graw Hill.
6. Computer Network by Andrew S. Tanenbaum, PHI.
7. Inter Networking With TCP/IP: Principles, Protocol And Architecture by D.E. CornerVol1,

References:

1. Introduction to Computers by A. Leon and M. Leon, Vikas Publishing House.
2. Fundamentals of Computers by Rajaraman V., PHI.
3. Computers Today by Sanders D. H., McGraw Hill.
4. Computer Architecture and Organizations by J. P. Hayes, Mc Graw Hill.
5. Modern Digital Electronics by R. P. Jain, Tata Mc Graw Hill.
6. Computer Network by Andrew S. Tanenbaum, PHI.
7. Inter Networking With TCP/IP: Principles, Protocol And Architecture by D.E. CornerVol1,

IBT 206 T **Biomolecules** **2credits**

1. Introduction /overview 2L
2. Water and Intermolecular Forces 2L
3. Thermodynamics in Biochemistry 2L
4. pH, acids bases and Buffers 3L
5. Amino Acids 2L
6. Peptide Bonds and Introduction to Proteins 3L
7. Sugars and Polysaccharides 2L
8. Glycoproteins and Proteoglycans 2L
9. Lipids 3L
10. Nucleosides and Nucleotides 2L
11. Structure of Nucleic Acids 3L
12. Vitamins, Coenzymes and other small molecules 4L

Reference

1. Garrett & Grisham, Biochemistry, Saunders Publishing,
2. Voet and Voet. Biochemistry, second edition, Prentice-Hall,
3. Lehninger, Nelson and Cox. Principles of Biochemistry
4. Zubay. Biochemistry
5. Mathews, van Holde and Ahern. Biochemistry
6. Stryer, Biochemistry

IBT 212T **Introduction to Microbiology and Genetics** **2credit**

Prokaryotic cell cycle: Binary fission, multi-fork replication, role of FtsZ, MreB, Z ring divisome, addiction modules for plasmid transfer to progeny 4L

Population growth: Growth phases-Generation time, Kinetics of growth 4L

Growth patterns: Synchronous, Batch, Continuous, Diauxic 4L

Control of Microorganisms: Sterilization, disinfection, cidal, static agents 2L

Control of microbial growth by physical methods: Dry heat, moist heat, filtration, radiation (mode of action, applications) 4L

Chemical control –dyes, alcohol, acid, alkali, halogen, heavy metals, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents (mode of action, applications) 3L

Control of Pathogens and chemotherapy: History and development of chemotherapy, principal groups of antibacterial agents, and mechanism of action, drug resistance: origin, mechanisms, and transmission, antiviral and antifungal agents. 6L

Reference:

1. Black, J.G. (2005) Microbiology Principles and Explorations 6th edition John Wiley and Sons Inc.
2.Pelczar M.J.Jr. Chan E.C.S., Kreig (2006) Microbiology 5 th edition Tata McGraw Hill.
3.Perry, J.J., Staley, J.T., Lory, S., (2002) Microbial life Sinauer Associates Publishers.
4.Schaechter, M., Ingraham J.L., Neidhardt, F. (2006) Microbe. ASM press
5.Madigan, M.T., Martinc J.M., Parker, J.Brock Biology of Microorganisms (Pearson prentice Hall)

IBT 221 P Laboratory Exercises in Physics II 2 credits

(Minimally Any 10 practical)

1. Determination of frequency of A.C Mains using sonometer box and LCR circuit- Series and Parallel resonance
2. Force acting on a current carrying conductor in a magnetic field
3. Verifying Biot Savart law of Magnetism &Tangent law of magnetism
4. Understanding Mutual Inductance using transformer
5. Surface tension – Jaeger's method (temperature variation)
6. Viscosity and Reynolds number of liquid by continuous flow method

IBT 222 P Laboratory Exercises in Chemistry II 2credits

(Minimally Any 10 practical)

1. Kinetics-order reaction
2. Determine simultaneously dichromate and permanganate ions in the given acid solution by colorimetric measurements
3. Study the hydrolysis of an ester in presence of hydrochloric acid
4. Determine the viscocity of a given liquid by Ostwald's viscometer
5. Potentiometry –Halide estimation of mixtures
6. To study the absorption of acetic acidon activated charcoal
7. Estimation of Van't Hoff factor
8. Solvent extraction -8 hydroxy quinoline
9. Preparation of 2, 4 Dinitrophenylhydrazine derivatives of carbonyl compounds

IBT 223 P Laboratory Exercises in Biology II 2 credits

(Minimally Any 10 practical)

I –Biomolecules (2C)

1. Measurement of pH
2. Estimation of carbohydrates –reducing /Non-reducing sugars
3. Estimation of proteins
4. Molar extinction coefficient of molecules
5. Extraction and estimation of lipids

II –Microbiology (2 C)

1. Growth curve of *Escherichia coli* by turbidometric method, calculation of specific growth rate and generation time 1P
2. Isolation of bacteria by streaking 1P
3. Spread plate technique 1P
4. Pour plate, Total viable count 1P
5. Cultivation of fungi: on Saborauds, Czapek Dox, Potato Dextrose agar 1P
6. Slide culture technique for morphological characterization of fungi 1P
7. Determination of thermal death rate of *Escherichia coli* and *Bacillus* 1P
8. Determination of thermal death rate of *Escherichia coli* and *Bacillus* 1P
9. Determination of antimicrobial activity by paper disc and well diffusion method 1P
10. Determination of Minimal inhibitory concentration (MIC) by microtitre plate assay 1P

IBT-225 P Practical in Statistics 1 credit

1. Sampling technique (simple random sampling, stratified sampling, probability proportional sampling, sampling procedures). Introduction to R
2. Model sampling from continuous distribution (such as uniform, exponential and normal)
3. Test of significance.
   T test,
   F test,
   Pair T test,
   Test of proportionality
4. Fitting of straight lines, curves (growth curve models, polynomials). Test of significance associated with correlation and regression
5. Goodness of fit test. (Distribution fitting and model validation)

Note:

a) Each practical duration -3 hours

b) The practical problem sheets are to be prepared in conclusion with life science teacher/ instructions.

Elective courses

Syllabus: E01- Introduction to Laboratory Instrumentation and Safety (T+P) 2 credit

Theory (1credit=15L)

1. Laboratory facilities in biotechnology (1L)
2. Handling and Use of Physics laboratory (1L)
3. Handling and Use of Chemistry laboratory (1L)
4. Microbiology laboratory (2L)
5. Molecular biology laboratory (2L)
6. Animal and plant cell culture laboratory (2L)
7. High end instrumentation (1L)
8. Laboratory operations and SOP (1L)
9. Hazards in laboratories (1L)
10. Laboratory safety measures and safe disposal of laboratory wastes(1L)
11. How to handle emergency conditions in the laboratory? (1L)
12. Personal and protective equipments and measures (1L)

Practical (1 credit)

1. Handling of glass and digital Pipettes
2. Handling of weighing machine
3. pH measurement through litmus paper and pH machine
4. Handling of tabletop centrifugal devices
5. Use of laminar flow and bio safety cabinet
6. Use of autoclaves
7. Using small laboratory equipments like stirrer, vortex, sonicator, nanodrop, waterbath, incubators, shakers
8. Operations and Maintenance of deep freezers
9. Storage and handling of general chemicals/acids, solvents
10. Safe disposal of laboratory wastes
11. Use of fume hood and personal safety measures
12. Laboratory safety demonstrations, fire extinguishers and first aid

Syllabus: E02: Introduction to Ecosystems and Ethology (T+P) 2 credit

Theory (1credit)

1. Ecology (bio network, fundamental operations, energy flow, food-chain, food-webs including trophic levels, ecological niche, abiotic and biotic factors, characteristics and regulation of population, ecological succession) (2L)
2. Types of Ecosystems and its components (1L)
3. Community, ecosystem and biomes (1L)
4. Ecosystem services and the economics of ecosystems (1L)
5. Ecological pollution (the sources, types and control of environmental pollution) (1L)
6. Conservation (1L)
7. Population dynamics and regulation (2L)

8. Behaviour ecology (1L)
9. Basic ethological concept (1L)
10. External stimuli (1L)
11. Temporal and hierarchical organization of behaviour (2L)
12. Case studies (1L)

Practical (1 credit)

1. Methods to study ecosystems
2. Study of local ecosystem(s)
3. Study of the abiotic components of ecosystems (water, soil, air)
4. Identification and data collection of plant/insect/amphibian/reptile/bird species in a nearby area (checklists)
5. Monitoring the monthly changes in the biotic and abiotic components of an ecosystem
6. Identification of threats to the ecosystem

Semester III:

IBT 208 (T+P) Advances in Computational Programming **2 Credits**

Module	Lectures
Overview of the Programming Languages:	2
Evolution of programming languages: What is C Language, Why C Language, Future in C Language, structured programming, the compilation process, object code, source code, interpreters, linkers, loaders, fundamentals of algorithms, flow charts	
C Language Fundamentals:	4
Data Type, Constants & Variables(T+P)	[3-T][1-P]
What is Data Types in C Language with practical Integers, long and short in C Language with practical Integers, signed and unsigned in C Language with practical Chars, signed and unsigned in C Language with practical Floats and Doubles in C Language with practical Constants, Variables, Keywords in C with practical How to get input from user(scanf()) with practical How to display output to user(prinf()) with practical	
Decision making and looping of c language(T+P)	4
IF-Else Statement in C Language with practical for Loop in C Language with practical While Loop in C Language with practical Do-While Loop in C Language with practical Break in C Language with practical Continue in C Language with practical Switch in C Language with practical	[2-T][2-P]
C Functions (T+P)	6
User defined and standard functions, Formal and Actual arguments, Functions category, function prototypes, parameter passing, Call-by-value, Call-by-reference, Recursion, Storage Classes	[4-T][2-P]
Arrays and Strings	5
One dimensional Array, Multidimensional Array declaration and their applications, String Manipulation	[3-T][2-P]
Pointers	6
Pointer variable and its importance, passing parameters by reference, pointer to pointer, pointers to functions, pointers to array, dynamic memory allocation	[4-T][2-P]
Structures, Unions	3[2-T][1-T]
Declaration of structures, declaration of unions, pointer to structure & unions	
Introduction : linked list	[1-T]

IBT 209 (T) Principles and advances in Molecular Biology **2 Credits**

Module	Lectures
Module 1	
Historical of molecular biology and Central Dogma	5
DNA and RNA as genetic material	1
DNA replication	2
Transcription	2
Translation	2
Mutation, DNA damage and repair	3
Module II	
DNA cloning and protein expression in bacteria, yeast, insect, plant and mammalian platform	5
Genetic Complementation and gene expression regulation	3

Sequencing of DNA, RNA and protein molecule	3
Techniques for detection of DNA, RNA and protein (Southern, Northern, Western blotting) and *in situ* characterization	4

***References*:**

1. Genes VIII : Benjamin Lewin
2. Molecular Biology of Gene: Watson et al.
3. Cell & Molecular Biology: Lodish et al.

IBT-305T Biomathematics & Biostatistics **2 Credits**

Module	**Lectures**
Mathematics	
Exactness and integrating factors, variation of parameters. Ordinary linear differential equations of n-th order, solution of homogeneous and non-homogeneous equations, operator method, method of undetermined coefficients and variation of parameters Eigen vectors systems of linear differential equations Sequence of series, power series methods for linear ordinary differential equations Laplace transform and its applications, Fourier series and Fourier transform and their applications Partial differential equations: models in chemical kinetics and physiology Introduction to solution techniques such as variable separation, product method and Laplace Transform method	15
Statistics	15
Frequency distributions and associated statistical measures Multivariate analysis. Multiple linear regressions, Factor analysis. Partial Least Square, Principle Component analysis Cluster Analysis (a) Nearest neighbor search (b)Search using stem numbers (c)Search using text signatures	

References:

1. Applied Multivariate analysis by Wicherman & Johnson.
2. Biostsistics: A foundation for analysis in Health Science. 7 th Edition Wayne Daniel
3. Fundamental and University Mathematics by Colin McGregor
4. Statistical methods in Biology by Norman Bailey
5. Biostatistics by Striecke
6. Mathematical models in biology by Allama
7. Introduction to Mathematics for Life Scientists by Edward Batschalet, Springer
8. Mathematics for the Biological Sciences by J.C. Acharya and R. Lardner, Prentice Hall

IBT 306T Microbial, Plant & Animal Biodiversity **2 Credits**

Module	**Lectures**
General Topics	6
Introduction to Biodiversity Taxonomy, Species diversity with respect to structural characters, Population concept (biological species concept) Ecological perspective of biodiversity: Interaction between habitat and organism Genetic perspective of biodiversity: Genetic variation amongst the members of a population or in populations throughout the distribution range Criteria for taxonomy: Kingdoms, Binomial, Hierarchies Morphological, Biochemical and Molecular Criteria Magnitude of Biodiversity- number of species – plant, animals and microbes, range of distribution Biomes of the world, Ecosystems: Types- freshwater, marine, terrestrial, forest etc., abiotic and abiotic factors Biodiversity hotspots – concept, listing, hotspots of World, India, Western Ghats-	

Case study
Change in biodiversity over time and space, threats to biodiversity, Environmental pressures, Causes (natural/manmade)
Conservation of biodiversity
Strategies- laws and legislation, public awareness
Methods- *ex situ- in vitro, ex vitro*, *in situ*
Restoration ecology
Biodiversity informatics

Microbial diversity	8
Microbial ecosystems and effect of environmental factors, Microbiology of specific environments	1
Plant microbe interactions	2
Animal microbe interactions	2
Specialized groups of microbes	3
Plant diversity (taxonomy and ecology)	8

Primitive and modern systems of plant classification, Phyto geography, phyto diversity, species diversity, ecosystem diversity, molecular diversity, crop/agricultural diversity
Chemotypes, ecotypes and cytotypes – Case study *Withinia somenifera*
Western Ghats – A plant diversity case study
Carnivorous, parasitic, epiphytic plants
Some important orders and families of higher plants
Vegetation succession in ecosystems, climax
Plants adapted to special habitat, Ecophysiology- plant responses to stress, altitude, and salinity, Crop ecosystems

Animal diversity	8

Animal kingdom, Fundamentals of animal systematics and methodology, Molecular sysmatics and DNA Barcoding used in Animal Biodiversity studies, Major groups in animal kingdom, Biome-wise Zoogeographical distribution and adaptative features, Factors implicated to influence animal biodiversity; Inter and Intra – specific relationships, Concept of animal conservations

References:

1. Zoology -- 5th edition, Miller S.A. and Harley J.B. (2002) McGraw Hill Publ
2. Campbell Biology – 10th edition, Reece J.B. et.al (2013) Benjamin & Cummings Publ.
3. Principles and practices of Animal taxonomy – Kapoor V.C. (1998) Science Publ.
4. Biological Diversity –Magurran A.E. (2011) Oxford University Press
5. Principles of Microbial Diversity Brown JW (2015) ASM Press
6. Brock Biology of Microorganisms (2017) Madigan MT, Martinko JM, Bender KS, Buckley DH. Pearson

IBT 321 Stereochemistry (T+P) 2 Credits

Theory	**Lectures**
Symmetry properties of organic compounds, Chirality of organic compounds, chiral centre, configuration of chiral centre, enantiomerism, diastereomerism, pseudo-asymmetric carbon	2
Homotopic and heterotopic ligands and faces	2
Stereochemistry of Natural products	2
Conformational concepts of acyclic molecules, cyclohexane and mono, di-substituted cyclohexane. Effect on physical properties of the molecules	2
Stereochemistry and drug action	1
Mechanistic and Stereochemical aspects of addition reactions of C-C multiple bonds including allenes, Ionic and free radical additions of halogens, halogen halides, hydration and related addition reactions	3
Mechanistic and Stereochemical aspects of elimination reactions, E2, E1, E1cb, eliminations	3
Practicals (Any 5)	15 h

Introduction to using molecular models
See the spatial arrangements of the atoms in a molecule
Build different models of molecules to understand the geometric isomerism, conformations and absolute configuration
Construct models of molecules in order to observe in three dimensions
Physical properties of enantiomers and diastereomers (melting point/boiling point, density)
Polarimeter

1. To handle and measure optical rotation of stereoisomer
2. Analysis of tartaric acid in wine by polarimetry
3. Mutarotation of glucose and Inversion of glucose

Stereochemistry of chemical reactions

1. carbonyl reduction for racemic benzoin molecule
2. reaction of cyclopentadiene with maleic anhydride

Resolution of racemic phenethylamine using tartaric acid
Separation of chiral compounds using chromatography/chelation methods

References:

1. Organic Chemistry Advances (2001) Carey F.A., Sundberg R.J. (Ed. IV), Part A, Kluwer Academic publishers.
2. Stereochemistry of carbon compounds E. L. Eliel.

IBT 322 (P) - Lab experiments in Molecular Biology 2 Credits

List of Experiments (Any 8)

1. Isolation and analysis of Bacterial genomic DNA
2. Isolation and analysis of Animal genomic DNA
3. Isolation and analysis of Plant genomic DNA
4. Isolation and analysis of bacterial plasmid DNA (alkaline lysis method)
5. Isolation and analysis of bacterial plasmid DNA (LiCl method)
6. Isolation and analysis of bacterial plasmid DNA (STET buffer method)
7. Isolation and analysis of bacterial plasmid DNA (TELT method)
8. Isolation and analysis of plasmid from bacteria by heat lysis method
9. Spectroscopic analysis of isolated DNA
10. Effect of temperature, pH and impurities on DNA stability (spectroscopic analysis)

IBT 323 (P) - Laboratory Exercises in Biodiversity 2 Credits

List of Experiments (Any 10)

1. Study the biotic and abiotic components of ecosystems (aquatic/terrestrial)
2. Study of plant communities by species area curve method
3. Study of plant communities by quadrant method and to determine % Frequency, Density, Abundance, Importance Value Index in protected and disturbed area
4. To determine diversity indices (richness, Simpson, Shannon-Wiener) and plant biomass in protected and disturbed area
5. To study selected Angiosperm families based on natural system of classification
6. Study of invertebrate animals from different soil samples
7. Study of zooplanktons from various water bodies
8. Study of animal biodiversity on SPPU campus using the transect method
9. Study and establishment of bee and/or ant colony
10. Study of physiochemical properties of water samples
11. Field visit to study plant, animal and microbial biodiversity (for study of various habitat types, niche, ecosystems, associations and degradation)
12. Introduction to biodiversity analysis software
13. Isolation and characterization of photosynthetic microorganisms
14. Isolation of microbes from aquatic and terrestrial environments
15. Isolation of marine microbes

16. Biochemical characterization

Elective Courses:

IBT-EL3T Advanced Biostatistics

Theory Modules	Lectures
UNIT I: Design of Experiments and Analysis of Variance (ANOVA) Basic principles of experimental designs, One-way ANOVA, Completely randomized designs, Post-hoc pairwise testing, Two-way ANOVA, Randomized block designs, Analysis of Covariance	15
UNIT II: Regression Modeling and Model Selection Causal associations among variables, Evaluating the dependence of a variable on independent variables, Principles and assumptions of regression modeling, Least-square estimation Simple and multiple regressions, Determining the subset of important variables, Forward selection and backward elimination methods, model diagnostics, residual analysis, model evaluation	15
UNIT III: Multivariate Analysis Multivariate data, Exploratory analysis and multivariate plots, Principal component analysis, Cluster analysis by hierarchical and non-hierarchical methods	15

References:

1. Bryan F. J. Manly, Jorge A. Navarro Alberto (2016). *Multivariate Statistical Methods: A Primer* (4th Edition) , Chapman & Hall/CRC
2. James, G., Witten, D., Hastie, T. and Tibshirani, R. (2013). *An Introduction to Statistical Learning with Applications in R*, Springer
3. Jonson, R. A. and Wichern, D. W.(2013). *Applied Multivariate Statistical Analysis*. PHI
4. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). *Introduction to Linear Regression Analysis*, Wiley.
5. Montgomery, D. C., (2010). *Design and Analysis of Experiments*, Fifth Edition, Wiley.
6. Ross, S. M. (2014). *Introduction to Probability and Statistics for Engineers and Scientists*. Academic Press.
7. Shaefer, S. J. and Theodore, L. (2007). Probability and Statistics Applications for Environmental Science, CRC Press
8. Walpole, R. E., Myers, R. H., Myers, S. L. and Ye, K. (2012). *Probability and Statistics for Engineers and Scientists*, 9th Edition, Prentice Hall.
9. Wayne Daniel (1991). *Biostatistics: A foundation for analysis in Health Science*. Wiley.

IBT-EL4T+P Introduction to Analytical Techniques and Applications 3 credits

Theory Module	Lectures
1. Homogenization and Sonication techniques	2
2. Filtration and dialysis techniques	3
3. Centrifugation techniques	2
4. Viscosity	1
5. Electrochemical cell, pH and electrodes	2
6. Chromatography principles: Paper, TLC, Gel filtration, affinity chromatography, Adsorption chromatography	5

Practical Module (Any 8-10)

1. Cell disruption by homogenization
2. Cell disruption by probe sonicator
3. Centrifugation
4. Thin Layer Chromatography
5. 1D / 2D Paper Chromatography
6. Column packing Determination of loading capacity of column
7. Affinity chromatography

8. Dialysis / Membrane filtration
9. Viscosity measurement
10. Gel filtration chromatography

References:

1. Biophysical Chemistry Friedfielder David
2. Analytical Biochemistry by David Holme and Hazel Peck.
3. Bioanalytical Chemistry (Susan R. Mikkelsen and Eduardo Cortón, Wiley-Interscience, 2004

IBT-EL5T+P Practices in Ethics **3Credits**

1) Introduction to Bioethics 2L

- History of ethics practices
- Current status of bioethics

2) Ethics committee 4L

- Institutional Ethics Committee (IEC)
- Institutional Committee for Stem Cell Research (IC-SCR)
- Institutional Animal Ethics Committee (IAEC)
- Institutional Biosafety Committee (IBSC)

3) Good Research Practices 3L

- Data acquisition, handling, analysis and storage.
- Malpractices related to data fabrication and manipulation.
- Plagiarism

4) Patents and Intellectual property rights 2L

5) Laws regarding research practices 2L

6) Guidelines for Biosafety (Biosafety Levels and Classes of Biosafety cabinets) 2L

7) Handling of biohazard and radioactive materials and procedure for their disposal 2L

8) Human cloning and human bioethics 2L

Practical:

1) Good Research Practices

- Data acquisition, handling, analysis and storage. 3P
- Plagiarism 1P

2) Guidelines for Biosafety (Biosafety Levels and Classes of Biosafety cabinets) 2P

3) Handling of biohazard and radioactive materials and procedure for their disposal 2P

Reference: Guidelines and Handbook for IBSCs contains the entire detailsabout IBSCs, which is available at following
link:http://dbtbiosafety.nic.in/Files/CD_IBSC/Files/Guidelines%20_Handbook_2011.pdf

Semester IV

IBT 204T English **3 Credits**

Module	Lectures
Module I	20
Scientific method: Hypothesis, theory, law; Design of experiment; Inductive & deductive reasoning	2
Types of presentation: Oral, poster, written, audio-visual	1
Effective writing. Preparing the manuscript. The IMRAD format	1
Title, byline; Abstract and Summary; Keywords	1
Introduction: Defining the problem; Literature survey; Justification of study	1
Materials and Methods: Contents, sources, procedures, techniques, reproducibility	2
Units of measurement, Abbreviations, Laboratory record book	
Results: Text; Presentation of qualitative and quantitative data	2
Discussion: Components and sequence. Conclusions and significance. Implications for further study	1
Acknowledgements. Reference citation systems. Sources of references: Journals, books, bibliographies, abstracting journals; Databases	2
Preparing and submitting the manuscript; its acceptance & rejection, Plagiarism	3
Biodata, Curriculum vitae, Resume	2
Types of visual aids, Poster presentation	3
Module II	10
Language as a communication tool, relationships among reading, writing, hearing and speaking	
Organization of English language: sentence structure, vocabulary, word formation, basic grammar, Syntax, context, paragraphs, paraphrase, précis	
Spoken English: pronunciation, diphthong, accent, clarity, speed, punctuation, simplicity and syntax	
Common errors in written and spoken presentation; tautology, double negatives and double positives, sequence, tenses	

References:

1. Barrass R (2002): Scientists Must Write. Edn. 2. Routledge, Oxon, UK.
2. Ebel HF, C Bliefert & WE Russey (2004): The Art of Scientific Writing: From student reports to professional publications in chemistry and related fields. Edn. 2. Wiley-VCH, Weinheim, Germany.
3. Gastel BA & Day RA (2016): How to Write and Publish a Scientific Paper. Edn. 8. Praeger Publishers Inc., USA.
4. Goodman NW & MB Edwards (2014): Medical Writing: A Prescription for Clarity. Edn. 4. Cambridge University Press, Cambridge, UK.
5. Gurumani N (2010): Scientific Thesis Writing and Paper Presentation. MJP Publishers, Chennai.
6. Fisher E & R Thompson (2014): Enjoy Writing your Science Thesis or Dissertation! Edn. 2. Imperial College Press, London, UK.
7. Hofmann, A.H. (2016): Scientific Writing and Communication: Papers, proposals and presentations. Edn. 3. Oxford University Press, Oxford, UK.
8. Mathews JR & RW Mathews (2014): Successful Scientific Writing: A step-by-step guide for the biological and medical sciences. Edn. 4. Cambridge University Press, Cambridge, UK.
9. McMillan VE (2012): Writing Papers in the Biological Sciences. Edn. 5. Bedford Books/ St Martin's, Boston, MA, USA.
10. Pechenik JA (2016): A Short Guide to Writing about Biology. Edn. 9. Pearson Education, Harlow, England.

11. Russey, WE, HF Ebel & C Bliefert (2006): How to Write a Successful Science Thesis. Wiley-VCH, Weinheim, Germany.

IBT 205T Cellular Basis of Structure and Function in Biology 2 credits

Module	Lectures
Ultra structure of plant and animal cell	2
Subcellular organelles (Endoplasmic reticulum, Plasma membrane, mitochondria, chloroplasts, vacuoles, perioxisomes, golgi, lysosomes, nucleus); Origin of organelles	8
Extra cellular matrix, Plant cell walls, plasmodesmata	2
Movement within the endomembrane system, Cytoplasmic structure	2
Ribosomes and protein	2
Cytoskeleton and its functioning; actin and microfilament, tubulin and microtubule, intermediate filaments. Differences in the cytoskeletons in plant and animal cells	4
Cell divisions and cell cycle, key enzymes regulating cell divisions,regulation of cell cycle in plants and animals	4
Transport –simple diffusion, facilitated diffusion, active transport, exocytosis and endocytosis, nuclear transport	2
Signal transduction- electrical signals, messengers and receptors	4

Reference:

1. https://www.sciencedirect.com/book/9780123742339/plant-cell-biology

IBT 307T Biochemical & Biophysical Techniques 2credits

Module	Lectures
Principles, Applications of UV-Visible, fluorescence (including FRET & Anisotropy), CD and ORD, ESR, Dynamic Light Scattering, Raman Spectroscopy, Mass spectroscopy	8
Surface plasmon response (SPR)	1
Isothermal titration calorimetry (ITC)	1
Microscale thermophoresis	2
Microscopy Techniques	10
Principle and Application of Electrophoresis	3
Advanced column chromatography and Chromatographic calculations	4
Surface tension and contact angle measurement	1

References:

1. Bioanalytical Chemistry (Susan R. Mikkelsen and Eduardo Cortón, Wiley-Interscience, 2004; ISBN 0-471-54447-7.
2. Biophysical Chemistryby David Friedfielder.

IBT 401T Modern Physics I & II 2 Credits

Module	Lectures
Classical Statistical Physics - Temperature and measurement, Boltzmann distribution, ensemble, statistical equilibrium, definition of statistical entropy, concept of entropy as applied to biological systems, relation with the information process and spontaneous reactions. (No rigorous mathematical proofs but concepts should have been cleared)	
Nuclear Physics - Structure of Nucleus, Binding energy curves of various elements, fission, fusion, effects of nuclear radiation, optical, microwave radiation, absorption, penetration, energy density, biological half life, interaction of radiation with living matter, isotopes used in biology and medicines. (No rigorous mathematical proofs but concepts should have been cleared)	
Solid State Physics -	

Types of solids, crystals structures, conductivity, diffusion, types of bonding, electronic structure of solids, x-ray diffraction, Introduction to the diffraction techniques as applied to the structure determination of the biological molecules. (There are no proofs in this so can be continued)

References:

1. Fundamentals of Optics by Francis Jenkins and Harvey White.
2. Optics,Principles and Applications by K K Sharma.
3. Optics by Ghatak.
4. Principles of Optics by M Born and E Wolf.

IBT 403T Spectroscopy of Biomolecules **2 Credits**

Module	Lectures
Ultraviolet-visible spectroscopy, solvent effects, Woodward rules	4
Infra-red spectroscopy, infrared absorption bands, shapes of absorption bands and intensity of absorption bands	6
Mass spectrometry, mass spectrum, fragmentation patterns, isotopes in mass spectrometry	6
Nuclear Magnetic Resonance, PMR, FT-NMR, chemical shift, position of signals, splitting of signals, diamagnetic anisotropy, CMR spectra, structure elucidation	14

References:

1. Spectrometric Identification of Organic compounds by R M Silverstein and F X Webster, Sixth edition (2002), Wiley.
2. Introduction to Spectroscopy by D Pavia, G Lampman, G Kriz, Second edition (1996), Saunders Golden Sunburst Series.
3. Spectrometric Identification of Organic compounds by R M Silverstein and F X Webster, Sixth edition (2002).
4. Introduction to Spectroscopy by D Pavia, G Lampman, G Kriz, Second edition (1996).

IBT 405 (T) - Plant and Animal Physiology **2 Credits**

Module	Lectures
Plant physiology	15
Transport of water, ions, solute and metabolites in plants, long and short distance transport, water balance	2
Mineral Nutrition - Effect of soil pH on mineral availability, uptake & assimilation of minerals, their physiological role	1
Translocation in phloem, Source sink relationships in plants	2
Leaf transpiration and stomatal physiology	
Biology of nitrogen fixation	
Photosynthesis and respiration in plants –	2
Photosynthesis – Photosynthetic pigments, organization of photosynthetic electron transport system in thylakoid membranes	2
Charge separation and electron transport, fluorescence and photochemistry, oxygen evolution, NAPD reduction, photophosphorylation	1
Rubisco – Natures carbon dioxide fixing enzyme and Calvin cycle, Photorespiration	2
CO_2 concentrating mechanisms in C4 and CAM plants, Evolutionary trends and ecology of in photosynthesis	
Novel applications of artificial photosynthesis, artificial leaf and enzymes	
Senescence and PCD	
Plant growth hormones – Structure, biosynthesis and metabolism of auxins, cytokinins, gibberellins, abscisic acid and ethylene. Physiological role of hormones	3
Photoreceptors in plants and their physiological roles; Photoperiodism, vernalization, Circadian rhythm,Tropic and nastic movements in plants	
Secondary metabolites – Terpenoids, phenolics, alkaloids. Major secondary metabolite	

synthesis pathways in plants. Role of secondary metabolites

Animal physiology	15
Introduction to Animal Physiology – overview, background, systems of study, physiology fundamentals, applications to medicine and scientific research	2
Fundamentals of Nutrition – basics of heterotrophic nutrition, food pyramid	
Fundamentals of Digestion – different digestive systems and processes	
The Animal Microbiome –microbial populations that inhabit animals, impact on nutrition and digestion, relationship to health and disease states	1
Energy Metabolism in the context of Nutrition, Digestion, and the Animal Microbiome – a comprehensive understanding the complex relationships and multifactorial elements such as genetic composition, microbiome, environmental factors, that impact nutrition, digestion and energy metabolism	2
Neural and Endocrine Control I – sensory and effector networks, response systems, circadian rhythm	1
Neural and Endocrine Control II –overview of endocrine systems, hormonal control of different behaviors	1
Muscular system – Physiology of skeletal muscle movement, role of smooth muscle in physiological functions	1
Thermoregulation and Osmoregulation I - core body temperature, insulation, heat transfer, hibernation	1
Thermoregulation and Osmoregulation II - osmotic pressure, dehydration, cooling mechanisms	1
Circulation - vascular and cardiac systems, circulation pathways, regulation of circulation	2
Respiration - ventilation, external and internal respiration, cellular respiration	2
Excretion - metabolic waste products, elimination of waste	1

References:

Plant physiology

1. Atwell, BJ, Kriedemann, PE & Turnbull, GN 1999, Plants in Action, Macmillian, New York
2. Salisbury, FB & Ross, EW 1992, Plant Physiology, 4th edn, Wadsworth Pub., Belmont.
3. Duca, Maria, 2015, Plant physiology, Cham, New York
4. Hopkins 2009
5. Teiz and Zigar - Plant Physiology

Animal Physiology

1. Hill, R. W., G. A. Wyse, and M. Anderson. 2016. Animal Physiology, 4th Edition. Sinauer Associates. Sunderland, MA.
2. One health relationships between human, animal, and environmental microbiomes: A mini-review. Trinh P, et al. Front Public Health 2018.
3. Katz PS. Neural mechanisms underlying the evolvability of behavior. Phil Trans R Soc B 2011.
4. Schlinger BA. Hormonal control of behavior: novel mechanisms and model organisms. J Comparative Physiology 2018.
5. Central osmoregulatory influences on thermoregulation. McKinley MJ, et al. Clin Exp Pharmacol Physiol 2008.
6. Integrating competing demands of Osmoregulatory and Thermoregulatory homeostasis. Mc Kinley MJ, et al. Physiology 2018.

Recommended scientific journals:

Plant physiology

1. New Phytologist
2. Journal of Experimental Botany
3. Plant Physiology
4. Plant Cell and Environment

5. Planta
6. Functional Plant Biology
   HortScience

Semester V:

Animal Developmental Biology

1. Logic of the diploid state.
   Spermatogenesis- structure of testis, sperm development and differentiation
   Ovogenesis: structure of ovary, development of the egg of the insect, sea urchin, frog, chicken, human- Logic and logistics.
   Structure and contents of the egg cell- maternal RNA, maternal organelles, Morphogens
   Fertilization: in eggs laid in aquatic conditions and eggs laid in utero- logic and logistics.
2. Cell structure and function- cell cycle regulation, plasma membrane, cell to cell junctions, cell motility.
3. Gene expression. Epigenesis.
4. Cleavage: types of cleavages – frog, insect, chicken, mammal.
5. Blastulation- Insect, frog, chicken, mammals. Slack and Smith experiments
6. Gastrulation: frog and chick. Cell migrations, presumptive fate maps.
7. Formation of the primitive embryonic axis.
8. Neural induction and competence- frog and chicken- cellular and molecular aspects.
9. Development of neural tube.
10. Development of somites and derivatives- myogenesis- regulation and quantal mitosis.
11. Metamorphosis in amphibians. Hormonal regulation, programmed cell death.
12. Development of the vertebrate eye- chick lens development and differentiation- programmed cell death. Lens regeneration in salamanders, tissue metaplasia.
13. Hematopoeisis. Lymphocytes, the structure of Immunoglobulin gene and recombination.
14. Limb regeneration in amphibia, blastema formation- metaplasia.
15. Developmental Biotechnology Allopheny, *in vitro* fertilization, Transfer of cells in the embryonal mass. Knockout mice.
16. Stem cell transplantation, therapy.
17. Neoplasia and carcinogenesis
18. Cellular aging and life span determinants.

Plant Developmental Biology

Characteristics of plant growth and development
Pollination biology
Formation of gamets, Fertilization and plant embryo types; Polyembryony and apoxixis
Embryo development and Seed Development, Dormancy & Germination – Molecular Aspects
Seed to seedling (Hormonal & light control of seedling growth, gene expression during seedling development)
Cellular and molecular features of development of seedling to adult vegetative plant body
Organization of shoot & root apex,
Cell fate & tissue differentiation in meristems,
Growth & development of roots, stems & leaves,
Development of vascular tissues
Flower development and the molecular controls
Molecular genetics of plant development
Cell – cell communication during plant development

IBT 406 T Microbial Biotechnology (2C)

1. Microbes as biocontrol agents Baculoviruses, entomopathogenic fungi, *BacillusthurinigiensisBacillussphaericusPaenibacilluspopilae*, Microbe derived inhibitors

06

2. Biology of nitrogen fixation, preparation of different types of inoculants (Types of inoculants (nitrogen fixers phosphate solubilizers, plant growth promoting rhizobacteria, PGPR, composting) 08
3. Introduction to the use of microbes in environmental Applications, Bioremediation, bioaugemntationBioemulsifiers, biosurfactants, MEOR, Leaching of ores 12
4. Microbial fuels (Methane, Hydrogen) 4

IBT 404T -Genetics of Higher Organisms (2C)

General topics:

1. Mendelian Genetics: Mendel's Laws, concept of dominance, segregation, independent assortment; Chromosome theory of inheritance.
2. Nuclear genome: Genes in nuclei, chloroplast and mitochondria, classes of DNA in nuclear genome
3. Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurosporacrassa*, yeast, *Arabidopsis*, maize, *Drosophila*, *C. elegans*, Zebra fish, *Homosapiens* - General outline of life cycle, importance in Genetic analysis
4. Allelic and non-allelic interactions: Concept of alleles, types of dominance, lethal alleles, multiple alleles, test of allelism, complementation; Epistasis.
5. Mutation – Classification, mechanism, repair, role in genetic analysis and evolution
6. Genome organization in viruses, prokaryotes and eukaryotes: Organization of nuclear and organellar genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping.
7. Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families.
8. Genome mapping: Physical maps -an overview and approaches.
9. Genome evolution

Plant Genetics:

1. Polyploidy: Introduction to euploids and anuploids and their cytogeneticbehavior. 1L
2. The inheritance of nuclear genes: qualitative v/s quantitative traits.
3. Quantitative inheritance – Concept, Genes and Environment - heritability, penetrance and expressivity
4. Phenotypic and molecular markers
5. linkage mapping and karyotypic evolution. 2L
6. Chlorplast genome: Breeding system, chloroplast genome organization, inheritance of chloroplast genes.
7. Mitochondria: mitochondrial genome organization, cytoplasmic male sterility. 1L
8. Transposable elements: Discovery of maize trasnposable elements 1L
9. Breeding systems in plants 1L

Animal genetics:

1. Historical overview: Mendel's laws, definition of terms, mutations, genes, alleles, multiple alleles, polymorphism, linkage groups, dominant and recessive lethal alleles, conditional mutants etc. 5L
2. Gene linkage: recombination, mapping of genes, *Drosophila* as model system. 5L
3. Population genetics: Hardy-Weinberg law, genes in population, mutation and selection as a means of variation. 5L

Suggested readings:

1. Concepts of Genetics Klug W. S. and Cummings M. R Prentice-Hall
2. Genetics-a Conceptual Approach Pierce B. A. Freeman
3. Genetics- Analysis of Genes and Genomes Hartle D. L. and Jones E. W. Jones & Bartlett
4. An Introduction to Genetic Analysis Griffith A. F. et al Freeman
5. Principles of Genetics Snustad D. P. and Simmons M. J. John Wiley & Sons.

6. Genetics Strickberger M. W. Prentice-Hall

IBT 422 P-Laboratory Exercises in Microbial Biotechnology (2C)

Studies on *Bacillus thurinigiensis*		2
Isolation and characterization of Nitrogen fixers	2	
Isolation and characterization of Phosphate solubilizers	1	
Preparation of inoculants		1
Enrichment culture for hydrocarbon degradation	2	
Production and characterization of emulsifiers by microbes		2

IBT 328P-Laboratory Exercises in Developmental Biology (1C)

Plant Developmental Biology (1C)

Any three of the following

1. Study of seed structure
    a. Dicotyledonous seed
    b. Monocotyledonous seed
2. Study of seed germination in different types of seeds (seeds collected by students)
3. Study of meristems (Shoot and root apical meristems)Isolation of shoot apical meristems from seedling, young and mature vegetative plant.Histochemical comparison between vegetative SA and reproductively induced SA 1P
4. Dissection of developing embryo and observation of the stages (Observations on stages of embryo development, dissection and isolation of developing)embryo (3 stages)
5. Study of permanent slides of types and stages of embryo developmental
6. Study of pollen germination and pollen tube development(*In vitro* germination of spore/pollen)
7. Tracing the course of stomatal development and observations on stomatal types.
8. Histochemical analysis of secondary growth (primary to secondary axis)
9. Observations on types of endosperm, dissection and isolation of endosperm

Animal Developmental Biology (1C)

1. Preparation of culture media, autoclaving and sterilization		1P
2. Gross anatomy of chick embryo	2P	
3. Filter paper ring method for *in vitro* culturing and harvesting of chick Embryo	3P	
4. Mounting of chick embryo and preparation of permanent mounts		2P
5. Heart and blood vessel formation during development	2P	
6. Identification of stages of development by formation of neural crest and somites	2P	

IBT 513 (T+P)-Basic Separation Techniques in Biology & Biophysics (3C)

1. HPLC,HPAEC, GC, Hydrophobic Interaction Chromatography, countercurrent chromatography
2. Advanced techniques: LC-MS, GC, GC-MS,SEC-MALS
3. Cell organelle separation/ Ultracentrifugation
4. Labeling techniques
5. Pull down assays
6. Ultrafiltration
7. Capillary electrophoresis, counter current immune-electrophoresis

Laboratory Practices in Basic Separation Techniques in Biology

- HPLC analysis of given sample (qualitative and quantitative)
- GC analysis of given sample(qualitative and quantitative)
- LC-MS analysis of tryptic digest of proteins
- LC-MS analysis to determine the molecular size of pure protein
- Ultracentrifugation for cell organelle separation
- Pull down assay
- Labeling techniques
- 2D-PAGE (Isoelectric focusing (IEF) followed by SDS-PAGE)

IBT 325 (T+P) -Introduction to Computational Biology (2C)

1. History of computation biology (2 Lecture)
2. Introduction of computation biology packages (6 Lecture)
   2.1. Python and biopython
   2.2. Perl and biolperl
   2.3. R packages, bioconductor
   2.4. MySql
   2.5. MATLAB
3. Application of computation biology in research and development (2)
4. Current status and future prospects of computational biology (5)
5. Hands on and the tutorials (5 Practicals)
   5.1. Python and biopython
   5.2. Perl and biolperl
   5.3. R package
   5.4. MySql
   5.5. MATLAB

Elective Courses: Pl note minimum 10 students/subject are required to run the course.

IBT-EL9 (T+P) Histochemistry and cytochemistry (3C)

1. Fundamentals of histology: tissue structure and their organization	2L	
2. Fixatives: Types and choice	3L	
3. Sample preparation		3L
4. Stains: Methods tools and techniques for tissue staining		3L
5. Principles of histochemical reactions	2L	
6. Staining and visualization of a) carbohydrates b) proteins c) lipids d) Nucleic acids	3L	

Practicals

1. Tissue fixation, Processing and sectioning		3P
2. Staining and permanent mount preparation	1P	
3. Detection of carbohydrates/ Lipids/ polysaccharides/nucleic acids /proteins	1P	
4. Immunohistochemistry techniques		2P
5. *In situ* detection of nucleic acid/ protein/ polysaccharide		1P

IBT-EL10 (T) - Heterocyclic Chemistry of Bioorganic Compounds(3C)

1. 5-membered heterocycles: Furan, Pyrrole and Thiophene, Condensed 5-membered heterocycles-Indoles, Benzofurans and benzothiophene,Pyridine, Quinoline and isoquinoline
2. Pyrimidines and Purines

Reference:

- Heterocyclic Chemistry by J A Joule and G F Smith
- Essentials of Organic Chemistry by P M Dewick, 2006

IBT-EL11 (T+P) -Basics of model systems in Biology (3C)

Model systems in research: (30 L)

1. Microorganisms (*Escherichia coli, Neurosporacrassa, Saccharomyces cerevisiae*)
2. Plant (*Arabidoposis*, *Nicotiana*)
3. Protozoa (*Entamoeba*, *Dictyostelium*)
4. Arthropoda (*Periplanata*, *Drosophila*)
5. Nematode (*Caenorhabditiselegans*)
6. Fish (Zebra fish)
7. Amphibian (*Xenopus*)
8. Bird (Chick)
9. Mammals (Mouse, Rat, Guineapig, Pig, Canine, Horse)
10. Higher primates (Macaque, Chimp, Gorilla)
11. Lynx (Ecology model)

Practical

Laboratory introduction to model systems, their cultivation/ maintenance (any 5)

Semester VI (New Syllabus)

IBT 210T- Immunology 1 (2 credit) (30L)

Overview of immunology	3L	
Cell and organs of immune system	3L	
Antibodies structure and function	3L	
Antigen and antibody interaction principles and application	3L	
Organization and expression of immunoglobulin gene	5L	
B cell generation, activation and differentiation	5L	
Antigen processing and presentation		4L
Cytokines	4L	

IBT 309 T – Bioinformatics (2 credits)

Overview of Bioinformatics		(1L)
Nature of biological data	(2L)	
Major Bioinformatics Resources	(1L)	
Literature databases (searching & downloading)	(1L)	
Introduction & overview of Biological databases	(1L)	
Nucleic Acid sequence databases	(3L)	
GenBank		
EMBL		
DDBJ		
Protein sequence databases	(3L)	
PIR-PSD		
SwissProt		
TrEMBL/GenPept		
Database searches: I	(2L)	
Text-based searching		
Simple and advanced forms		
Manipulation of displays		
Entrez/SRS- query engines		
Computational molecular biology & genetics	(2L)	
Overview		
Exploring EMBOSS series		
Exploring OMIM		
Database searches: II		
Sequence comparisons & alignment concepts	(6L)	
Fundamentals of sequence-based searching		
Scoring Matrices		
Introduction to BLAST series		
Introduction to FASTA		
Pairwise Sequence Alignments	(6L)	
Global Alignments - Needleman Wunsch Algorithm		
Local Alignments - Smith Waterman Algorithm		
Structure databases	(2L)	
PDB		
NDB		
Visualization& other utilities		

Reference:

BAXEVANIS, A.D. & OUELLETTE, B,F.F.: Bioinformatics: a practical guide to the analysis of genes and proteins. 2nd Ed.. 2002. John Wiley & Sons, Inc. Publications, New York.

BAXEVANIS, A.D., DAVISON, D.B., PAGE, R.D.M. & PETSKO, G.A.: Current protocols in bioinformatics. 2004. John Wiley & Sons, Inc. Publications, New York.

ORENGO, C., JONES, D. & THORNTON, J.: Bioinformatics: genes, proteins and computers. 2003. Bios Scientific Publishers, Ltd. Oxford.

IBT 409 (T+P) - Plant Tissue Culture (2C)

Introduction & Historical Overview of Plant Tissue Culture 1 L
Nutritional Media: Obligatory & Optional Constituents 2 L
Plant Growth Regulators with special reference to Plant Tissue Culture Systems 2L
Incubation Systems: Light & Dark, Static & Agitated 1L
Totipotency, Growth & Cytodifferentiation of Cultured Plant Tissues 1L
Callus & Suspension Culture Systems 1L
Organogenesis: Direct & Indirect- Basic aspects 1L
Culture Systems: Differentiated, Undifferentiated 2L
Somaclonal&Gametoclonal Variation2L
Spontaneous & Genetic Variations
Genetic & Epigenetic Variations
Problems in Plant Tissue Culture: Contamination, Phenolics, Recalcitrance, 2L
Seasonal Variations in Response

Practical:

1. Hydroponics experiment to identify the importance of major, minor elements on plant growth
2. Preparation of stock solutions, glassware and labware for plant tissue culture & media
3. Preparation of PTC media in plates, tubes, jars, flasks.
4. Surface sterilization of seeds and *in vitro* germination
5. Effect of plant growth regulators and their combinations on *in vitro* developments in *Nicotiana tabacum*
6. Establishment of callus culture/organ culture

IBT 326 P- Lab Exercises in Bioinformatics (2C)

Major Bioinformatics Resources (2P)
Literature databases (searching & downloading) (2P)
Nucleic Acid sequence databases (3P)
GenBank
EMBL
DDBJ
Protein sequence databases (3P)
PIR-PSD
SwissProt
TrEMBL/GenPept
Database searches: I (3P)
Text-based searching
Simple and advanced forms
Manipulation of displays
Entrez/SRS- query engines
Computational molecular biology & genetics (4P)
Overview
Exploring EMBOSS series
Exploring OMIM
Database searches: II
Sequence comparisons & alignment (8P)
NW, SW, BLAST & FASTA
Structure databases (5P)

PDB
NDB
Visualization& other utilities

IBT 224 P Techniques in Immunology **2 credits**

Raising antibodies 1P
Routes of immunization 1P
Purification and characterization of immunoglobin 3P
Ouchterlony double diffusion 1P
Immunoelectrophoresis 1P
Conjugation of antibodies 2P
Development of dot blot 1P

IBT 423 (T+P) - Animal Cell Culture I (2C)

Theory

1. Introduction to animal tissue culture lab: Instrumentation and working principles; culture vessels; glass wares and plastic wares. 3L
2. Types of media (Basic and Specialized) and their composition: Balanced salt solution, synthetic media, sera, dissociation media, antibiotics, growth factors and substrates. 3L
3. Types of contamination in a tissue culture lab and their sources. 2L
4. Maintenance of sterility and aseptic techniques. 1L
5. Types of cultures: On the basis of adherence; On the basis of *in vitro* morphology; explant and disaggregated; anchorage-dependent and independent; undifferentiated and differentiated.2L
6. Primary culture: Types of tissues; tissue harvesting; processing of tissue; cell counting
7. Secondary cell cultures and Cell lines: Characterization; Maintenance; Cryopreservation; Differentiation. 4L
8. Cell Growth Curve; Viability assays. 3L
9. Principles of cell separation and purification. 4L
10. Scale up of suspension and adherent cultures. 3L

Practical

1. Media preparation and Sterilization 1P
2. Primary culture of chick embryo fibroblast 1P
3. Cytogenetic Techniques 1P

IBT-EL12 (T+P) - Food Biotechnology (3C)

Theory:

Food Microbiology (microbes associated with food, Spoilage preservation food poisoning, food infection) 10
Foods made by microbial activity (cheese making, Oriental food products, pickles, mushroom cultivation Single cell proteins) 10
Algal Biotechnology 5
Polysaccharides, biopalstics 5

Reference:

1. Jay, J.M. (2000)Modern Food Microbiology.Sixth Edition. Aspen Publishers, Inc., Gaithersburg, Maryland.
2. Doyle, M.P., Beuchat L.R., Montville, T.J. (2001) Food Microbiology. Fundamentals and Frontiers, ASM Press, Washington, DC.
3. Ray. B. (2001) Fundamental Food Microbiology.Second Edition. CRC Press

Practical:

1. Isolation and characterization (morphological, and biochemical) of Lactic acid bacteria (LAB) 2

2.	Isolation and characterization of microbes from grains		2
3.	Isolation of dextran form *Leuconostoc*	1	
4.	Fermentation of fruit juices		1
5.	Thermal Death rate		1
6.	Thermal Death time		1
7.	Determination of most probable number of coliforms	2	

IBT-EL13 (T+P) - High-end instrumentation in Biology (3C)

Topics 2 credits (30 h)

1. Advanced Microscopy- Confocal Microscopy (Lifetime imaging, Multi photon imaging, super resolution), Phase contrast Microscopy (live cell imaging, scanning probe, annotation and analysis), Total Internal Reflection Fluorescence (TIRF) Microscopy (TD), Stimulated Emission Depletion (STED) Microscopy, Hybrid Multiplexed Sculpted

Semester VII:

SEMESTER VII-Core Courses

IBT 407T Enzyme Technology **3 credits**

1. Enzyme nomenclature/classification 2L
2. Enzyme Specificity, Enzyme activity & Specific activity 2L
3. Mechanism of enzyme catalysis 2L
4. Enzyme kinetics 18L

4.1 Rates of chemical reaction
4.1.1 Collision theory
4.1.2 Activation energy and transition-state theory
4.2 Kinetics of enzyme catalyzed reactions
4.2.1 single substrate reactions
4.2.2 concept of rate, velocity and order of reaction
4.2.3 Methods or Equations for plotting and analyzing data
4.2.3.1 Michealis-Menten, Lineweaver Burk plots
4.2.3.2 Modifications of MM kinetics and resulting plots(Wolf-Agusstinsson- Hofstee plot, Hanes-Woolf plot, Eadie-Scatchard plot, Scatchard plot for equilibrium binding)
4.2.4 Multi-substrate reactions
4.2.5 Enzyme inhibition
4.2.5.1 Reversible inhibition
4.2.5.1.1 LWB and modified plots for reversible inhibition
4.2.5.1.2 Dixon plots
4.2.5.2 irreversible inhibition
4.2.6 Ligand binding to protein/enzymes
4.2.6.1 Cooperativity
4.2.6.2 Hill equation
4.2.6.3 Adair equations for cooperative effects
4.2.7 Allosteric enzymes
4.2.7.1 Monod Wyman Changeux model
4.2.7.2 Koshland Nemethyl Filmer model

5. Immobilized enzymes 5L

5.1 Preparation or methods of immobilization
5.2 Kinetics of immobilized enzyme preparations
5.3 Diffusional limitation
5.4 Factors affecting immobilized enzyme preparation
5.5 Storage, stability and reusability

6. Whole cell immobilization 1 L
7. Enzyme preparation and use 1 L
8. Large scale enzyme production 2 L
9. Enzyme stabilization 2 L
10. Biphasic systems 2 L

IBT 602T Advances in Molecular Biology (30L) **2 credits**

1. DNA replication 2L
2. DNA damage & repair 2L
3. Chromatin architecture 3L
4. Transcription 3L
5. Post transcriptional modifications 3L
6. Translation 3L
7. Post translational modifications 3L
8. Protein trafficking 3L
9. Molecular biology techniques (e.g Sequencing, PCR, Microarray) 8L

IBT 310T Immunology II (30L) **2credits**

1. T cells maturation, activation and differentiation 5L
2. B cell generation, activation and differentiation 5L
3. Complement system 3L
4. Cell mediated effector function 3L
5. Leukocyte migration and inflammation 3L
6. Hypersensitive reactions 3L
7. Immune response to infectious diseases & vaccines 3L
8. Tolerance, Autoimmunity, and Transplantation 3L
9. Immunodeficiency and immunomodulation 2L

IBT311 (T + P) Animal cell culture II **2 credits**

Theory :(1 credit)

1. Cytogenetic Studies: Chromosome preparation and banding techniques. 1L
2. Stem Cells biology and its applications. 7L
3. Specialized cell culture: Keratinocytes, Melanocytes, Nerve Cells, Hepatocytes, Islets, Skin Cells, Osteoclasts. 2L
4. Cell Fusion and Hybridoma Technology. 2L
5. Pathophysiology of tumor: tumorigenesis, angiogenesis and metastasis in *in vivo* and *in vitro* studies. 5L

Practical :(1 credit)

1. Secondary culture: Handling and maintenance of cell lines – subculturing of adherent and suspension cell lines. 2P
2. Cell counting: Trypan blue exclusion method 1P
3. Cryopreservation and revival of cell cultures 2P
4. Specialized Cell culture: Stem cell culture and differentiation. 2P

IBT 411 (T + P) Bioinformatics II **3 credits**

Revision - Sequence alignment concepts 1L

Multiple Sequence Alignments

- Overview 1L
- Clustal-W method 2 + 3P
- Applications of MSA 1 + 3P

Molecular Phylogeny 6+ 4P

Introduction to phylogeny

Clustering techniques

Hierarchial & non-hierarchial

Bootstrapping

Interpretation of phylogenetic trees

Derived Data and Derived Databases

- Concept of derived data 2L
- Types of derived data - consensus, patterns, motifs, blocks 2 + 3P
- Derived databases: PROSITE, BLOCKS, PRINTS, Pfam 2 + 3P
- Exploring various databases at InterPro 2 P
- Derived Databases: SCOP, CATH, DALI 4 + 4(P)

Analysis of Macromolecular sequences

- Applications of various tools for protein sequence 6+4 (P)

Analysis available at ExPASy such as

Prediction of various secondary & tertiary structure of proteins

Hydropathy profiles

Post-translational modifications

Signal peptides

- Basic Concepts and tools for Prediction of B- and T-cell epitopes 3 + 4(P)

References

1. Baxevanis, A.D. & Ouellette, B,F.F.: Bioinformatics: a practical guide to the analysis of genes and proteins. 2nd Ed.. 2002. John Wiley & Sons, Inc. Publications, New York.
2. Baxevanis, A.D., Davison, D.B., Page, R.D.M. & Petsko, G.A.: Current protocols in bioinformatics. 2004. John Wiley & Sons, Inc. Publications, New York.
3. Orengo, C., Jones, D. & Thornton, J.: Bioinformatics: genes, proteins and computers. 2003. Bios Scientific Publishers, Ltd. Oxford.

For Advanced / Additional Reading:

1. Ingvar Eidhammer, Inge Jonassen, William R. Taylor: Protein Bioinformatics. 2003 John Wiley And Sons Ltd (UK)
2. Higgins, D. & Taylor, W.: Bioinformatics : sequence, structure, and databank. 2000. Oxford University Press, Oxford, UK.
3. David Mount: Bioinformatics : sequence and genome analysis. 2004.. Cold Spring Harbor Laboratory Press, New York

IBP 621P Laboratory Exercises in Enzyme Technology 2 credits

Practical related to theory course

SEMSTER VII-Electives courses

IBT-EL15 (T+P) Nucleic acid and protein chemistry 3 credits

Nucleic acid chemistry 15L

1. DNA and RNA structure
   regular and irregular and dynamic structures
2. Chemical Synthesis of oligodeoxyribonucleotides
   Esters and anhydrides of Oxy phosphorus acids
   Preparation of monomers, protecting and deprotecting groups
   Diester triester and and H-phosphonate chemistry
   Solid-phase organic synthesis - phosphramidate chemistry
   Synthesis of oligoribonucleotides
   Synthesis of modified oligonuleotides and their applications
3. Sequencing methods
4. Biosynthesis of nucleic acids

Biosynthesis of purine and pyrimidines nucleotides (De novo and salvage pathways)
Drug inhibition of biosynthesis
Polymerization
Applications of synthetic oligonucleotides

Protein chemistry 15 L

1. Background information : Amino acids, peptide bonds,primary and secondary structures 1 L
2. Protein folding structure and function

Determination of primary structure: Techniques, interpretation etc. including post translational modification of proteins(viz. glycosylation, N-terminal modification, hydroxylation & modified amino acids) 2L

Determination of secondary structure: UV, CD and fluorescence 2L

Determination of quaternary structure: X-ray 2L

Functional proteins : Hemoglobin and some well characterised enzymes / lectins / peptide hormones 4L

3. Solid phase synthesis of peptides and their biological applications 2L
4. Chemical modifications 2L

References:

1. Introduction to Protein Structure(Garland Press, Second Edition), by Carl Branden and John Tooze.
2. Introduction to protein structure by Thomas Creighton
3. DNA structure and function by R. Sinden

4. Nucleic Acids: Structures, Properties, and Functions (University Science Books) edited by Victor Bloomfield, Donald Crothers, and Ignacio Tinoco

Practical: Based on theory portion (**1 credit)**

IBT-EL16 (T+P) -Model systems to study Human biology 3 credits

Theory: (2 credits)

1. In silico model 8L
    a) QSPR modelling
    b) Tissue modelling
    c) Morphogenesis
    d) Immune system
    e) Tumour modelling
2. In vitro model
    a) Organ biology (organoid, organ on chip) 8L
    b) Tissue Engineering & regenerative biology (thin film, hydrogel, scaffold, electro spun mat and others for Bone, heart, lung, skin, brain tissue) 8L
    c) Disease biology (Cancer, nephropathy, neuropathy, cardiomyopathy, liver and others) 7L

Practical: Based on theory portion (**1 credit)**

IBT-EL17 (T+P)- Natural Product and Medicinal Chemistry 3 credits

Theory: (2 credits)

1) Biodiversity for novel drug lead discovery
2) Isolation and structure determination of organic natural products of medicinal significance from plants and microbes
3) Studies on the structure and biochemistry of biological products
4) Examination of the biosynthesis of natural products
5) Evaluation of the biochemical effects of these active constituents
6) Semi- or total synthetic chemistry of pharmacologically active natural products (any one drug-taxol)

References:

1. Natural Products in Medicinal Chemistry, Volume 60, Editor(s): Stephen Hanessian |DOI:10.1002/9783527676545, © 2014 Wiley-VCH Verlag GmbH & Co. KGaA, Book Series: Methods and Principles in Medicinal Chemistry
2. Natural Products Chemistry Sources, Separations and Structures By Raymond Cooper and George Nicola, Copyright Year 2015, ISBN 9781466567610. Published July 30, 2014 by CRC Press206, Pages178
3. Natural Products and Drug Discovery, 1st EditionAn Integrated Approach, Editors: Subhash Mandal Vivekananda Mandal Tetsuya KonishieBook ISBN: 9780081021040, Paperback ISBN: 9780081020814, Imprint: Elsevier. Published Date: 16th February 2018

Practical: (1 credit)

1) Draw chemical structures and reactions by Chem draw software.
2) Analyze the purity of medicinal compounds.
3) Prepare medicinally important compounds / intermediates.
4) Synthesize medicinal compounds.

SEMESTER VIII- Core Courses

IBT 501(T+P)Introduction to Omics I 3 credits

Introduction to Types of Omics:1L

Genomics, transcriptomics, proteomics, metabolomics, lipid omics, metagenomics, interactomics, glycomics, epigenomics, secretomics, volatilomics, single cell omics (and any other relevant biomolecular omics)

DNA/RNA sequencing using the next generation sequencing approaches:2L

Technologies involved: Sanger, Solid, Illumina, Ion torrent, Roche 454 (pyrosequencing), single cell sequencing, Nanopore PacBio

De novo Sequencing, Reference based resequencing, Applications and limitations

Transcriptomics: 8L

subtypes as applicable to different RNA molecules including mRNA, rRNA, tRNA, miRNA, siRNA and other non-coding RNA

Sample processing and analysis pipeline, instrumentation used and outline of data analysis with emphasis on clustering and hierarchical analysis

DeNovo transcriptome assembly pipeline- Trinity workflow

Reference based transcriptome pipeline- Tuxedo workflow

Genome sequencing: 2L

Approaches, technologies used, Introduction to ways for genome sequence assembly and data analysis

Steps and methods for Chromosome-level genome assembly- Hybrid approach

Proteomics: 5L

Mass spectrometry-based instrumentation used for proteomics

2D proteomics, peptide mass fingerprinting

Label free quantitative proteomics (In solution digestion)

Introduction to High-throughput quantitative proteomics, post-translational modifications,

Targeted proteomics, phosphoproteomics, Ion mobility to understand structural changes

Discovery vs targeted proteomics

Differential proteomics, relative vs absolute quantification

Sample preparation and data analysis for representative of the following methods

Labeling based quantitative proteomics: metabolic, isobaric, isotopic

Label free quantitative proteomics

Mass Spectrometry and Protein Identification

Protein Arrays, Protein Chips and their application

Applications of Proteomics in Life Sciences- Biomarker discovery, Understanding signaling cascade, protein-protein interaction, Diagnostics

Metabolomics: 8L

Mass spectrometry-based instrumentation used for metabolomics

Frontend: HPLC, UPLC, Nano-LC, TLC with robotic arm

MS Ionization Sources: MALDI, ESI, APCI, APPI, DESI

Mass analyzer: Single Quadrupole, Ion trap/Orbitrap /, Triple Quadrupole, Q-TOF, FT-ICR

Sample preparation methods, instrumentation and data acquisition for MS based methods (MS, MS/MS, MSn, DDA, DIA)

NMR based metabolomics, sample preparation, instrumentation and data analysis

Comparison of NMR and Mass Spectrometry for performing metabolomics investigations

Key considerations in metabolomics: Sample preparation, Separation optimization, Selection of appropriate data acquisition method (positive and/or negative mode),

Metabolomic libraries and metabolite identification: using available software, databases and libraries. METLIN, HMDB, MONA etc

Quantitation of the annotated metabolites.

Analysis of the metabolomics data and identification of unknowns: GNPS, MZmine2, XCMS online.

Approaches for Identification of unknown metabolites

Multivariate analysis methods used for analyzing large dimensionality data; construction of metabolic pathways involved.

Metagenomics:5L
Introduction to metagenomics; an overview of molecular techniques used in metagenomic;
Sample preparation, processing, steps, types of primers used for amplifications,
Construction of small-insert and large-insert metagenomic libraries, sequence-based and function bases screening of metagenomic libraries, Sequencing and data analysis
Use of T-RFLP and DNA-DNA hybridization methods for complementing metagenomics studies.
Novel tools for the functional expression of metagenomic DNA; functional metagenomics as a technique for the discovery of novel enzymes and natural products approaches to mutagenic analysis.

Practical: (1credit)

1. Sample preparation, workflow, MS method development, data acquired and analyses methods for various omics applications -focus on transcriptomics and metabolomics
2. Role of different Bioinformatics tools and platforms in Proteomics
3. Proteomics Databases, Proteomics Analysis Tools at ExPaSy
4. Metabolomics online tools and platforms (Hands on sessions for analysis using the Metaboanalyst software)

IBT 601T Introduction to Genetic Engineering **2 credits**

1.Regulation of gene expression in prokaryotic and eukaryotic systems. 4L
2. Mutations & Site directed mutagenesis 3L
3. Phage display and genetically engineered antibodies 2L
4.Types of Vectors: Viral and Non-viral vectors 6L
5. Isolation and application of recombinant proteins, fusion proteins 5L
6. Diagnosis of genetic diseases and designing of Gene therapy 6L
7. Recombinant protein expression technologies using various systems
    a. Bacterial
    b. Yeast
    c. Insect
    d. Mammalian
    e. Plant
8. Construction of genomic and cDNA libraries 4L

IBT603T Metabolic Pathways **3 credits**

1. Metabolism overview 3L
2. Bioenergetics and role of ATP and phosphoryl group transfers
3. Biological oxidation
4. Carbohydrate Metabolism
   Carbohydrate and their physiological importance 4L
   Glycolysis & its regulation
   Gluconeogenesis, Control of blood sugar and Anaplerotic reactions 2L
   Glycogen metabolism 3L
   Pentose phosphate pathway & other pathways of hexose metabolism 2L
5. Pyruvate oxidation, TCA Cycle its regulation and Glyoxylate Cycle 5L
6. Oxidative phosphorylation, Electron transfers in biology and Role of ATP synthase 5L
7. Fatty Acid metabolism 8L
   Physiological significance of lipids
   Biosynthesis of fatty acid and eicosanoids
   Biosynthesis of Triacylglycerols
   Oxidation of fatty acid (ketogensis)
   Acylglycerol &sphingolpids metabolism
   Cholesterol/sterol metabolism
8. Carbohydrate synthesis in plants and bacteria 8L
   Photosynthetic Carbohydrate Synthesis
   Photorespiration and C4 & CAM Pathways

Starch and Glucose biosynthesis
Synthesis of Bacterial Cell Wall Polysaccharides

9. Amino acid metabolism 6L

References:

1. Garrett & Grisham, Biochemistry, Saunders Publishing,
2. Voet and Voet. Biochemistry, second edition, Prentice-Hall,
3. Lehninger, Nelson and Cox. Principles of Biochemistry
4. Zubay. Biochemistry
5. Mathews, van Holde and Ahern. Biochemistry
6. Stryer, Biochemistry

IBT 604 (T+P) Applications of Plant Tissue Culture 2 credits

1. Micropropagation: Theory & Commercial Applications 2L
2. Use of Organogenesis & Embryogenesis for Commercial Utilization 1L
3. Commercial Production of Plant Secondary Metabolites 3L
   Increase in production by use of suitable media supplements (Elicitors, Growth Factors, Stress Factors, Precursors, Antimetabolites, Defense Proteins etc.)
4. Protoplast Culture & Somatic / Parasexual Hybridization for Overcoming Incomapatibility Barriers – Somatic Hybrids, Cybrids 2L
5. Germplasm Conservation 2L
6. Ovule, Anther & Pollen Culture, Embryo rescue & Embryo Culture 2L
7. Transgenic Plants 3L
   Single Gene Transfer to Plant Cells: Concepts
   Methods of Gene Transfer: Direct & Indirect
   Stabilities & Instabilities in Transgene Expression

References:

1. Biotechnology: Theory and techniques of Plant Biotechnology, Animal cell culture and Immunobiotechnology vols 1 and 2 by Jack K Chirikjian
2. Plant Biotechnology and its applications in Plant tissue culture by Ashwani Kumar and Shikha Roy
3. Altman A, Hasegawa PM, editors. Plant biotechnology and agriculture: prospects for the 21st century. Academic press; 2011 Oct 20.

Practical:(1 credit)

1. Micropropagation of *Nicotiana tabacum*
2. Somatic embryogenesis
3. Protoplast isolation and culture
4. Induction of callus and suspension culture
5. Ovule, Anther & Pollen Culture, Embryo rescue & Embryo Culture
6. Exploratory experiment to establish a plant culture of choice

IBT 622P Laboratory Exercises in Recombinant DNA Technology 3 credits

1. Preparation of probe, gel electrophoresis and blotting, Hybridization
2. Construction of recombinant molecule using simple plasmid vector include isolation of plasmid, preparation of vector, preparation of donor DNA ligation, transformation,identification of recombinant, restriction analysis, conformation by Southern
3. Isolation of total DNA and RNA from tissue culture plants, RNA gel, Northern blot
4. Cell culture (CHO, COS), Transfection with GFP vector, selection of clone
5. Expression in bacterial system

IBT 623 (T+P) Advances in Cell Biology 2 credits

Cell proliferation (cell cycle and cell metabolism) 7L
Cell death (apoptosis, necrosis and others) 5L
Diseases related to cellular organelles 6L
Principle of Flow Cytometry and its applications in cell biology. 4L

Advances in microscopic techniques for cell biology applications (Confocal microscopy, TIRF, Live cell imaging, AFM). 5L
Single cell analysis (Single cell RNA sequencing, trajectory analysis)3L

SEMESTER VIII-Electives courses

IBT-EL18 (T+P)Structural Biology and Protein Engineering 3 credits

Structural Biology (1 credit)

Unit1: Revision -Basic concepts and theory of diffraction (both X-ray and electron diffraction) and Fourier optics and gives a basis to understand several of the most important methods for biomacromolecular structure determination (X-ray diffraction, cryo-EM).
Unit 2: Cryo electron microscopy- theory and applications of high-resolution structure determination and application for biological macromolecules including sample preparation, methodology, data acquisition, interpretation and model building. Case studies
Unit 3: X-Ray Crystallography- theory for X-ray crystallography and its application for biological macromolecular structure determination. Sample preparation, methodology, collection and processing of data from synchrotron radiation sources, experimental phasing, interpretation of electron density maps and modelling, refinement, replacement and validation of structural models. Case studies
Unit 4: NMR- Theory of solution state NMR spectroscopy with emphasis on applications to proteins and biological macromolecules. Classical and quantum mechanical descriptions of NMR, product operator formalism, multidimensional NMR, phase cycling, gradient selection, relaxation phenomena, and protein resonance assignments. Determination of three-dimensional structure of proteins and nucleic acids using distance constraints.

Protein Engineering (1 credit)

Unit 1: Overview and applications of protein engineering in biotechnology. Revision- Isolation of genes from host organisms, cloning, preparation of recombinant proteins, host organisms, protein expression and protein purification
Unit 2: Rational design, prediction of the structure of enzyme variant, primer design to introduce mutations, evaluation of the effect of mutations on protein- construction of plasmids
Unit 3: Directed evolution, random mutagenesis, mutant screening and selection strategies, Bacteriophage display libraries-phage and cell surface display systems for protein-protein interaction.
Unit 4: Computational protein design, Non-natural amino acids in protein engineering, Post-translational modifications in protein engineering,
Unit 5: Tools and techniques for protein analysis, Application of protein engineering to improve enzyme catalytic efficiency, stability, enantioselectivity. Case studies

References:

1. Textbook of structural biology. Liljas Anders, Liljas Lars, Ash Miriam-Rose, Lindblom Göran, Nissen Poul, Kjeldgaard Morten, World Scientific, 2009
2. Schwede T, Computational Structural Biology: Methods and Applications, World Scientific, 2008.
3.Petsko G, Ringe D, Protein structure and Function, Oxford University Press, 2009.
4.A.McPherson, Introduction to Macromolecular Crystallography. 2nd edition (2009)., John Wiley Co.
5. Sheldon Park and Jennifer Cochran. Protein Engineering and Design. CRC Press, 2010
6. Stefan Lutz and Uwe Bornscheuer. Protein Engineering Handbook. Wiley-VCH, 2006
7. Directed evolution library creation: methods and protocols. Edited by Frances Hamilton Arnold - George Georgiou. Totowa, N.J.: Humana Press, 2003. x, 224. ISBN 1588292851. info
8.Fersht, Alan. Structure and mechanism in protein science:a guide to enzyme catalysis and protein folding. New York: W.H. Freeman, 1998. xxi, 631 s. ISBN 0-7167-3268-8. info
9. Protein Engineering: Principles and Practice. Jeffrey L. Cleland (Editor), Charles S. Craik (Editor) ISBN: 978-0-471-10354-7. Wiley

Practical: Based on theory portion **(1 credit)**

IBT-EL19 (T+P) Applications of Biotechnology in the Environment **3 credits**

Theory: **(2 credits)**

Status and Scope of Biotechnology in Environmental protection	1L
Biological Processes for Industrial and domestic effluent Treatment, Aerobic Biological Treatment, Anaerobic Biological Treatment.	9L
Role of biotechnology in water purification systems	2L
Metal microbe interactions: Heavy Metal Pollution and impact on environment, Microbial Systems for Heavy Metal Accumulation, Biosorption, molecular mechanisms of heavy metal tolerance, role of Microbes in synthesis of nanoparticles	8L
Biotechnology for Hazardous Waste Management Persistent organic pollutants, Xenobiotics, Biological Detoxification of PAH	5L
Biotechniques for Air Pollution Control.	2L
Solid Waste Management	3L

References:

1. Biotechnology: Theory and techniques of Plant Biotechnology, Animal cell culture and Immunobiotechnology vols 1 and 2 by Jack K Chirikjian
2. Plant Biotechnology and its applications in Plant tissue cultureby Ashwani Kumar and Shikha Roy

Practical: Based on theory portion **(1 credit)**

IBT-EL20 (T+P) High-End Instrumentation II **3 credit**

1.Atomic force microscope, instrumentation, principle, methodology, Resolution,recent advances, data analysis and case study

2. Protein thermal shift/ melt curve and ligand interactions analysis

Protein stability and thermal denaturation,

Differential scanning fluorimetry, Melting curve/thermal shift/ligand screening data analysis and case studies

3. Protein-binding measurement instruments

Microscale thermophoresis, ITC, experimental set up, measurement and data analysis

4. Medical Instruments

A. Imaging

Basics of Laser physics, Laser beam in biology & medicine, applications of Lasers in therapy and diagnosis, photo-thermal effects, photochemical effect, X-ray imaging, CT scan, MRI, Ultrasound applications.

In-vitro & in-vivo imaging using radioisotopes, PET scan

B. Electrophysiology

ECG, working of patch-clamps, EEG & use of metal discs, EMG test and basis for analysis

References:

1. Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications. Book by Greg Haugstad, Wiley.
2. Atomic Force Microscopy by Paul West and Peter Eaton, Oxford University Press.
3. Introduction to Biomedical Equipment technology by Joseph J. Carr& John. M. Brown
4. Medical instrumentation: Application and design by J. G. Webster John Wiley and Sons
5. Protein-Ligand Interactions by Holger Gohlke,Wiley-VCH Verlag GmbH & Co. KGaA
6. Biophysical Approaches Determining Ligand Binding to Biomolecular Targets: Detection, Measurement and Modelling by Alberto Podjarny, Annick P Dejaegere, Bruno Kieffer, Wiley.

Practical: Based on theory portion **(1 credit)**

SEMESTER IX

Core Courses

IBT-502T+P Omics II **2 credits**

1. Introduction to post genomic bioinformatics
2. Comparative Genomics: methods, applications
3. Structural and functional genomics
4. Bioconductor as applied to the analysis of the omics data
5. Case studies in Omics – detailing the pipeline and impact of the outcome on Biology
    a. Transcriptomics
    b. Proteomics
    c. Genomics
    d. Metagenomics
6. Gene ontology

Omics Practical: (Any 3) **1 Credit**

1. Data analysis using Python, retrieving genes based on sequence similarity from the transcriptomics data
2. Bioconductor based data analysis
3. Tools for metabolomics data analysis
4. Tools for gene ontology

IBT 503 T- Review Writing **1 Credit**

Students will write a review on a Contemporary topic in Biotechnology

IBT 701T Fermentation Technology and Downstream Processing **3 Credits**

Fermentation Technology

Process calculations and stoichiometry.	3
Metabolic engineering	2
Transport in reactors (oxygen, substrates, heat, (material balance)	5
Bioreactor design	
Types of reactors, sterilization Utilities: steam air water	3
Solid-state fermentation	2
Instrumentation and control (probes of different types)	2
Specific industrial process applications in plant systems	6
(Suspension callus and hairy root cultures)	
ii) Specific industrial processes involving microbes	1
Specific industrial process applications in animal systems	

Background, need, current products, cell lines. 1

Production strategy, Production platform 1

Vector design 1

Cell line development 1

Media development 1

Bioreactor design (animal cell culture specific) 1

Downstream processing

Removal of insoluble: Centrifugation, sedimentation 2

Flocculation, electro-precipitation, gravity settling

(grinding, homogenization, leaching if required)

Product isolation: distillation, solvent extraction, 8

Adsorption, ultrafiltration, membrane separation, precipitation.

Product purification: chromatography, (fractional) 5

Crystallization, recrystallization, desiccation,

spray drying, product formulation

References:

1. Bioseparations: Downstream Processing for Biotechnology by Paul A. Belter (Author), E. L. Cussler , Wei-Shou Hu
2. Principles of Fermentation Technology P F Stanbury, A Whitaker, S Hall
3. Fermentation and Enzyme Technology Wang W
4. Fermentation Microbiology and Biotechnology, Second Edition by E. M. T.
5. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A.R. Allman

IBT-702T+P Plant Biotechnology in Agriculture 3 (1T + 2P) credit

Theory 1 credit

1. Endosperm Culture & Production of Seedless Plants 2L
2. Apomixis & Experimental Polyembryony 2L
3. Molecular Farming & Marker assisted plant breeding 2L
4. Present Status of Transgenic Plants - Scientific and commercial 5L

with case studies: Edible vaccine, CRISPER-CAS in plant, Food traits modified

transgenic, phytoremediation, yield & quality of food/ fruit, Bioplastics

5. Gene silencing in plants 1L
6. Use of Bioreactors in Plant Production & Scale-up of specialized metabolites 1L
7. Metabolic Engineering in plants 1L

8. Diagnostic Kits & Virus Indexing 1L

References:

1. Plant Biotechnology and its applications in Plant tissue culture by Ashwani Kumar and Shikha Roy
2. Introduction to plant biotechnology (3/e). Chawla H. CRC Press; 2011 May 24.
3. Plant biotechnology in agriculture. Job D. Biochimie. 2002 Nov 1;84(11):1105-10.
4. Modern applications of plant biotechnology in pharmaceutical sciences. Bhatia S, Sharma K, Dahiya R, Bera T. Academic Press; 2015 Jul 22.

Practical:

1. Designing primers for overexpression and silencing of genes in plants
2. *Agrobacterium tumefaciens* mediated genetic transformation of plants
3. *Rhizobium rhizogenes* mediated hairy root induction in plants
4. Agroinfusion of plants for transient gene expression
5. Suspension culture for specialized metabolite biosynthesis in plant cultures

IBT-703T Seminars in Advanced Genetic Engineering 2 credits

The course will be conducted in the form of student presentations on latest technologies with case studies.

1. Powerful tools for genome-scale engineering Crisper CAS9, Zinc finger nuclease technology
    a. Clustered regularly interspaced short palindromic repeats (CRISPR)-Cas9, CRISPRa; CRISPRi
    b. Multiplex automated genome engineering (MAGE),
    c. Promoter engineering,
    d. CRISPR-based regulations,
    e. Synthetic small regulatory RNA (sRNA)-based knockdown
2. ChiP Sequencing and Ribosome fingerprinting
3. High C analysis - genome-wide Chromatin Conformation Capture
4. Lentiviral libraries
5. Functional genomics and phenomics
6. Genome wide expression profiling
7. Epigenomic mapping- Tools for study of epigenetic modifications
    a. DNA methylation
    b. Chromatin
    c. RNA

d. microRNA regulatory activities

e. Non-coding RNA

8. Gene drive
9. GE techniques as applicable in species conservation
9. Inclusion of any other recent advanced tool and technique developed in the field of genetic engineering.

IBT-721P Laboratory Exercises in Fermentation Technology and Downstream Processing 3 credits

Practical corresponding to IBT 701T

Semester X		
Core Courses		
Subject Code	**Subject Title**	**Number of Credits**
IBT-723P	Project	20