Integrated MSc in Life Sciences

(Programme Code: INTMSCLS)

Program Educational Objectives (PEOs), Program Outcomes (POs) and Learning Outcomes (LOs)/ Course Outcomes (COs)

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Department of Molecular Biology and Biotechnology
Tezpur University Tezpur, Assam, India

Preamble

Integrated MSc in Life Science is a ten semester programme, which encompasses theory and practical in different areas of biological Sciences. It also contains two research components one during sixth semester while other in the tenth semester to enhance the knowledge and research skills in the area of life sciences during the course. The programme is of 210 credits, theory 146 credit and practical is of 64 credits.

1. Introduction

Integrated MSc in life sciences aimed at developing skills to understand the biological diversity, evolutionary phenomena and molecular understanding of life forms. The course contains basic physics, chemistry, mathematics up to third semesters. Botany and zoology are the main subjects of this course. Subjects like molecular biology, cell biology, biochemistry, microbiology, immunology, bioinformatics, biotechnology are incorporated in the post graduate level. Students will carry out mini project of 8 credit in the sixth semester. In the ninth semester, students have the option to choose electives of either botany or zoology. In the tenth semester students will carry out in-house project work in the areas of botany or zoology as opted in 9^{th} semester of 15 credits. Project work carried out in 6^{th} and 10^{th} semesters will enable them to be able to peruse career in research/academia or any other biotech industries.

2. Qualification descriptors for the graduates

Knowledge and Understanding

i) In dept knowledge and understanding in diversity of life forms
ii) In dept knowledge and understanding of origin and evolution of plants and animals
iii) In dept knowledge and understanding cellular and molecular biology

Skill and Technique

i) Graduates will be skilled in life sciences.
ii) Graduates will be skilled in molecular biology and biotechnology.
iii) Graduates will be skilled in economic botany and zoology.

Competence

i) Graduates will be competent to critically analyse biological problem.
ii) Graduates will be able to carry out research in diverse areas of life sciences.
iii) Graduates will be competent to contribute to academia and the society.

3. Graduates Attributes

i) Graduates with knowledge and specialization in life sciences.
ii) Graduates with skilled to contribute to societal developmental activities such as academics, small scale industry, bio-entrepreneurship etc.
iii) Graduates will be able to improve their knowledge and competence through continuously learning.

4. Program Outcomes (POs)

PO1: Graduates will gain fundamental knowledge in biology.

PO2: Graduates will gain fundamental understanding on evolution and diversity of life forms.

PO3: Graduates will develop research skills for taking up challenges in solving complex biological problems.

PO4: Graduates will gain communication skills for disseminating knowledge of biology.

PO5: Graduates will gain knowledge and confidence to participate as a member of a multidisciplinary team with ethical values and social responsibility.

5. Programme structure

Total Credits: 210

Structure of the curriculum

Course category	No of courses	Credits per course	Total Credits
I. Core courses	53	3	159
II. Core courses	3	2	6
III. Core courses	2	4	8
IV. Core courses	1	1	1
V. Elective courses	3	3	9
VI. Elective courses	1	4	4
VII. Project	1	8	08
VIII. Project	1	15	15
Total credits	65		210

6. SEMESTER-WISE SCHEDULE

SEMESTER I

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 101: Biology Major I (Biodiversity (Microbes, Algae, Fungi and Archegoniate)	3	0	0	3	3
	LI 103: Biology Major I Lab	0	0	3	6	3
	PI 101: Physics I	3	0	0	3	3
	CI 101: Chemistry I	3	0	0	3	3
	MI 101: Mathematics I	3	0	0	3	3
	PI 197: Physics I Lab	0	0	3	6	3
	EG 101: Communicative English	3	0	0	3	3

SEMESTER 2

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 102: Biology Major II (Animal Diversity)	3	0	0	3	3
	LI 104: Biology Major II Lab	0	0	3	6	3
	PI 102: Physics II	3	0	0	3	3
	CI 102: Chemistry II	3	0	0	3	3
	MI 102: Mathematics II	3	0	0	3	3
	CI 107: Chemistry I Lab	0	0	3	6	3
	ES 103: Environmental Studies	3	1	0	4	4

SEMESTER 3

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 201: Plant Ecology and Taxonomy	3	0	0	3	3
	LI 203: Comparative anatomy of vertebrates	3	0	0	3	3
	LI 205: Plant Anatomy and Embryology	3	0	0	3	3
	LI 207: Biology Major III Lab (Anatomy: Plant and animal)	0	0	3	6	3
	LI 209: Introduction to computing	3	0	0	3	3
	PI 201: Physics III	3	0	0	3	3
	CI 201:Chemistry III	3	0	0	3	3
	NS 201: NSS	2	0	0	2	2

SEMESTER 4

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 202: Genetics and Evolutionary Biology	3	0	0	3	3
	LI 204: Microbiology	3	0	0	3	3
	LI 206: Cell Biology-I	3	0	0	3	3
	LI 208: Biochemistry I	3	0	0	3	3
	LI 210: Biology Lab-IV (Biochemistry)	0	0	3	6	3
	LI 212: Biology lab V (Cell Biology)	0	0	3	6	3
	LI 214: Seminar	0	1	0	2	1
	DM 101: Disaster Management	3	0	0	3	3

SEMESTER 5

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 301: Plant Physiology	3	0	0	3	3
	LI 303: Animal Physiology	3	0	0	3	3
	LI 305: Basic Bioinformatics	2	0	1	4	3
	LI 307: Molecular Biology	3	0	0	3	3
	LI 309: Biology lab VI (Physiology)	0	0	3	6	3
	LI 311: Biology lab VII (Molecular Biology)	0	0	3	6	3
	LI 313: Public Health and Hygiene	0	0	3	6	3

SEMESTER 6

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 302: Immunology I	3	0	0	3	3
	LI 304: Biocomputing & Biostatistics	2	0	1	4	3
	LI 306: Developmental Biology	3	0	0	3	3
	LI 308: Analytical Techniques	3	1	0	4	4
Project	LI 310: Mini Project	0	0	8	16	8

SEMESTER 7

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 401: Biochemistry – II	3	0	0	3	3
	LI 403: Molecular Genetics	3	0	0	3	3
	LI 405: Immunology II	3	0	0	3	3
	LI 407: Biological Database Management System	3	0	0	3	3
	LI 409: Cell Biology II	3	0	0	3	3
	LI 411: Biology Lab VIII (Biochemistry)	0	0	3	6	3
	LI 413: Biology Lab –IX (Immunology)	0	0	3	6	3

SEMESTER 8

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 402: Biophysics & Structural Biology	3	0	0	3	3
	LI 404: Genetic Engineering	3	0	0	3	3
	LI 412: Biology Lab X (Genetic Engineering)	0	0	3	6	3
	LI 406: Applied Microbiology and Bioprocess engineering	3	0	0	3	3
	LI 408: Computational Biology	2	0	1	4	3
	LI 410: Cell & Tissue culture	3	0	0	3	3
	LI 414: Biology Lab XI (Applied Microbiology)	0	0	3	6	3

SEMESTER 9

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Core	LI 501: Genomics & Proteomics	3	0	0	3	3
	LI 503: Bioinformatic softwares & algorithm	3	0	0	3	3
	LI 505: Lab on advanced programming	0	0	2	4	2
	LI 507 : Biosafety and IPR	2	0	0	2	2
Elective	LI 509: Plant Biotechnology/ LI 515: Animal Biotechnology	3	0	0	3	3
	LI 511: Economic Botany/ LI 517: Economic Zoology	3	0	0	3	3
	LI 513 Biology Lab XII (Plant Sciences)/ LI 519: Biology Lab XII (Animal Science)	0	0	4	8	4

SEMESTER 10

Course type	Course title	Lecture (L)	Tutorial (T)	Practical (P)	Contact Hour(CH)	Credits
Elective	LI 522: Evolutionary Biology LI 524: Ethnomedicine & Herbal Technology LI 526: Plant metabolism & secondary metabolites LI 528: System Biology LI 530: Wild life & Animal Behavior LI 532: Fish Biology LI 534: Cancer Biology LI 536: Pyschoneuroimmunology LI 538: Insect vector and Diseases LI 540: Immunotechnology LI 542: Computer aided drug designing	3	0	0	3	3
Project	LI 502: Project - I	0	0	15	30	15

7. Mapping: Program Educational Objectives (PEOs) and Program Outcomes (POs)

Course title	PO1	PO2	PO3	PO4	PO5
LI 101: Biology Major I (Biodiversity (Microbes, Algae, Fungi and Archegoniate)	X	X	X	-	-
LI 103: Biology Major I Lab	X	X	X	X	-
PI 101: Physics I	X	X	X	-	-
CI 101: Chemistry I	X	X	X	-	-
MI 101: Mathematics I	X	X	X	X	-
PI 197: Physics I Lab	X	X	X	X	-
EG 101: Communicative English	-	-	-	X	X
LI 102: Biology Major II (Animal Diversity)	X	X	X	-	-

LI 104: Biology Major II Lab	X	X	X	X	-
PI 102: Physics II	X	X	X	-	-
CI 102: Chemistry II	X	X	X	-	-
MI 102: Mathematics II	X	X	X	-	-
CI 106: Chemistry I Lab	X	X	X	-	-
ES 103: Environmental Studies	X	X	X	-	-
LI 201: Plant Ecology and Taxonomy	X	X	X	-	-
LI 203: Comparative anatomy of vertebrates	X	X	X	-	-
LI 205: Plant Anatomy and Embryology	X	X	X	-	-
LI 207: Biology Major III Lab (Anatomy: Plant and animal)	X	X	X	X	-
LI 209: Introduction to computing	X	X	X	-	-
PI 201: Physics III	X	X	X	-	-
CI 201:Chemistry III	X	X	X	-	-
NS 201: NSS	-	-	-	X	X
LI 202: Genetics and Evolutionary Biology	X	X	X	-	-
LI 204: Microbiology	X	X	X	-	-
LI 206: Cell Biology-I	X	X	X	-	-
LI 208: Biochemistry I	X	X	X	-	-
LI 210: Biology Lab-IV (Biochemistry)	X	X	X	X	-
LI 212: Biology lab V (Cell Biology)	X	X	X	X	-
LI 214: Seminar	-	X	X	X	-
DM 101: Disaster Management	-	-	-	-	X
LI 301: Plant Physiology	X	X	X	-	-
LI 303: Animal Physiology	X	X	X	-	-
LI 305: Basic Bioinformatics	X	X	X	-	-
LI 307: Molecular Biology	X	X	X	-	-
LI 309: Biology lab VI (Physiology)	X	X	X	X	-
LI 311: Biology lab VII (Molecular Biology)	X	X	X	X	-
LI 313: Public Health and Hygiene	X	X	X	-	X
LI 302: Immunology I	X	X	X	-	-
LI 304: Biocomputing & Biostatistics	X	X	X	-	-
LI 306: Developmental Biology	X	X	X	-	-
LI 308: Analytical Techniques	X	X	X	-	-
LI 310: Mini Project	X	X	X	X	X
LI 401: Biochemistry – II	X	X	X	-	-
LI 403: Molecular Genetics	X	X	X	-	-
LI 405: Immunology II	X	X	X	-	-
LI 407: Biological Database Management System	X	X	X	-	-
LI 409: Cell Biology II	X	X	X	-	-
LI 411: Biology Lab VIII (Biochemistry)	X	X	X	X	-
LI 413: Biology Lab –IX (Immunology)	X	X	X	X	-
LI 402: Biophysics & Structural Biology	X	X	X	-	-
LI 404: Genetic Engineering	X	X	X	-	-
LI 412: Biology Lab X (Genetic	X	X	X	X	-

Engineering)					
LI 406: Applied Microbiology and Bioprocess engineering	X	X	X	-	-
LI 408: Computational Biology	X	X	X	-	-
LI 410: Cell & Tissue culture	X	X	X	-	-
LI 414: Biology Lab XI (Applied Microbiology)	X	X	X	X	-
LI 501: Genomics & Proteomics	X	X	X	-	-
LI 503: Bioinformatic softwares & algorithm	X	X	X	-	-
LI 505: Lab on advanced programming	X	X	X	X	-
LI 507: Biosafety and IPR	X	X	X	X	X
LI 509: Plant Biotechnology/ LI 515: Animal Biotechnology	X	X	X	-	-
LI 511: Economic Botany/ LI 517: Economic Zoology	X	X	X	-	-
LI 513 Biology Lab XII (Plant Sciences)/	X	X	X	X	-
LI 519: Biology Lab XII (Animal Science)	X	X	X	X	-
LI 522: Evolutionary Biology LI 524: Ethnomedicine & Herbal Technology LI 526: Plant metabolism & secondary metabolites LI 528: System Biology LI 530: Wild life & Animal Behavior LI 532: Fish Biology LI 534: Cancer Biology LI 536: Pyschoneuroimmunology LI 538: Insect vector and Diseases LI 540: Immunotechnology LI 542: Computer aided drug designing	X	X	X	-	-
LI 502: Project - I	X	X	X	X	X

8. Evaluation plan:

- Understanding of subject is constantly evaluated through discussion and cross questioning.
- Examinations of specific duration (1 Hr/2 Hr)
- Assignment on critical problems related to specific subject.
- Constant assessment during laboratory courses and practical records.
- Viva voce
- Individual and group oral presentations.
- Research paper presentation in seminar.
- Project work and report writing.
- Presentation (oral/poster) of project work.
- Research ability and research findings.

9. DETAIL SYLLABUS

Semester I

LI 101: Biology Major I **L3-T0-P0-CR3**
(Biodiversity of Microbes, Algae, Fungi and Archegoniate)

Course outcome
CO 1: Ability to understand different life forms.
CO2: Ability to identify bacteria, viruses, algae, fungi, bryophytes, pteridophytes, Gymnosperms.

Course content
Unit I: General Introduction: Introduction to living organisms: plant, animal, microbes

Unit II: Viruses: Discovery, general structure, DNA viruses, RNA viruses, replication (general account), lytic and lysogenic cycle, retroviruses, Bacteria: Discovery, General characteristics and cell structure; Gram-positive and Gram-negative bacteria, Archaea: Discovery, General characteristics and cell structure, extremophiles

Unit III: Algae: General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles, Economic importance of algae

Unit IV: Fungi: Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition, nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle; Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit V: Introduction to Archegoniate: (Bryophytes, Pteridophytes, Gymnosperms): Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Unit VI: **Bryophytes**: General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction, Ecology and economic importance of bryophytes

Unit VII: Pteridophytes: General characteristics, classification, Early land plants, Classification (up to family), morphology, anatomy and reproduction, Heterospory and seed habit, stelar evolution. ecological and economical importance of Pteridophytes.

Unit VIII: Gymnosperms: General characteristics, classification. Classification (up to family), morphology, anatomy and Reproduction, Ecological and economical importance.

Textbooks

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi
3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY

Suggested Readings

1. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
2. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 12. 2nd edition.

3. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
4. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

LI 103: Biology Major I Lab **L0-T0-P3-CR3**

Course outcome

CO 1: Ability to perform microbiological and other plant science experiments.
CO2: Ability to prepare microbiological media, isolate pure microbes identify and characterize them.
CO3: Ability to identify and characterize different plant groups and their habitat.

Course content

1. Introduction to microbial growth media. Media preparation.
2. Bacterial growth on solid and broth media
3. Bacterial colony morphology and diversity
4. Gram staining of bacteria
5. Microbes growing under extreme conditions (thermophiles, psychrophiles and mesophiles)
6. Specimen study of blue green algae/cyanobacteria
7. Specimen study of Algae
8. Study of fungi: colony, view of the hyphae under microscope
9. Specimen study of Bryophytes
10. Specimen study of Pteridophytes
11. Specimen study of Gymnosperms

Textbook

1. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi, India.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.

PI/ PD 101: PHYSICS-I **L2-T1-P0- CR3**

Course Outcomes:

CO1: Ability to understand the basics of vectors and matrices, introductory mechanics and properties of matter.
CO2: Ability to learn the detail of the coordinate systems: plane polarized, cylindrical and spherical; along with various vector and scalar properties.
CO3: Ability to use of vectors and matrices in solving various problems in an intended learning outcome.
CO4: Ability to understand the basic mechanics in both inertial and non-inertial frames, motion under a central force and the mechanics of a system of particles.

Course Content:

Coordinates, Vectors and Matrices:
Coordinate systems, plane polar, cylindrical and spherical polar; line element, surface element and volume element; gradient, divergent and curl.
Line, surface and volume integrals.

Properties of matrices; complex conjugate matrix, transpose matrix, hermitian matrix, unit matrix, diagonal matrix, adjoint of a matrix, self-adjoint matrix, cofactor matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix, eigenvalue, diagonalization of matrices.

Mechanics:
Work-energy theorem, conservative forces and potential energy; energy diagram; non-conservative forces; motion in non-inertial frames; uniformly rotating frame; centrifugal and Coriolis forces.

Motion under a central force.

System of particles; centre of mass, equation of motion of the centre of mass; laboratory and centre of mass frame of references; elastic and inelastic collisions; linear and angular momentum and their conservation laws; fixed axis rotation; moment of inertia; theorem of parallel and perpendicular axes; compound pendulum, Kater's and bar pendulum.

Properties of Matter:
Elasticity; elastic constants; Hooke's law; torsional oscillation; bending of a beam; cantilever; surface tension; viscosity; kinematics of moving fluids.

Textbooks:

3. Spiegel M., *Vector Analysis: Schaum's Outlines Series*, 2nd edition (McGraw Hill, 2017).
4. Potter M. C., Goldberg J., *Mathematical methods*, 2nd edition (Phi Learning Pvt. Ltd., 2008).
5. Mathur, D. S., *Mechanics*, (S. Chand & Co. Ltd., 2000).
6. Kleppner, D. and Kolenkow, R., *Introduction to Mechanics*, (McGraw-Hill, 1973).

Suggested Readings

1. Harper C., *Introduction to Mathematical Physics*, 1st edition *(*Phi Learning Pvt. Ltd., 2008).
2. Chow, T. L., *Mathematical Methods for Physicists: A concise introduction*, 1st edition (Cambridge Univ. Press, 2000).
3. Takwale R., Puranik P., *Introduction to Classical Mechanics*, (McGraw Hill, 2017)
4. Young, H. D. and Freedman, R. A., *University Physics*, 12th edition (Pearson, 2009).

CI 101 Chemistry-I **L3-T0-P0-CR3**

Course outcome:

CO1: Ability to understand atomic theory and its evolution
CO2: Ability to understand the Periodic propertied of elements
CO3: Ability to know the basic of organic molecules, structure, bonding and organic reaction Mechanisms, chemical thermodynamics and other properties

Course Content:

Unit 1

Structure of atom, Hund's rule, Aufbau principle, Pauli's exclusion principle.

Unit 2

Periodic Properties: Periodicity of the elements, shielding, effective nuclear charge, Slater's rule, the size of the atoms, atomic, covalent and van der Waals radii, ionization energy, electron affinity, electronegativity.

Unit 3

Basics of organic chemistry-1 : Bonding, structure and physical properties of organic compounds: Valence bond theory: Concept of hybridization of organic compounds and shapes of molecules; MO theory: Acyclic π orbital system and cyclic π orbital systems;
Physical properties: Melting point, boiling point, solubility, dipole moment.

Unit 4

Basics of organic chemistry-2: Electronic and steric effects: Inductive effect, resonance, hyperconjugation, steric effect, steric inhibition of resonance.

Unit 5

Basics of organic chemistry-3: Thermodynamics and kinetics of organic reactions:
Free energy and equilibrium, enthalpy and entropy factor, intermolecular & intramolecular reactions, rate constant and free energy of activation, free energy profiles for one step and multi-step reactions, catalyzed reactions, kinetic control and thermodynamic control, kinetic isotopic effect, principle of microscopic reversibility, Hammond postulate.

Unit 6

Alkanes: Synthesis by: Decarboxylation, reduction of alkyl halides and tosylates, Kolbe electrolysis, Wurtz reaction, Corey–House synthesis; Reactions of alkanes: Halogenation, nitration, sulphonation, oxidation and cracking of alkanes.

Unit 7

Alkenes and alkynes: Synthesis, Dehydration of alcohols, pyrolysis of esters, Cope reaction, Elimination of alkyl halides, germinal- and vicinal dihalides, Hofmann elimination; Reactions: Addition of X_2 (X = halogen), H-X, HO-X, interhalogens, water, Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, catalytic reduction, dihydroxylation, epoxidation, polymerization, alkylation of alkynes, oxidation of alkynes to 1,2-diketones, allylic and benzylic halogenation of alkenes mediated by radicals.

Unit 8

First Law of Thermodynamics: Thermodynamics terms, state and path functions, concept of heat and work, internal energy, enthalpy, first law of thermodynamics; w, q, ΔU and ΔH for expansion and compression of ideal gases, heat capacities, physical change, standard enthalpies of physical and chemical changes, Hess's law, Kirchhoff's law.

Unit 9

Second Law of Thermodynamics: Spontaneous processes, Carnot cycle, entropy, criteria of spontaneity, statements of the second law of thermodynamics, entropy changes, Clausius inequality, Gibbs energy, Helmholtz energy, Third law of thermodynamics.

Unit 10
Solutions: Ideal and non-ideal solutions

Unit 11
Colligative properties

Textbook

1. Lee, J. D. *Concise Inorganic Chemistry*, 5th Edn., (Chapman & Hall, 2002).
2. Atkins, P. and Paula, J. de. *Atkins' Physical Chemistry*, 10th Edn., (Oxford University Press, 2014).
3. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2nd Edn., (Oxford University Press, 2012).
4. Finar, I. L., *Organic Chemistry* (Volume 1), 6th Edn., (Pearson Education, 2002).

Suggested Readings

1. Levine, I. N., *Physical Chemistry*, 6th Edn., (McGraw Higher Edn., 2008).
2. Carey, F. A., Sundberg, R. J. *Advanced Organic Chemistry, Part A: Structure and Mechanisms*, 5th Edn., (Springer, New York, 2007).
3. March, J., Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., (Wiley, 2007).

Course outcomes

CO1: Ability to describe the fundamental properties of the real numbers that lays the foundation of the formal development of mathematical ability.
CO2: Ability to demonstrate an understanding of the theory of convergence of sequences and series, continuity, differentiation.
CO3: Ability to develop skills in constructing mathematical arguments.
CO4: Ability to utilize the concepts in solving the problems in their respective fields of study.

Course content

UNIT 1:

Inequalities involving arithmetic, geometric, and harmonic means, Cauchy-Schwarz inequality.

UNIT 2:

Sequences: Cauchy sequence, Cauchy's General principle of convergence, Subsequences, Convergence and divergence of monotonic sequences, Sandwich theorem. Infinite series: statements of basic properties of infinite series (without proofs), Convergence, Absolute and conditional convergences. Tests for convergence: Comparison test, Ratio test, Raabe's test, Leibnitz's test.

UNIT 3:

Functions of one variable: Limit, Continuity, Differentiability, Rolle's Theorem, Mean value theorems and applications, Taylor's theorem.

UNIT 4:

Critical points, convexity, curvature of plane curves, Asymptotes. Curve tracing: tracing of catenary, cissoids, asteroid, cycloid, folium of Descartes, cardioid, lemniscate.

UNIT 5:

Functions of two or more variables: Limit, Continuity, Partial derivatives, Euler's theorem on homogeneous functions, Differentiability, Chain rule, Directional derivatives, Gradient vectors and Tangent planes, Taylor's theorem (statement only), Criteria for Maxima/Minima/Saddle points, Lagrange's method of multipliers.

Textbooks

1. Thomas and Finney, *Calculus and Analytic Geometry*, (Pearson Education, Eleventh (Indian) Edition)
2. Bartle, R. G. and Sherbert, D. R., *Introduction to Real Analysis,* (John Wiley and Sons, Third (Indian) Edition)

Suggested readings:

1. Apostol, T. M., *Calculus, Vol I & II,* (John Wiley and Sons, Second (Indian) Edition).
2. Mapa, S.K., *Higher Algebra,* (Asoke Prakashan, Kolkata)

PI/PD 197: Physics Lab –I **L0-T0-P3- CR3**

Course Outcomes:

CO1: Ability to use the different components and equipment in physics practical.
CO2: Ability to work effectively and safely in the laboratory environment independently and as well as in teams.

Course Contents:

1. Laboratory related components:
    a. Laboratory safety measures; handling of chemical; electrical and electronics items and instruments; handling of laser and laser related instruments and experiments; handling of radioactive samples and related instruments; general safety measures etc.
2. Familiarization with equipment and components:
    a. Familiarization of different Electrical and Electronics components and hence identification & determination of values of unknown components
    b. Familiarization of different optical and hence show different optical behavior & pattern by using different optical components and optical sources (white light, laser, sodium light etc.)
    c. Familiarization of Microsoft excel, Origin and other software for data analysis
    d. Soldering and de-soldering of components in a circuit board.

3. Use of equipment:
    a. Multimeter and its uses
    b. Function generator and its uses
    c. CRO and its use to measure the wavelength, frequency, amplitude etc. of a given electrical signal.
4. Study the variation of time period with distance between center of gravity and center of suspension for a bar pendulum and,
    a. determine
        a) radius of gyration of the bar about its axis through its center of gravity and perpendicular to its length and,
        b) value of g
5. Determine the moment of a given magnet and horizontal component of Earth's magnetic field using magnetometers
6. Determine g through Kater's Pendulum
7. Find the refractive index of a given prism with the help of a spectrometer.
8. To determine the surface tension of the given liquid (water/CC14) by capillary tube method.
9. To measure the focal length of a given lens using (a) Bessel's method and (b)Magnification method.
10. To study elastic and inelastic collisions using suspended spherical balls of different materials.
11. Determination of Young's modulus of the given wire by torsional oscillation (Searl's method)

EG 101: Communicative English **L3- T0- P0- CR3**

Course outcomes

CO1: Ability to speak English with reasonable correctness of pronunciation and write English with reasonable clarity in different language contexts. .
CO2: Ability to communicate in English on specific occasions such as office and business work.
CO3: Ability use vocabulary and grammar in various language tasks such as taking and making notes, and writing letters, reports and essays effectively.
CO4: Ability to make oral presentations in English as part of their need to enhance their professional skills.

Course content

A. Oral Communicative Activities

Information transfer activities: Pair and group works involving transfer of information: describing pictures, interpreting diagrams, gleaning information from different types of written materials including articles etc. and talking about them; taking part in formal seminar presentation and group discussion.

B. Reading

Reading and comprehension: global and local comprehension, drawing interferences. 74 Materials: Stories and essays (preferably a collection of comparatively short essays on scientific, interestingly written topics, biographical/autobiographical writings, short stories adventure and scientific fiction, and shorter poems). ¬ Reading silently in class followed by short comprehension questions, brief writing exercises, summaries in brief, personal responses (not typical question-answer type)- both oral and written. Reading material from Internet and talking and writing about them; reading scientific reports, literary writings, articles collected from newspapers and magazines, Internet etc. and writing notes etc on them.

C. Writing

Preparing reports, project proposals. Writing applications of various types and for various purposes, curriculum vitae/resume, letters to the editors, letters to various agencies. Writing short notes on article/reports that had been read, notes on lectures (talks-radio/TV/audio, video cassettes), opinions on discussions/letters heard, notice both formal and informal/friendly, notes to inform others etc., interpreting pictures, advertisements, visuals (video, TV etc.) and writing briefly about them.

D. Vocabulary and grammar

Discussion on the following before and/or after the activities mentioned in A, B and C above. Structure of simple sentences; Agreement of verb and subject; use of adverbials; Tenses, Use of passive in scientific discourse, various types of questions, direct and indirect narration, Articles, Prepositions, English modal verbs, Errors in the use of individual words.

Textbooks:

1. Sharma, S. and B. Mishra. (2009). Communication Skills for Engineers and Scientists. PHI, New Delhi.
2. Wood, F. T. (2010). A Remedial English Grammar for Foreign Students. Macmillan, Delhi. Suggested readings:
3. Greenbaum, Sidney. (2005).Oxford English Grammar. Oxford University Press, New Delhi. Kenneth, Anderson, Tony Lynch, and Joan Mac Lean. (2008). Study Speaking. CUP, New Delhi.
4. Lynch, Tony. (2008). Study Listening. CUP, New Delhi.
5. Thomson and Martinet. (2008). A Practical English Grammar. Oxford ELBS, Delhi

Semester II

LI:102 Biology Major II (Animal Diversity) L3-T0-P0-CR3

Course outcome

CO1: Ability to identify and characterize different phyla in animal kingdom.
CO2: Ability to develop skills in describing the animal biodiversity.
CO4: Ability to identify and characteristics an organism and classify them under different phylum/class/order.

Course content

Unit I: Protista and Cnidaria: General characters and classification up to classes; Locomotory Organelles and locomotion in Protozoa; Porifera**:** General characters and classification up to classes; Canal System in Sycon**.** General characters and classification up to classes; Polymorphism in Hydrozoa;

Unit II: Platyhelminthes: General characters and classification up to classes; Life history of Taenia solium Nemathelminthes: General characters and classification up to classes; Parasitic adaptations

Unit III: Annelida: General characters and classification up to classes; Metamerism in Annelida; Arthropoda: General characters and classification up to classes; Metamorphosis in Insects

Unit IV: Mollusca: General characters and classification up to classes; Torsion in gastropods; Echinodermata: General characters and classification up to classes; Water-vascular system in Asteroidea

Unit V: Protochordates: General features and Phylogeny of Protochordata; Agnatha: General features of Agnatha and classification of cyclostomes up to classes

Unit VI: Pisces, Amphibia and Reptiles: General features and Classification up to orders; Fin systems, types of scales, lateral line and swim bladders of fish. Amphibi**a**: General features and Classification up to orders; Parental care; Reptiles: General features and Classification up to orders; Poisonous and non-poisonous snakes, Biting mechanism in snakes

Unit VII: Aves and Mammals: General features and Classification up to orders; Flight adaptations in birds. Origin of mammals.

Textbook

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.
2. Kingsley J. Text Book of Vertebrate Zoology Publisher: Nabu Press ISBN: 9781171586524, 1171586523

Suggested Readings

1. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science • Young, J. Z. (2004).
2. The Life of Vertebrates. III Edition. Oxford university press. • Pough H. Vertebrate life, VIII Edition, Pearson International.
3. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

LI: 104: Biology Lab (Major II Practical) **L0-T0-P3-CR3**

Course outcome

CO 1: Ability to identify and differentiate different organisms.
CO 2: Ability to use tools for collection, preservation and identification of different organism.
CO3: Ability to work effectively and safely in the laboratory environment independently and as well as in teams.

Course content

1. Study of the following specimens:
   Amoeba, Euglena, Plasmodium, Paramecium, Sycon, Hyalonema, and Euplectella, Obelia, Physalia, Aurelia, Tubipora, Metridium, Taenia solium, Male and female Ascaris lumbricoides, Aphrodite, Nereis, Pheretima, Hirudinaria, Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus, Pentaceros, Ophiura, Echinus, Cucumaria and Antedon, Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis, Any six common birds from different orders, Sorex, Bat, Funambulus, Loris

2. Study of the following permanent slides:
   T.S. and L.S. of Sycon, Study of life history stages of Taenia, T.S. of Male and female Ascaris

Practical Book

1. Dr. P S Verma A Manual of Practical Zoology: Invertebrates, ISBN : 9788121908290
2. Dr. P.S.Verma A Manual of Practical Zoology : Chordates. ISBN 9788121908306

PI/PD 102: PHYSICS-II **L2-T1-P0- CR3**

Course Outcomes:

CO1: Ability to understand relativity, electricity, magnetism and electronics.

CO2: Ability to learn advanced courses like General relativity, Electrodynamics, Digital electronics etc.

Course Content:

UNIT 1:

Special Theory of Relativity:

Frames of reference, relative velocity and accelerations, Concept of ether, Michelson-Morley experiment, elements of special theory of relativity, the postulates, Galilean and Lorentz transformations, equivalence of mass and energy, time dilation, length contraction, simultaneity, Doppler effect, twin paradox.

UNIT 2:

Electromagnetism:

Coulomb's law (electric), electric field due to a system of charges, Gauss's law in differential and integral forms, electric dipole, its electric field and potential, capacitance of parallel plates.

Coulomb's law (magnetic), Biot-Savart law, force on a current and on moving charges in a B-field.

UNIT 3:

Electronics:

Kirchhoff's law, network theorem, nodal analysis, mesh analysis, maximum power transfer theorem, series circuits, parallel circuits (DC analysis only), semiconductors, p-type, n-type semiconductors, p-n junction, diode, triode.

Textbooks:

1. Beiser A., *Concepts of Modern Physics,* 6th edition (Tata McGraw Hill, 2008).
2. Rakshit, P. C. and Chattopadhaya, D., *Electricity and Magnetism,* (New Central Book Agency, 2012).
3. Robbins, A. H. & Miller, W. C., *Circuit Analysis* (Delmar Cengage Learning, 2003).

Suggested Readings

1. Resnick, R., *Introduction to Special Relativity*, 1st edition (Wiley, 2007).
2. Griffith, D. J., *Introduction to Electrodynamics*, 3rd edition (Prentice Hall of India, 1999).
3. Edminister, J. A., *Electrical Circuits- Schaum's Outline series*, 2nd edition (McGraw Hill,1983).

CI 102 Chemistry-II **L3-T0-P0- CR3**

Course outcomes:

CO1: Ability to understand structure and bonding of homonuclear diatomic molecules, Polarizability of ions.
CO2: Ability to understand the stereochemistry of organic molecules – conformation and configuration, symmetric molecules and nomenclature.
CO3: Ability to understand the properties of gases and liquids
CO4: Ability to understand the kinetics of simple reactions, fundamentals of electrochemistry

Course Content:

Unit 1

Structure and Bonding: Valence Bond and LCAO-MO theory, bonding in homonuclear diatomic molecules (e.g.: H_2, N_2, O_2, F_2), covalent and ionic bonding, bond order, resonance, formal charge, VSEPR model, Polarizability of cations and anions, Fazan's rules.

Unit 2

Basics organic chemistry-4: Nucleophiles, electrophiles, keto-enol tautomerism, acidity and basicity of organic compounds, Frost diagram, Hückel's rules for aromaticity, antiaromaticity, homoaromaticity.

Unit 3

Stereochemistry-1: Representation of organic molecules in Fischer, saw horse, Newman, and flying-wedge, projection formulae and their interconversion, symmetry elements, molecular chirality, optical activity, optical purity, meso compounds, racemic mixture, resolution, enantiomers, diastereomers, epimers, anomers, atropisomers, basic concepts of stereochemical nomenclatures: *threo*/*erythro*, *syn*/*anti*, *R*/*S*, *cis*/*trans* and *E*/*Z*).

Unit 4

Reactive intermediates: Carbocation, carbanion, carbene, nitrene, free radical and benzyne: Generation, stability and reactions.

Unit 5

Properties of gases and liquids: Equations of state, kinetic model of gases, collision theory, real gases, Maxwell distribution of molecular speeds, qualitative description of the structure of liquids, surface tension and viscosity.

Unit 6

Electrochemistry: Conduction in electrolyte solutions, ionic mobility, Kohlrausch law, Ostwald's dilution law, transport number, Debye-Huckel Limiting Law, electrochemical cells, EMF, Nernst equation.

Unit 7

Rate of reactions: Rate equations of zero, first, second, pseudo 1^{st} order reactions, determination of order of a reaction, activation energy, activated complex theory, collision theory.

Textbooks

1. Atkins, P., Paula, J. de. *Atkins' Physical Chemistry*, 10^{th} Edn., (Oxford University Press, 2014).
2. Overton, T., Armstrong, F., Rourke, J., Weller, M. *Inorganic Chemistry*, 6^{th} Edn., (Oxford University Press, 2015).
3. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2^{nd} Edn., (Oxford University Press, 2012).
4. Sengupta, S. *Basic Stereochemistry of Organic Molecules*, 1^{st} Edn., (Oxford University Press, 2014).

Suggested Readings

1. Laidler, K. J., Meiser, J. H., Sanctuary, B. C.**,** *Physical Chemistry*, 4th Edn., (Brooks Cole, 2002).
2. Carey, F. A., Sundberg, R. J. *Advanced Organic Chemistry, Part B: Reactions and Synthesis*, 5th Edn. ,(Springer, New York, 2007).
3. March, J., Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edn., (Wiley, 2007).
4. Eliel, E. L., Wilen, S. H., Doyle, M. P. *Basic Organic Stereochemistry*, 1st Edn., (Wiley-Interscience, 2001).

MI102 / MD 102 : Mathematics II **L 2 T1 P0 CR3**

Course outcomes

CO1: Ability to use the basic methods and tools of solving ordinary differential equations.
CO2: Ability to understand vectors as well as surface and volume integrations.
CO3: Ability to develop an aptitude in finding applications of the methods.

Course content

UNIT 1:

Ordinary differential equations(ODE): Basic definitions: order and degree of differential equation, primitives, solutions of differential equations, Integral curves, isoclines, formulation of ODE, Linear and non-linear differential equations.

UNIT 2:

Variables separable equation, homogeneous and non-homogeneous equation, exact equations and integrating factors, linear and Bernoulli's equation, equations reducible to first order Clairaut's equation.

UNIT 3:

Second order Differential Equations: Linear equations with constant coefficients. Standard methods for solution of homogeneous and non-homogeneous linear differential equations, linear differential equations with variable coefficients and Method of Variation of Parameter.

UNIT 4:

Line integral, Double integral, triple integral, Jacobian, Surface integral and their applications. Space co-ordinates, lines and planes, Polar coordinates, Cylinders, Quadric surfaces, Volume, Area, length, volume and surface area of solids of revolution.

UNIT 5:

Vector Calculus, vector point function, continuity and differentiation of vector point function, partial derivative of vectors, Curl, Grade, Divergence; Green, Gauss and Stokes Theorem.

Textbooks:

1. Boyce, William E. and Dprima, Richard, C. *Elementary Differential Equations*, (John Wiley, Indian Edition, 2000).
2. Spiegel, M. R., *Vector Analysis*, *Schaum's outline series, (*Publishing House India).
3. Thomas *and* Finney, *Calculus and Analytic Geometry*, (Pearson Education, Eleventh (Indian) Edition).

Suggested readings:

1. Jain, R. K. and Iyengar, S. R. K., *Advanced Engineering Mathematics,* Third Edition, (Narosa publishing house, India).
2. Ramana, B. V., *Higher Engineering Mathematics*, (McGraw Hill, India).

CI 107 Chemistry Laboratory (for MBBT and Physics) L0-T0-P3-CR3

Course outcomes

CO1: Ability to analyze different inorganic mixture
CO2: Ability to estimate different chemical compounds.
CO3: Ability to measure and determine viscosity, surface tension of solutions.

Course Content:

1. Qualitative Analysis of Inorganic Mixtures (excluding interfering radicals)
2. Preparation of Mohrs salt
3. Estimation of Glucose
4. Nitration of organic compounds
5. Reduction of functional groups
3. Preparation of buffer solution and measurement of pH
4. Viscosity measurement of solution
5. Conductometric acid-base titration
6. Measurement surface tension of liquid by stalagmometer
7. Verification of Beer-Lamberts law
8. Titration of a mixture of AcOH, HCl and $CuSO_4$ by conductometric method

Textbooks

1. Furniss, B. S., Ford, A. J. H., Smith, P. W. H., Tatchell, A. R. *Vogel's Textbook of Practical*, 5^{th} Edn., (Wiley, 1989).
2. Jadav, J. B. *Advanced Practical Physical Chemistry*, (Krishna Prakashan, 2015).
3. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M., Sivasankar, B. *Vogel's Quantitative Chemical Analysis*, 6^{th} Edn., (Pearson Education, 2009).
4. Gurdeep, R. *Advanced Practical Inorganic Chemistry*, (Krishna Prakashan, 2013).

ES 103: Environmental Studies **L4 T0 P0 CR4**

Course outcomes

CO1: Ability to recognize the need for learning environmental studies and develop foundational knowledge on the topic.

CO2: Ability to appreciate the environment around us, spread awareness on environment degradation, promote environment protection and sustainable mitigation strategies.

CO3: Ability to develop critical thinking and analytical ability to resolve interdisciplinary issues related to the environment around us.

Course content

Unit 1: Introduction to environmental studies

Multidisciplinary nature of environmental studies Scope and importance; Concept of sustainability and sustainable development.

Unit 2: Ecosystems

What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems:

a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3: Natural Resources: Renewable and Non-renewable Resources

Land resources and landuse change; Land degradation, soil erosion and desertification.

Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4: Biodiversity and Conservation

Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots. India as a mega-biodiversity nation; Endangered and endemic species of India. Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5: Environmental Pollution

Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution. Nuclear hazards and human health risks. Solid waste management: Control measures of urban and industrial waste. Pollution case studies.

Unit 6: Environmental Policies & Practices

Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture. Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).

Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Unit 7: Human Communities and the Environment

Human population growth: Impacts on environment, human health and welfare. Resettlement and rehabilitation of project affected persons; case studies. Disaster management: floods, earthquake, cyclones and landslides. Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan. Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

Unit 8: Field work

1. Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
2. Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.
3. Study of common plants, insects, birds and basic principles of identification.
4. Study of simple ecosystems-pond, river, Delhi Ridge, etc.

Textbooks:

1. E. Bharucha, *Textbook of Environmental Studies*, Orient Black Swan, 2015.
2. P.H. Raven, D.M. Hassenzahl and L.R. Berg, *Environment*, 8th edition, John Wiley & Sons, 2012
3. E.P. Odum, H.T. Odum and J. Andrews, *Fundamentals of Ecology*, Philadelphia: Saunders, 1971.

Suggested readings:

1. R. Carson, *Silent Spring*, Houghton Mifflin Harcourt, 2002.
2. M., Gadgil, & R. Guha, *This Fissured Land: An Ecological History of India*, Univ. of California Press, 1993.
3. B. Gleeson and N. Low, *Global Ethics and Environment*, London, Routledge, 1999.
4. P. H. Gleick, *Water in Crisis. Pacific Institute for Studies in Dev.*, Environment & Security. Stockholm Env. Institute, Oxford Univ. Press, 1993.
5. Martha J. Groom, Gary K. Meffe, and Carl Ronald Carroll, *Principles of Conservation Biology, Sunderland*, Sinauer Associates, 2006.
6. Grumbine, R. Edward and M.K. Pandit, *Threats from India's Himalaya dams*, Science, 339: 36-37, 2013.
7. P. McCully, *Rivers no more: the environmental effects of dams*, Zed Books, 1996.
8. McNeill and R. John, *Something New Under the Sun: An Environmental History of the Twentieth Century*, W. W. Norton & Company, 2000.
9. I.L. Pepper, C.P. Gerba and M.L. Brusseau, *Environmental and Pollution Science*, Academic Press, 2011.
10. M.N. Rao and A.K. Datta, *Waste Water Treatment*, Oxford and IBH Publishing Co. Pvt. Ltd.,1987.
11. Rosencranz, S. Divan, and M.L. Noble, *Environmental law and policy in India*, Oxford, 1992.
12. R. Sengupta, *Ecology and economics: An approach to sustainable development*, OUP, 2003.
13. J.S. Singh, S.P. Singh, and S.R. Gupta, *Ecology, Environmental Science and Conservation*, S. Chand Publishing, New Delhi, 2014.
14. N.S., Sodhi, L. Gibson, and P.H. Raven, *Conservation Biology: Voices from the Tropics*, John Wiley & Sons, 2013.
15. V. Thapar, *Land of the Tiger: A Natural History of the Indian Subcontinent*, India Book House, 1998.
16. C. E. Warren, *Biology and Water Pollution Control*, WB Saunders, 1971
17. O. Wilson, *The Creation: An appeal to save life on earth*, New York: Norton, 2006.
18. World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987.

Semester III

LI 201 Plant ecology and taxonomy **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to recognize plant ecosystem.
CO 2: Ability to classify plants using morphological characters and molecular techniques.

Course content

Unit I: **Ecological factors**: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Unit II: **Plant communities**: Characters; Ecotone and edge effect; Succession; Processes and types.

Unit III: **Ecosystem**: Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous. Principle biogeographical zones; Endemism.

Unit IV: **Introduction to plant taxonomy**: Identification, Classification, Nomenclature. Taxonomic evidences from palynology, cytology, phytochemistry and molecular data. Taxonomic hierarchy: Ranks, categories and taxonomic groups.

Unit V: **Identification**: Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.

Unit VI: Botanical nomenclature: Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit VII: Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker, Engler and Prantl.

Unit VIII: Biometrics, numerical taxonomy and cladistics: Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms.

Textbook:

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.

Suggested Readings

1. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
2. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

LI 203 Comparative anatomy of vertebrates **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to recognize anatomical parts of vertebrates.
CO 2: Ability to recognize different parts physiological systems of vertebrates.
CO 3: Ability to recognize the different development stages of vertebrates.

Course content

Unit I: Introduction to skeletal system: Integumentary and Skeletal Systems Structure, functions and derivatives of integument Overview of axial and appendicular skeleton, Visceral arches of birds and mammals

Unit II: Digestive and Respiratory Systems: Alimentary canal and associated glands in mammals Respiratory organs in amphibians, birds and mammals; gills and accessory respiratory organs in fishes

Unit III: Circulatory: General plan of circulation, evolution of heart and aortic arches Urinogenital system in vertebrates, its evolution and types of mammalian uteri

Unit IV: Nervous System: Comparative account of brain in vertebrates Autonomic nervous system, Spinal cord, Cranial nerves in mammals

Unit V: Neurons and Sense Organs: Type of neurons, classification of receptors. Chemoreceptor, mechanoreceptor in vertebrates

Unit VI: Anatomy of gonads in vertebrates Gametogenesis: Spermatogenesis and oogenesis vitellogenesis in birds; Fertilization: external (amphibians), internal (mammals), Early development of vertebrates, types of morphogenetic movements; Fate of germ layers;

Unit VII: Development: Control of early embryonic Development. Intercellular communication, cell proliferation, differentiation and movements; cell death.

Textbooks

1. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.

LI 205 Plant Anatomy and Embryology **L3-T0-P0-CR3**

Course outcome

CO 1: Ability to recognize anatomical parts of plant and different embryological stages of plant.
CO 2: Ability to recognize the anatomy of monocot and dicot plants, and plant reproduction.
CO 3: Ability to recognize the different development stages of plant

Course content

Unit I: Meristematic and permanent tissues: Root and shoot apical meristems; Simple and complex tissues

Unit II: Organs: Structure of dicot and monocot root stem and leaf.

Unit III: Secondary Growth: Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Unit IV: Adaptive and protective systems: Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit V: Structural organization of flower: Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit VI: Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit VII: **Embryo and endosperm**: Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship.

Unit VIII: Apomixis and polyembryony: Definition, types and practical applications.

Text Book

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

LI 207 Biology Major III Lab: (Anatomy Plant & Animal) L0-T0-P3-CR3

Course outcome

CO1: Ability to dissect and analyze monocot and dicot plants, and plant reproduction and embryo developments stages.

CO2: Ability to prepare animal tissue for analysis of anatomy, reproductive and embryological developments stage of animal.

Course content

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae -Brassica, Alyssum / Iberis; Asteraceae -Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae - Asphodelus / Lilium / Allium.
2. Preparation of root stem and leaf transverse and longitudinal sections, differential staining and study the different anatomical structures.
3. Mounting of a properly dried and pressed specimen of any plant with herbarium label.
4. Study of developmental stages - whole mounts and sections through permanent slides – cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages of frog.
5. Study of the different types of placenta- histological sections through permanent slides or photomicrographs.

Practical Books

1. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
2. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

LI 209 Introduction to computing **L3-T0-P0-CR3**

Course outcome

CO1: Ability to operate computers and write programs.
CO2: Ability to use computers for operations on data.
CO3: Ability to use computer without compromising ethics and society.

Course content

Unit I: Introduction: The von Neumann architecture, machine language, assembly language, high level programming languages, compiler, interpreter, loader, linker, text editors, operating systems, flowcharts.

Unit II : **Internet and WWW**: Data communications and Networking, E-commerce.

Unit III: **Basic features of programming (Using C):** data types, variables, operators, expressions, statements, control structures, functions;

Unit IV: **Advanced programming features**: arrays and pointers, recursion, records (structures), memory management, files, input/output, standard library functions, programming tools, testing and debugging;

Unit V: **Fundamental operations on data**: insert, delete, search, traverse and modify.

Unit VI: **Fundamental data structures**: arrays, stacks, queues, linked lists; Searching and sorting: linear search, binary search, insertion-sort, bubble-sort, selection-sort, radix-sort, counting-sort;

Unit VII: **Object oriented Programming**: Introduction to object-oriented programming and basics.

Unit VIII: **Computing ethics and Society:** Security, ethics, and privacy. Artificial intelligence, future of computing, impact of computing on society.

Textbooks:

1. A Kelly and I Pohl, *A Book on C*, 4th Ed., Pearson Education, 1999.
2. A M Tenenbaum, Y Langsam and M J Augenstein, *Data Structures Using C*, Prentice Hall India, 1996.
3. Computing Essentials 2017 Complete Timothy O‟Leary & Linda O‟Leary ISBN: 9781259563652

Suggested Readings:

1. H Schildt, *C: The Complete Reference*, 4th Ed., Tata Mcgraw Hill, 2000
2. B Kernighan and D Ritchie, *The C Programming Language*, 4th Ed., Prentice Hall of India, 1988.

PI/PD 201: Physics-III **L2-T1-P0-CR3**

Course Outcomes:

CO1 : Ability appreciate quantum mechanics and its applications.
CO2 : Ability to solve problems using Schrodinger equation

Course Content:

Particle properties of waves: Wave particle duality, Photoelectric effect, Black body radiation, Plank radiation law, Rayleigh-Jeans law, Stefan's law.

Atomic physics: Rutherford model, Bohr model, hydrogen atom (quantum numbers and spectral series; qualitative), X-ray, Moseley's law, Basics of Lasers. Basics particle physics: elementary forces and particles.

Limitations of classical physics: Qualitative discussions of the problem of the stability of the nuclear atom. The photo-electric effect. Franck-Hertz experiment and the existence of energy levels. Experimental evidence for wave-particle duality, X-ray diffraction and Bragg law. Compton scattering. Electron and neutron diffraction. Einstein and de Broglie's relations ($E = h\gamma$, $p = h/\lambda$).

Schrodinger equation: The concept of the wave function as a probability amplitude and its probabilistic interpretation. Plane wave solutions of the one-dimensional time-dependent Schrodinger equation for a particle in free space and elementary derivation of the phase and group velocities (quantitative discussion of wave packets is not required).

Uncertainty relation: The position-momentum uncertainty relation and simple consequences. Solutions of the one-dimensional Schrodinger's equation for an infinite square well potential; qualitative treatment of the finite well (derivation not required). Linear harmonic oscillator.

Textbooks:

1. Beiser, A., *Concepts of Modern Physics* (McGraw-Hill, 2002).
2. Krane, K. S., *Modern Physics* (Wiley).

Suggested Readings:

1. Beiser, A., Perspectives *of Modern Physics* (McGraw-Hill Inc.,US).
2. Thornton, S. T. and Rex, A., Modern Physics for Scientists and Engineers (Cengage Learning; 4 edition).
3. Gautreau, R. Schaum's Outline of Modern Physics, (McGraw-Hill; 2 edition).
4. Young, H.D. and Freedman, R.A., *University Physics*, 12^{th} edition, (Pearson, 2009).

CI 201 Chemistry-III (For non-major) L0-T0-P3-CH3

Learning outcome:

CO1: Ability to recognize and determine the strength of acids and bases.
CO2: Ability to understand the fundamentals of coordination chemistry.
CO3: Ability to recognize aromatic compounds and aromaticity.
CO4: Ability to develop skills for synthesis and determine the properties of hydrocarbons.
CO5: Ability to determine weak electrolyte and ionic equilibrium

Course Content:

Unit 1

Acid -Base concept: Arrhenius concept, Brønsted-Lowry acids and bases, Lewis acids and bases, Hard Soft acids - bases and HSAB principle, Acid and base strength, levelling effect.

Unit 2

Coordination chemistry: Werner's theory, classification of ligands, coordination number, nomenclature of coordination compounds, isomerism.

Unit 3

Aromaticity and Hückel Rule, Orientation of substituents, Directive influence of substituents, o/p ration, kinetically and thermodynamically controlled reactions.

Unit 4

Alkynes: Preparation, properties and reactions.

Unit 5

Alkyl halides: Preparation, properties and reactions.

Unit 6

Ionic equilibrium: Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Dissociation constant of week acids and bases, Ionization of water, pK_w and pH, Salt effect, pH expressions for various neutralization reaction, Henderson- Hasselbalch equation, solubility product, common ion effect, Buffer solutions, theory of acid base indicators, acid base titration curves (pH variation).

Textbook(s)

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. *Inorganic Chemistry*: Principles of *Structure and Reactivity*, 4th Edn., (Pearson Education, 2006).
2. Barrow, G. M. *Physical Chemistry*, 5th Edn., (McGraw Hill, 2007).
3. Finar, I. L. *Organic Chemistry* (Volume 1), 6th Edn., (Pearson Education, 2002).
4. Ghosh, S. K., *Advanced General Organic Chemistry*, 3rd Edn., (New Central Book Agency (P) Ltd., 2008).

Suggested Readings

1. Smith, M. B., March, J. *March's Advanced Organic Chemistry, Reaction Mechanism and Structure* 6th Edn., (Wiley, 2007).
2. Clayden, J., Greeves, N., Warren, S., Wothers, P. *Organic Chemistry*, 2nd Edn., (Oxford University Press, 2012).

NS102 National Service Scheme **L1-T0-P1-CR2**

Course Outcomes:

CO1: Ability do community service and educate society about good health and hygiene
CO2: Ability to develop civic and social responsibility and democratic spirit
CO3: Ability to communicate to community the problems and needs of the community
CO4: Ability to demonstrate leadership quality

Content

Unit - 01: Introduction and Basic Concepts of NSS

a) History, philosophy, aims & objectives of NSS
b) Emblem, flag, motto, song, badge
c) Organizational structure, roles and responsibilities of various NSS functionaries

Unit - 02: Understanding Youth and Volunteerism

a) Definition, profile of youth, categories of youth
b) Issues, challenges, and opportunities for youth
c) Youth as an agent of social change, Importance and role of youth leadership
d) Indian Tradition of volunteerism, Needs & importance of volunteerism

Unit - 03: Community Mobilisation

a) Mapping of community stakeholders
b) Designing the message in the context of the problem and the culture of the community
c) Identifying methods of mobilisation, Youth-adult partnership

Practicum

1. Community service
2. Practice of volunteerism
3. Special camp and national integration camp

Textbooks:

1. Panwar, JDS et al (2020) National Service Scheme: A Youth Volunteers Programme for Under Graduate Students, New Delhi, Daya Publishing House
2. Rao, P. Ramachandra and Sampath Kumar, R.D. (2017), Training of Trainers in National Service Scheme, Visakhapatnam , Uday Publishing House

Reference Books:

1. Devendra, Agochiya(2018) Life Competencies for Growth and Success: A Trainer's Manual, New Delhi, SAGE Publications.
2. Prasad, R.R. (2015) Community Mobilisation: Methods & Models, New Delhi, Discovery publishing House.
3. Sanghi, Seema (2007) The Handbook of Competency Mapping - Understanding, Designing and Implementing Competency Models in Organizations, New Delhi, Sage Publications.
4. Silbereisen, Rainer K. and Lerner, Richard M. (2007) Approaches to Positive Youth Development, LA, Sage Publications .
5. Stallings, Betty B. and Ellis, Susan J. (2010) Leading the Way to Successful Volunteer Involvement: Practical Tools for Busy Executives, Philadelphia: Energize Books.
6. Villarruel, Francisco A. et al (2003) Community Youth Development: Programs, Policies, and Practices, LA, Sage Publications.

Semester IV

LI 202 Genetics and Evolutionary Biology **L3-T0-P0-CR3**

Course outcome

CO 1: Ability to differentiate between classical genetics and fundamentals of evolution.
CO 2: Ability to know the Mendelian genetics as well as population genetics.
CO 3: Ability to know genetics encompassing complex traits and genetics of evolution.

Course content

Unit I: Introduction to Genetics & Evolution: Definition, History, Terminology, Scope of the course.

Unit II: Mendelian Genetics: Fundamental concepts in genetics, Mendel's Laws, Monohybird and Dihybrid cross, Test Cross, Back Cross, Application of probability in genetics, Binomial expansion, Chi-square test.

Unit III: Deviations from Mendel's Law-I: Linkage, Genetic mapping, Epistasis (Gene interactions), Co-dominance, Sex linked, Sex influenced, Sex limited inheritances, quantitative traits/loci.

Unit IV: Deviations from Mendel's Law-II: Epigenetics, Imprinting, Extra nuclear inheritance (Mitochondrial and Chloroplast).

Unit V: Genetics of Development: Homeotic genes in plants and animals, genetics of circadian rhythm

Unit VI: Theories of Evolution: Lamarck's theory, Darwin's theory, Weismann's germ plasm theory; Evolution in bacteria, experimental evolution.

Unit VII: Molecular evolution: Mutation in organisms, mechanisms, mutation rate, theories of molecular evolution (selection, neutral, nearly neutral).

Unit VIII: Population genetics: Hardy Weinberg equilibrium, factors influencing the Hardy Weinberg's equilibrium.

Textbook

1. Genetics: Analysis of Genes and Genomes Authors: Daniel L. Hartl and Bruce Cochrane Jones and Bartlett Publishers, Inc; 9th Revised edition edition (30 November 2017)

Suggested readings

1. Genetics: Analysis & Principles Author: Robert J. Brooker Publisher: McGraw-Hill Science Engineering; 4 edition (21 January 2011)
2. Concepts of Genetics Authors: William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, Darrell KilliannPublisher: Benjamin-Cummings Pub Co; Student edition (19 November 2014)
3. Introduction to Genetic Analysis (Introduction to Genetic Analysis (Griffiths)) Hardcover – Import, 16 Feb 2007 Authors: Anthony J. F. Griffiths, Susan R. Wessler , Richard C. Lewontin, Sean B. CarrollPublisher: WH Freeman; 11th ed. 2016 edition (12 January 2015)

LI 204: Microbiology **L3- T0- P0-CR3**

Course outcome

CO1: Ability to identify microbial diversity, morphology, physiology and nutrition.
CO2: Ability to identify and demonstrate how to control microbial growth, demonstrate.
CO3: Ability to evaluate the interactions between microbes, hosts and environment

Course content

Unit I: Brief history and development of microbiology: Introduction to study of Microbiology, conflict over spontaneous generation, role of microorganisms in disease, scope of microbiology, development of Koch's postulate.

Unit II: Microbial Taxonomy: Classification system- phenetic, phylogenetic, numerical, morphological, biochemical and molecular characteristics; Novel genomic tools including signatures, uncultured microbes.

Unit III: Prokaryotic cell structure: Bacterial cell wall, cytoplasmic structure and inclusions bodies, sporulation and spore, diversity in bacterial structure actinomycetes, rickettsias, mycoplasma; archaea.

Unit IV: Viruses: Basic structures, classification, double stranded and single stranded DNA and RNA viruses, replication strategies of DNA and RNA viruses; viroids and prions; bacteriphages with suitable examples.

Unit V: Microbial growth and Nutrition: Culture media, microbial growth curve, influence of environmental factors on growth; Common nutrient requirements, introduction to nutritional types in microorganisms, uptake of nutrient by the cell, energetic of biosynthetic reactions; photosynthesis (oxygenic an anaoxygenic), autotrophs, heterotrophs, assimilation of inorganic phosphorous, sulphur and nitrogen.

Unit VI: Microbial diseases and their control: Host-pathogen relationship, mechanisms of virulence, quorum sensing, pathogenesis in plants and animals.

Unit VII: Applications of Microbes: Antimicrobial chemotherapy, microbial biofilm, microbiome.

Textbooks

1. Willey, J., Sherwood, L. and WoolvertonC., *Microbiology*, 10th edition (McGraw-Hill Science, 2017).
2. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R., *Microbiology*, Publisher McGraw Hill Education (India) Private Limited, ISBN-10 0074623206, 5th Edition, 2001.
3. Tortora, G.J., Fernke, B.R. and Case, C.L., *Microbiology – An Introduction*, 9th Edition,
4. Benjamin Cummings, 2009.

Suggested Reading

1. M. T. Madigan, J. M. Martinko, K. S. Bender, D. H. Buckley, D. A. Stahl, T. Brock, *Brock Biology of Microorganisms, 14th* Edition , Pearson Hall International, 2017.
2. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.

LI 206 Cell Biology I **L3-T0-P0-CR3**

Course outcome

CO 1: Ability to understand basics of cell structure and function.
CO 2: Ability to understand cell signaling and cellular transport of macromolecules.

Course content

Unit I: Introduction to Cell Biology: The Cell – introduction to Prokaryotes and Eukaryotes. Difference between normal cell and cancer cell. Evolutionary link between prokaryotes and eukaryotes (recent molecular evidences).

Unit II: Cell imaging: Light microscopy (Bright field, Phase contrast and DIC), electron microscopy.

Unit III: Cell division: Cell division in Microbes, Plant and Animal (both mitotic and meiotic). Cell cycle and its molecular events. Cell Cycle: Checkpoint controls, Stem Cells.

Unit IV: Cell Membrane and extracellular components: Plasma membrane: Membrane lipids, Membrane proteins Membrane fluidity, Lipids Rafts- Organization and Functions. Components of extracellular space and their functions.

Unit V: Transport: Principle of Membrane transport- Active and passive transport, transporters, ion channels.

Unit VI: Endomembrane systems: Endoplasmic reticulum, golgi body, lysosomes. Cell nucleus-nuclear membrane, structure and organization. Sorting and trafficking of proteins in the endomembrane system. Cytoskeleton-Microfilaments and intermediate Filaments; cell motility.

Unit VII: Fundamentals of cell signaling: Signaling in cells: G-protein mediated, RTK , $Ca^{++\ m}$, Insulin , Ras-MAPK, Wnt , Hedgehog and toll-like receptor.

Textbooks

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6th Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).
4. Becker, W. M. et al., The World of Cell, 8th Edition (Benjamin Cummings, 2011).

Suggested Readings

1. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D.Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. Cooper, G. M. and Hausman, R. E., The Cell: A Molecular Approach, 5th Edition (ASM Press and Sinauer Associates, Inc., 2009).

LI208: Biochemistry I **L3-T0-P0-CR3**

Course outcome

CO1: Ability to identify biomolecules such as protein, carbohydrates, lips, nucleic acids, vitamins. biochemistry.

CO2: Ability to understand biochemical principles with specific emphasis on different metabolic pathways.

Course content

Unit I: Introduction to Biochemistry: Chemical basis of life; Composition of living matter; Water –role of water in life, properties, pH, ionization and Hydrophobicity, Four families of biological macromolecules, importance of studying biochemistry.

Unit II: Proteins: Amino acids structure and functional group properties; Peptides and covalent structure of proteins; Classification of proteins; Protein configuration-primary, secondary, tertiary and quaternary structures.

Unit III: Protein structure: Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc; biological functions of proteins; protein and unfolding

Unit IV: Carbohydrates: Source and biological functions of carbohydrates; Sugars - mono, di, and polysaccharides; Mutarotation, anomers, epimers etc; classification of carbohydrates with examples of each class, glycoproteins and glycolipids.

Unit V: Lipids: Lipids structure, biological functions and properties of lipids, classification of lipids; important members of storage and membrane lipids; lipoproteins. Biological membrane transport and membrane dynamics.

Unit VI: Nucleic acids: Nucleosides: DNA, RNA; nucleotides, nucleic acids - structure, sugar puckering; diversity and function; sequencing; Brief overview of central dogma.

Unit VII: Bioenergetics: Bioenergetics-basic principles; Equilibria and concept of free energy; Enzyme catalysis Coupled processes; Thermodynamic principles-first and second laws of thermodynamics; ATP as universal currency of energy in biological system. Biological oxidation reduction reaction and free energy.

Textbooks

1. Voet D, Pratt CW,Voet JG. Principles of Biochemistry, 4th edition, Wiley, John & Sons.2012.
2. Nelson DL, Cox MM. Lehninger Principles of Biochemistry, 6th edition, Macmilan. 2013.

Suggested Reading

1. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. Berg JM, Tymoczko JL, StryerL.Biochemistry: International Edition, 7th edition, W.H. Freeman and Macmilan. 2011.

LI 210 Biology Lab-IV (Biochemistry) **L0-T0-P3-CR3**

Course outcome

CO 1: *Ability to identify the basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry.*

CO 2: *Ability to perform biochemistry experiments in a problem oriented manner.*

Course content

1. Introduction to pH and buffers.
2. Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose)
3. Quantitative estimation of protein, protein, DNA and RNA.
4. Quantitative estimation of carbohydrates by anthrone method.
5. Separation of amino acids by TLC and determination of Rf values

Practical book

1. An introduction to practical biochemistry, 3rd edition by David T Plummer

LI 212 Biology lab V (Cell Biology) **L0-T0-P3- CR3**

Course outcome

CO1: Ability to identify laboratory instruments and understand the principle of measurements using those instruments with experiments in cell biology.
CO2: Ability to perform experimental methods in cell biology in a problem oriented manner.

Course content

1. Prepare culture media for animal tissue culture and handling of cell lines.
2. Isolation of lymphocytes from blood and check their cell viability using trypan blue exclusion method.
3. Membrane fragility/stability test using red blood cells.
4. Identification of stages from permanent slides showing Mitosis and Meiosis.
5. Isolation of sub-cellular fractions
6. Staining methods to differentiate between live, apoptotic and necrotic cells

Practical books

1 Culture of Animal Cells. A Manual of Basic Technique:. Third Edition. 486 R. I. Freshney. John Wiley and Sons, Inc., Publication. New York,
2 Molecular Cloning A Laboratory Manual 1 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
3 Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

Semester V

LI 301: Plant Physiology **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to identify different physiological processes in plant.
CO 2: *Ability to understand absorption, transpiration, photosynthesis, growth in plants.*

Course content

Unit-I: Introduction to physiology and homeostasis: Plant nutrition: essential nutrients, deficiencies and plant disorders; heavy metal stress and homeostasis; mechanism of ion uptake by plants.

Unit-II: Transport mechanism in plant: Osmosis, Active transport and Passive transport, Xylem transport, Phloem Transport; loading and unloading mechanism of food, Short Distance Intracellular transport.

Unit-III: Water relations in plants: Polarity; water potential in plants; movement of water in plants; soil-plant-atmosphere continuum.

Unit-IV: Photoperiodism: Photoperiodic response, Physiology of flowering, phytochrome chemistry and mechanism; Senescence and its molecular aspects; Dormancy & Vernalization mechanism; plant biological clock.

Unit-V: Photosynthesis: Photophosphorylation, Thylakoid membrane in photophosphorelation, C3 cycle, C4 cycle and CAM pathways, photorespiration.

Unit-VI: Plant growth regulators: Auxins, gibberellins, cytokinins, ethylene, abscissic acid, brassinosteroids, salicylic acid, jasmonic acid, mode of senescence.

Unit-VII: Rhizosphere physiology: Root respiration, rhizosphere and allelopathy, types of chemicals and volatiles.

Textbooks

1. Taiz, L. and Zeiger, E., Plant Physiology, 5th edition (Sinauer Associates, USA, 2012).
2. URL: http://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf

Suggested Readings

1. Lambers, H. and Chapin, F. S., Plant Physiological Ecology (Springer, 2000).
2. Mukherji, S. and Ghosh, A.K., Plant Physiology, 1st edition (New Central Book Agency Private Ltd. Kolkata, 2009).
3. http://www.annualreviews.org/journal/arplant
4. Hormones: http://nptel.ac.in/courses/102103012/27

LI 303: Animal Physiology **L3- T0- P0-CR3**

Course outcome

CO1: Ability to identify different physiological process in animal.
CO2: Ability to understand the mechanism of digestive, circulatory, respiratory and nervous system in animals.
CO3: Ability to understand the diseases related to physiological systems

Course content

Unit I: Introduction to Physiology: An overview of animal anatomy and body plan; Homeostasis, Organs and Organ systems.

Unit II: Circulatory system: Closed and Open circulatory system, Structure and function of heart in higher vertebrates (mammals); Blood as connective tissue- Components of Blood; Blood groups; Blood clotting; Lymph and lumph nodes.

Unit III: Respiratory system: Anatomy of lungs in mammals; Mechanism and regulation of breathing; Hemoglobin & Oxyhemoglobin dissociation curve, oxygen and carbon dioxide transport; Acid-Base balance of the blood.

Unit IV: Digestive system: Anatomy of alimentary canal in mammals. Role of liver and pancreas in digestion. Mechanism of digestion and absorption in mammals.

Unit V: Muscular system: Structure and type of muscles; neuromuscular junction, muscle contraction; Energy requirements of skeletal muscles and metabolism, Neural control of skeletal muscles.

Unit VI: Nervous system: Types of neurons and supporting cells. Nerve impulse and mechanism of impulse conduction, Neurotransmitters, Synaptic Integration, Synaptic Plasticity and inhibition.

Unit VII: Excretory system: Structure and function of mammalian kidney, Nephron as a functional unit of kidney, Process of filtration and urine formation: Renal control of electrolyte and acid-base balance.

Unit VIII: Reproductive and Endocrine system: Female reproduction system – reproductive cycle, Structure of Ovary. Male reproductive system: Structure of testis, mechanism of spermatogenesis, structure of sperm. Endocrine organs and hormones in vertebrates (mammals); Mechanism of hormone action and signal transduction; thyroid and pancreatic metabolic disorders.

Textbooks

1. Guyton, C. and Hall, E., Text book of Medical Physiology, 12th edition (W.B. Saunders Company, 2010).
2. Hill, R.W., Wyse, G. A. and Anderson, M., Animal Physiology, 3rd edition (Sinauer Associates, 2012).

Suggested Readings

1. Kim E. Barrett. et. al., Ganong's Review of Medical Physiology, 24th Edition (Lange Basic Science, Tata McGraw Hill, 2012.)

LI 305 Basic Bioinformatics **L2-T0-P1-CR3**

Course outcome

CO1: Ability to use common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

CO2: Ability to use computational approached for critical analysis and interpret the results of their study.

Course content

Unit I: History of Bioinformatics: Life in space and time, dogmas: central and peripheral, challenges in biology, intersection of classical biology, mathematics and computer science.

Unit II: Introduction to Bioinformatics: Overview of bioinformatics, Bioinformatics and the internet, Use of information technology for studying Biosciences, observables and data archives, Information flow in bioinformatics.

Unit III: Introduction to nucleic acid world: The structure of DNA and RNA, gene structure and control, the tree of life and evolution. Protein structure, protein structure prediction and engineering, introduction to proteomics: DNA microarrays, mass spectrometry and systems biology.

Unit IV: Archives and information retrieval: Database indexing and specification of searching terms, the archives: some of the important biological databases (Nucleic acid, Genome and protein sequence), gateways to archives: access to databases in molecular biology

Unit V: Future of Bioinformatics: Emerging areas in Bioinformatics: Big data in biology, Systems and synthetic biology, personalized medicine.

Textbooks

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Suggested Readings

1. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
2. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
3. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
4. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

LI 307: Molecular Biology **L3- T0- P-0- CR3**

Course outcome

CO1: Ability to understand the molecular basis of various biological processes.
CO2: Ability to understand three fundamental aspects in biological phenomenon: The central dogma
CO3: Ability to understand the molecular basis of life.

Course content

Unit I: Nucleic acid structure and function: Introduction to molecular biology, chemical nature of the genetic material: Avery et al experiment; Hershey and Chase experiment; Structure of DNA and RNA: DNA double helix; Base pairings in DNA, A, B and Z DNA, RNA secondary structures

Unit II: DNA to Chromosome: Introduction to genomes of bacteria, eukaryotes, organelle and viruses: linear and circular chromosomes, single stranded and doubles stranded DNA/RNA viral genome, Organization DNA into chromosomes: DNase I sensitive regions, heterochromatin and euchromatin, DNA methylation (e.g. X chromosome inactivation)

Unit III: Replication and repair: DNA replication: Chemistry of replication, DNA polymerases, synthesis of leading and lagging strands Errors in DNA and repair: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; photolyase; mismatch, base excision and nucleotide-excision repair mechanisms, SOS response.

Unit IV: Recombination: Homologous recombination, site specific recombination, transposition

Unit V: Transcription: Prokaryotic transcription: RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent), Eukaryotic transcription: types of RNA polymerases, promoters and enhancers, transcription factors, TBP and TAFs, RNA modification and processing

Unit VI: Translation: Translation in prokaryotes and eukaryotes: Ribosome, tRNA, amino-acyl tRNA synthetases, genetic code, translation-initiation, elongation, termination and ribosome recycling,

Unit VII: Regulation of gene expression in prokaryotes: Transcriptional regulation in bacteria: regulation of lac and trp operons in bacteria, regulation by sigma factors, anti-sigma factors, anti-sense RNA, two component regulatory system in bacteria,

Unit VIII: **Regulation of gene expression in eukaryotes**: Concept of eukaryotic gene regulation, nucleosomes, chromatin structure remodeling, activation of transcription factors.

Textbooks:

1. Lewin's Genes XII by J. E. Krebs, E. S. Goldstein and S. T. Kilpatrick (Edn 12th 2017) (Alternatively, Lewin's Gene X and Lewin's
2. Genex XII by same authors)
3. Molecular Biology of the Gene by J. D. Watson, T.A. Baker, S.P. Bell, Gann, M. Levine and R. Losick (Edn 6th 2007).

Suggested Readings

1. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, D, Morgan Molecular Biology of the Cell (Edn 6th, 2014).

LI 309 Biology lab VI (Physiology) **L0-T0-P3-CR3**

Course outcome

CO1: Ability to do experiments related to various physiological processes in plants and animals.
CO2: *Ability to do blood cell counting, seed metabolism, and characterization of body fluids.*

Course content

1. Seed germination (under light and dark condition; under different chemicals).
2. Seed exudates characterization with respect to protein, carbohydrate and polyphenol during seed imbibitions.
3. Starch hydrolysis in germinating seed.
4. Plant nutrition.
5. Haematological experiments: Preparation and staining of blood film with Leishman's stain.
6. Identification of blood corpuscles. Differential count of WBC. Total count of RBC and
7. WBC. Blood grouping (ABO and Rh). Clotting time.
8. Study and identification of permanent slides of different human tissues.
9. Estimation of Glucose, Protein, blood & bile in urine.

Practical books

1. Dr. P S Verma A Manual of Practical Zoology: Invertebrates, ISBN: 9788121908290
2. Dr. P.S.Verma A Manual of Practical Zoology : Chordates. ISBN 9788121908306

LI 311 Biology lab VII (Molecular Biology) **L0-T0-P3-CR3**

Course outcome

CO1: Ability to perform experiments related to molecular biology.

CO2: *Ability to isolation of vectors and cloning of gene into vectors for protein expression and purification.*

Course content

1. Study of hyperchromic and hypochromic effect in DNA by spectrophotometry
2. Study of chromatin organization
3. Plasmid DNA isolation and agarose gel electrophoresis
4. Restriction mapping of plasmid DNA
5. Competent cell preparation 6. Transformation of plasmid to competent cells
6. Blue-white screening of transformed cells.

Practical books

1. Microbiology Laboratory Manual, 5th Edition, James G. Cappucciino and Natalie Sherman
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis

LI 313 Public Health and Hygiene **L3-T0-P0-CR 3**

Course outcome

CO1: Ability know various aspects of human health.
CO2: Ability to identify foods related to health and hygiene in human.
CO3: Ability to identify the signs and symptoms of various human diseases

Course content

Unit I: Social Aspects of Health: Health Determinants and Standards (individual health parameters, key health indicators); Health status in India and disease burdens; Challenges in public health; Biosafety and Biosecurity.

Unit II: Basics in human Anatomy and Physiology: Fundamental Concepts-Integumentary system; Skeletal system; Digestive system; Nervous system; Visual system; Respiratory system; Urinary system; Reproductive system.

Unit III: Nutrition and Health: Concept of food and nutrition; Balanced diet; Vitamins; Malnutrition; Deficiency diseases; Determining caloric intake and expenditure; Obesity: causes and preventing measures – role of diet and exercise.

Unit IV: Communicable diseases: Background and definition of communicable diseases; Epidemiology; Agents and vectors of communicable diseases; Vector borne diseases, Few common communicable diseases-TB, AIDS/HIV, Malaria, Hepatitis etc.

Unit V: Non-communicable diseases: Background and definition of non-communicable diseases; Genetic disorders- monogenic/Mendelian disorders (eye disease, respiratory diseases, kidney disorders, etc.); Multifactorial/Multigenic diseases/disorders, Metabolic disorders (Tay-Sachs disease, galactosemia, etc.; Life-style disorders (obesity, diabetes, hypertension, etc.).

Unit VI: Better health through disease management and hygiene: National programs/governmental initiatives related to prevention & eradication of communicable and non-communicable diseases; Universal immunization programmes;

Unit VII: Personnel hygiene: Food hygiene; Sanitation; Environmental hygiene; Some harmful drugs and their control; Multiple Drug resistance (MDR) and their Control; Stress management; Occupational health hazards (physical ,chemical and biological hazards); Management of health through exercise & yoga.

Textbooks:

1. P.K. Ray, Health, Hygiene and Nutrition - 3 Tiers of a Good Living: Know Your Health, Notion Press, 1st Edition, 2017, ISBN: 9781946822277
2. Benjamin A W., Hygiene and Public Health, Nabu Press, 2013. ISBN: 9781287915867

Suggested Readings

3. Bergey D. H., The Principles of Hygiene; A Practical Manual for Students, Physicians, and Health Officers, Hardpress Publishing, Edition: 2013, ISBN: 9781314537550.
4. Cherilyn T., Principles of Occupational Health & Hygiene, Viva Books Pvt Ltd., 2007. ISBN: 9781741750584.

Semester VI

LI 302 Immunology I **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to understand the basis of immunology.
CO 2: Ability to design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.

Course content

Unit I: Introduction: Basics of an immune response, discrimination between self and non-self, innate and acquired immune response, comparative immunity and evolution of immune system.

Unit II: Innate Immunity: Anatomic and Physiological Barriers, Inflammation, Toll receptors and PAMPs, DAMPs , Defensisns, and Complement system, NK Cells

Unit III: Cells, tissues and organs of the immune system: Haematopoeisis, cells of innate and adaptive immune system, organs of the immune system.

Unit IV: Antigen: Antigenicity vs immunogenicity, factors that influence immunogenicty, B and T cell epitopes, haptens.

Unit V: Immunoglobulins: Basic structure, Ig fold and domains, Classes and subclasses of Ig, Biological activities of Igs, B cell receptor, Antigenic determinants on immunoglobulin, Ig diversity -multigene organization of Ig genes, Class switching, Affinity maturation and somatic hypermutation, Monoclonal antibodies.

Unit VI: MHC and Antigen Presentation: General organisation and inheritance of the MHC, MHC molecules and genes, Cellular distribution of MHC molecules, Intracellular and extracellular antigen processing pathways.

Unit VII: Cytokines and cytokine receptors: Properties of cytokines, cytokine receptors, Cytokine signal transduction, cytokines secretion by Th1 and Th2 subsets and cross regulation

Unit VIII: T cell and B cell maturation and activation: Basics of T and B maturation, Self-MHC restriction of T and of B cells, T and B cell activation and differentiation. Effector T cells, cytotoxic T cells, NK cells, ADCC, and hypersensitivity.

Textbooks

1. Basic Immunology: Functions and Disorders of the Immune System, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai (Elseviers Saunders 4 th Edition).
2. Kuby Immunology, Thomas J. Kindt, Barbara A. Osborne, Richard A . Goldsby (W.H. Freeman Publishers, Sixth Edition).

Suggested Readings

1. Delves, P., Martin, S., Burton, D., Roitt, I. Roitt's Essential Immunology (WileyBlackwell, 11th Edition).

LI 304 Biocomputing & Biostatistics **L2- T0- P1- CR 3**

Course outcome

CO 1: Ability to apply the theory of probability and statistics in biological experiments.
CO 2: *Ability to write computer programming language.*

Course content

Unit I: Basics of biostatistics: Frequency Distributions and Statistical Measures: mean, mode, median, variance, standard deviation, coefficient of variation, measures of skewness and kurtosis

Unit II: Probability: Introduction to theory of Probability, Conditional Probability, Bayesian Rules, Random variable, Distributions of random variables, Binomial, Poisson Fundamental concepts in applied probability

Unit III: Data analysis: Exploratory data analysis and statistical inference, Chi-square test for independence, P-value and z-score of the statistic, statistical software and their use for data analysis.

Unit IV: Programming languages:
C language Introduction –Tokens –Keywords, Identifier, Variables, Constants, Operators – Expression–Data types, Conditional and Unconditional Control Statement–Looping Statement: while, do-while, for –nested loop, 2D and 3D Arrays.

(1) C: File handling in C, Modes for files, Functions used in files.
(2) String Handling: String declaration–String library functions –String Manipulation
(3) C++: Introduction and application of Object Oriented programming languages, Differences between C and C++, Different properties of C++, Inheritance, Polymorphism, Virtual Functions, Decision and Loops, Array, Functions.

Textbooks

1. Jhonson RA et al. (2015) Miller & freud's probability and statistics for engineers.
2. Ross S (2018) Introduction to probability and statistics for engineers and scientists.
3. Kamthane AN (2008) Programming with ANSI and Turbo C.
4. Kanethkar Y (2016) let us C.
5. Kernighan BW & Ritchie D (2015) The C Programming Language.

Suggested Readings

1. Object Oriented Programming with C++ by Balagurusamy Publisher: TMH; Sixth edition
2. Introduction to Java Programming by Y. Daniel Liang Publisher: Pearson; 10 edition
3. Fundamentals of Biostatistics by Bernard Rosner Publisher: Cengage Learning; 7 edition
4. Programming with Java by Balagurusamy Publisher: McGraw Hill Education (India)

LI 306: Developmental Biology **L3- T0- P0- CR3**

Course outcome

CO1: Ability to understand the molecular basis of development in animals and plants.
CO2: Ability to understand how multicellular organism develops from a single cell through differentiation and development in animal and plants.

Course content

Unit I: History of developmental biology: Historical perspective and different techniques in developmental biology, Model Organisms: An overview of model organisms Criterion of model organism. Key features of some model organisms.

Unit II: Developmental genetics: Developmental events and genetics: Genes in early development, control of gene expression and cell signalling, Early embryonic development: Gametogenesis, Fertilization, Cleavage I, Cleavage II, Gastrulation I, Gastrulation II.

Unit III: Patterning of body plan in model Invertebrate: Early pattern formation and laying of body axis planes, Axis formation and anterior/posterior patterning and dorsal/ventral patterning in Drosophila/C.elegans (maternal effect genes, segmentation, zygotic genes).

Unit IV: Patterning of body plan in model Vertebrate: Early embryogenesis: morula and blastula formation, early cell differentiation, Cell lineages and developmental controls, formation of germ layers, gastrulation, Axis formation and anterior/posterior patterning and dorsal/ventral patterning in zebra fish/mouse/human.

Unit V: Cell differentiation: Cell fate determination, Differentiation of Specialized Cells: Stem cell differentiation, tissue regeneration, morphogenesis, Cancer stem cells.

Unit VI: Plant Embryonic Development and Patterning: Embryogenesis in plant: Development of Male and Female Gametophyte. Embryogenesis. Axial and Radial patterning in plants. Developmental control genes in a model plant (*Arabidopsis*).

Unit VII : Plant Meristems and Differentiation: Organization of Shoot Apical Meristem (SAM) and Root Apical Meristems (RAM). Floral meristems and development. Leaf Ontogeny.

Unit VIII: Factors influencing Plant Development: Photomorphogenesis and Skotomorphogenesis. Role of Micro RNAs. Recent advances in apomixes and Self-incompatibility**.**

Textbooks

1. Scott F. Gilbert. Developmental Biology, (Sinauer Associates Inc; 10 edition (2013)
2. Lewis Wolpert. Principles of Development, (Oxford University Press, 5th edition, 2015)

Suggested Readings

1. Bruce Alberts et al, Molecular Biology of the Cell, (Garland Science; 6th edition, 2014).
2. Benjamin Lewin, Gene XII (Jones and Bartlett Publishers, 12th edition, 2017).
   James D. Watson et al., Molecular Biology of the gene (Pearson Prentice Hall, 6thedition, 2013).

LI 308: Analytical Techniques **L3- T1- P0- CR 4**

Course outcome

CO1: *Ability to understand the basic principles of the new technologies and other research tools.*
CO2: *Ability to apply the new technologies in solving complex biological questions in life-sciences.*

Course content

Unit I: Microscopy: Techniques Principles and application of electron microscopy, optical microscopy, phase contrast and fluorescence microscopy. Confocal microscopy, FRET, FRAP, TIRF.

Unit II: Spectroscopy: UV, Visible, Photoluminescence; and Raman Spectroscopy; Theory and application of Circular Dichroism; FTIR, MS, NMR, PMR, ESR and Plasma Emission spectroscopy.

Unit III: Chromatography: Techniques Principles of chromatography; TLC and Paper chromatography; Chromatographic methods for macromolecule separation – Gelpermeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC andFPLC; Criteria of protein purity, Ultrafiltration and other membrane techniques, dialysis.

Unit IV: Electrophoretic: Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary gel electrophoresis; 2D-gel Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis.

Unit V: Centrifugation: Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge -microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit VI: Radioactivity: Radioactive materials and Radiological techniques Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography; Measurement of stable isotopes. Use of radioactivity in biochemistry.

Unit VII: Protein crystallization: Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis, FACS.

Textbooks

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 1. 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th
3. Edition, Cambridge University Press, 2000. 4. D. Holme& H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

Suggested Readings

1. Molecular and Cell Biology (Schaum's Outlines series special Indian edition) by W. D. Stansfield, J. S.C. Colome, R. J. Cano and R. N. Sharan (2010), McGraw Hill Education.
2. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

Semester VII

LI 401: Biochemistry II **L3- T0- P0- CR3**

Course outcome

CO1: Ability to understand the chemistry of biomolecules and metabolism.
CO2: *Ability to identify biomolecules such as carbohydrates, lipids. proteins and nucleic acids. Role of enzymes and vitamins in biochemical reaction.*

Course content

Unit I: Metabolism: Basic concept and function of metabolism, metabolic pathways, regulation of metabolism.

Unit II: Enzyme: Enzyme nomenclature, unique features of enzyme catalysis, concept of enzyme – substrate complex, thermodynamic principles – effect of catalyst on activation energy; enzyme kinetics, significance of Km/Kcat, allosteric enzymes, enzyme regulation-feedbackregulation, covalent and non-covalent mechanisms of enzyme regulation; coenzymes. Isolation and purification of enzymes. Methods of enzyme isolation and purification, determination of molecular mass and purity of enzymes; some examples of industrial application of enzymes

Unit III: Biochemistry of polypeptide and steroid hormones: Hormones and hormonal cascade system, structure, biosynthesis, hormone-receptor interaction and regulation

Unit IV: Carbohydrate metabolism and biological oxidation: Glycolysis and citric acid cycle, glyoxalate cycle, gluconeogenesis,Calvin cycle, pentose phosphate pathwayand glycogen metabolism; oxidoreductases, redox potential, electron transport chain, oxidativephosphorylation and photophosphorylation;-Diseases related to impaired carbohydrare metabolism

Unit V: Lipid metabolism: Metabolism of fatty acids, ketone bodies – formation and utilization, biosynthesis of cholesterol. Diseases related to impaired lipid metabolism

Unit VI: Protein metabolism: Pathways of amino acid metabolism, transamination, transdeamination and deamination; Biosynthesis. Diseases related to impaired protein metabolism

Unit VII: Nucleic acid metabolism: Synthesis and degradation of nucleotides; metabolism of purines and pyrimidines. Diseases related to impaired nucleic acid metabolism

Textbooks

1. Stryer L. (2007) Biochemistry, W.H.Freeman.
2. Voet D and VoetJ.G.,. Fundamentals of Biochemistry (John Wiley and Sons, 2004).
3. Nelson D.L. and Cox M.M. (2017) Lehninger's Principles of Biochemistry, Freeman & Co, New York.
4. Thomas M Devlin(2010) Text of Biochemistry with Clinical Correlations, Wiley-Liss

Reference books

1. Zubay G. (1999) Biochemistry, 4th Ed., Win C. Brown Comm.,lnc.
2. Devlin, T.M., Text book of Biochemistry (John. Wiley and Sons. 2002).

LI 403: Molecular Genetics **L3 -T0- P0- CR3**

Course outcome

CO 1: Ability to understand the basis of recombinant DNA technology.
CO 2: *Ability to perform PCR, analysis of gene polymorphisms, tools to modify genes.*

Course content

Unit I: Fundamentals of molecular genetics: Background, definition, scope and applications. Introduction to biomolecules - DNA, RNA, proteins, cell precursors- carbohydrates and lipids.

Unit II: Molecular events leading to variations: Origin of mutants, nomenclature, types of mutations, mutation at the level of DNA, gene, organism, isolation (Ames test), forward and reverse mutations, mutation rate, Applications of mutant organisms.

Unit III: Recombinant DNA technology: Polymerizations including polymerase chain reaction (PCR) and other types (Multiplex, LAMP, RT, Real time), polymerase enzymes, restriction endo/exo-nuclease enzymes, ligases; cloning vectors (Prokaryotic, Eukaryotic, Shuttle), functional complementation, transposon tagging, subtractive hybridization, marker assisted cloning, cDNA and genomic libraries.

Unit IV: Identification and assessment of variations: Restriction fragment length polymorphism (RFLP), Single strand polymorphism (SSCP), Denaturing high performance liquid chromatography (DHPLC), Random amplification of polymorphic DNA (RAPD), DNA sequencing-conventional method, Sanger's method, Next generation sequencing.

Unit V: Human, plant and microbial molecular genetics: Nomenclature of human genes and mutations, Phenotype, Genotype, Pedigree analysis- construction and analysis of monogenic diseases/disorders (Autosomal-dominant and recessive, X linked-dominant and recessive, Mitochondrial, multifactorial inheritance/complex traits, SNPs-Types & application, Y chromosome, Fluorescence In-Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH), Linkage analysis, GWAS.

Unit VI: Sequencing of genomes of different organisms: Inception, major milestones, accomplishments, challenges (ELSI), applications in modern medicine.

Unit VII: Genome editing approaches: Homologous Recombination, RNAi technique, Site specific nucleases- Cas9-CRISPR, TALENS, Zn-Finger protein. Conditional knockout-Cre-Lox p mechanism, Knock-in, Animal models for human diseases.

Unit VIII: Evolution at molecular level in population: Gene frequency; Hardy Weinberg law; Factors influencing Hardy Weinberg equilibrium-Mutation, Selection, Migration, Gene flow, Genetic drift; Human genetic diversity, Origin of major human groups.

Texts Books:

1. Kothari, M. L., Essentials of Human Genetics, 5th Edition, Orient Black Swan Publisher, 2008. ISBN: 978-8173716478.
2. Strachan, T and Read, A. P, Human molecular genetics, 4th Edition, Garland Publishing, 2010. ISBN-13: 978-0815341499.
3. Tamarin R H. Principles of Genetics, 7th Edition, McGraw Higher Ed Publishers, 2010. ISBN: 9780070486676.

Reference Books

1. Edward S. T. Michael. C, M. F. Smith, Essential medical genetics, 6th Edition, Wiley-Blackwell publications, 2011. ISBN: 978-1405169745.2.
2. John P, Redesigning Life: How genome editing will transform the world, 1st Edition, Oxford

University Press, 2016. ISBN-13: 978-0198766827.
3. Susan Elrod, Schaum's Outline of Genetics, 5th Edition (Schaums Outline Series), McGraw Hill Education, 2010. ISBN-13: 978-0071625036

LI 405: Immunology II **L3 -T0- P0-CR3**

Course outcome

CO1: Ability to understand immune system and immunological disease in human.
CO2: Ability to develop skills for vaccine and antibody development
CO3: *Ability to use tools for studying autoimmune disease, cancer immunity, and immunogenetics*

Course content

Unit I: Vaccinology: Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines.

Unit II: Antibody: Antibody genes and antibody engineering: chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit III: Clinical immunology: Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy;

Unit IV: Tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies,

Unit V: Autoimmune: autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI: Immunogenetics: Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations,

Unit VII: Genetic diseases: genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Textbooks:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York:
2. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press.

Suggested Readings

1. W.H. Freeman. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology.* London: Gower Medical Pub.
2. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology*. New York: Garland Science.
3. Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology*. London: Academic Press.
4. Parham, P. (2005). *The Immune System*. New York: Garland Science.

LI 407: Biological Database Management System **L3 -T0-P0 CR3**

Course outcome

CO1: Ability to generate data, data management concepts, data mining strategies and their effective utilization using computational tools.

CO2: *Ability to comprehend the aspects of data integration, data Management, data mining for defined applications.*

Course content

Unit I: Introduction: Database -System Applications- Purpose of Database Systems, View of Data, Database Languages, introduction to Relational Databases, Database Design, Data Storage and Querying, Transaction Management, Database Architecture, Database Users and Administrators, History of Database Systems.

Unit II: Database design and E-R model: Overview of the Design Process, The Entity-Relationship Model, Constraints, Removing Redundant Attributes in Entity Sets, Entity-Relationship Diagrams, Reduction to Relational Schemas, Entity-Relationship Design Issues, Extended ER Features, Alternative Notations for Modeling Data, Other Aspects of Database Design.

Unit III: Relational model and design techniques: Introduction to the Relational model: Structure of Relational Databases, Codd's 12 rule, Database Schema, Keys, Schema Diagrams, Relational Query Languages, Relational Operations. Relational Database Design: Features of Good Relational Designs, Atomic Domains and First Normal Form, Decomposition Using Functional Dependencies, Functional-Dependency Theory, Algorithms for Decomposition, Decomposition Using Multivalued Dependencies, More Normal Forms, Database- Design Process, Modeling Temporal Data.

Unit IV: Structure and Language: Overview of the SQL Query Language, SQL Data Definition, Basic Structure of SQL Queries, Additional Basic Operations, Set Operations, Null Values, Aggregate Functions, Nested Subqueries, Modification of the Database.

Unit V: Biological database management: Introduction to Biological Data Integration - specifications. -Challenges Faced in the Integration of Biological Information: -Nature of Biological data,- Data sources in Life Sciences, -Challenges in information integration-. Data management in Bioinformatics, Dimensions -Describing the Space of Integration Solutions.

Unit VI: Types of Biological Databases: Microbiological Databases, Virological Databases, Organism Databases, Primary Sequence Databases, Carbohydrate Databases, RNA databases, Biodiversity, Sequence Database (Nucleotide and Protein Sequence DB), Structural Databases, Gen bank sequence database, submitting sequences to database: NCBI, EMBL, PDB etc.

Textbooks

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, 6th Edition, 2011.
2. Date C.J, "An Introduction to Database", Addison-Wesley Pub Co, 7th Edition, 2001
3. Elmashri & Navathe, "Fundamentals of Database System", Addison-Wesley Publishing, 3rd Edition, 2000

Suggested Reading

4. Raghu Ramakrishnan, Johannes Gehrke, "Database Management System", McGraw Hill, 3rd Edition 2003
5. Jeffrey D. Ullman, Jennifer Widom, "A First Course in Database System", Prentice Hall, AWL 1st Edition, 2001

6. Peter Rob, Carlos Coronel, “Database Systems - Design, Implementation, and Management”, 4th Edition, Thomson Learning, 2001.
7. Zoe Lacroix, Terence Critchlow,” Bioinformatics: Managing Scientific Data”, Morgan Kaufmann Publishers (Elsevier Science), 2003

LI 409: Cell Biology II **L3 -T0-P0- CR3**

Course outcome

CO1: Ability to understand the basic of cellular interaction with the environment and intracellular signaling and their relation in the understanding of various biological processes.

CO2: *Ability to understand cellular aspects of cancer biology and other cellular biological processes*

Course content

Unit I: Techniques in Cell Biology: Advanced Microscopy: Confocal and immunofluorescence microscopy, FISH. Scanning and transmission microscopes, fixation and staining techniques for EM. Techniques for detection of Cancer.

Unit II: Cancer Biology: Cell Cycle disregulation and cancer. Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, virus-induced cancer, metastasis. Therapeutics for Cancer

Unit III: Interaction of the cell with its environment: General principles of cell communication: cell-cell communications, cell-environment communications. Role of different adhesion molecules: Desmosomes, Hemi-desmosomes, Gap junctions, Tight Junctions, Plasmodesmata. Organelle Interconnectivity and communications.

Unit IV: Cell Organelles: Energy utilization in cells. Mitochondria: Structure, function and its role in aerobic respiration. Chloroplast: Structure and function. Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Organelle Interconnectivity and communication of Mitochondria with the endomembrane system.

Unit V: Cell signaling: Bacterial two component system. Plant two component system. Bacterial chemotaxis and quorum sensing. Cytokine signaling. Signaling pathways in Apoptosis. Signal transduction associated with Cancer.

Textbooks:

1. Karp G., Cell and Molecular Biology: Concepts and Experiments, 7th Edition (John Wiley & Sons, Inc., 2013).
2. Scott, M. P. et al, Molecular Cell Biology, 6th Edition (W. H. Freeman, 2007).
3. Alberts, B. et al., Molecular Biology of the Cell, 5th Edition (Garland Publishing, 2008).

Reference Books:

4. Pecorino, Lauren. Molecular biology of cancer: mechanisms, targets, and therapeutics. 4th Edition (Oxford university press, 2012.)

LI 411: Biology Lab VIII (Biochemistry) **L0-T0-P3- CR3**

Course outcome

CO1: Ability to use methods in biochemistry in a problem oriented manner
CO2: *Ability to elaborate the concepts of biochemistry with easy to run experiments*

Course content

1. Purification and characterization of an enzyme from a natural/recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
    a) Preparation of cell-free lysates
    b) Ammonium Sulfate precipitation
    c) Ion-exchange/ Gel Filtration / Affinity Chromatography
    d) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
    e) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
    f) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis Enzyme Kinetic Parameters: Km, Vmax and Kcat.

Practical book

1. An introduction to practical biochemistry, 3rd edition by David T Plummer

LI 413 Biology Lab –IX (Immunology) **L0 -T0- P3 CR3**

Course outcome

CO1: Ability to identify tools and techniques used to study immune system as well as their function.
CO2: *Ability to evaluate the usefulness of immunology in different pharmaceutical companies*

Course content

1. Blood film preparation and identification of leucocytes by Giemsa stain.
   b. Antibody titre by ELISA method.
   c. Ouchterlony's double diffusion assay
   d. Immunoelectrophoresis and radial immune diffusion.
   e. SDS-PAGE and immune blotting.
   f. Immunodiagnostics using commercial kits.
   g. Enzyme linked immunosorbent assay (DOT-ELISA)

Practical books

1. Practical Immunology, 4th Edition Frank C. Hay, Olwyn M. R. Westwood Wiley-Blackwell, ISBN: 978-0-86542-961-1.
2. Molecular Cloning A Laboratory Manual 1 3rd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.
3. Molecular Cloning A Laboratory Manual 2 2nd Edition, J. Sambrook, E.F Fristsch and T. Maniatis.

Semester VIII

LI 402 Biophysics & Structural Biology **L3-T0-P0-CR3**

Course outcome

CO1: Ability to use structural biology and biophysical techniques to understand the biology of macromolecules at the level of 3D-structure.
CO2: Ability to apply biophysical and computational tools for drug designing.

Course content

Unit I: Introduction to Macromolecular Structure: Proteins: Primary Structure, Secondary Structure, Domain, Motif, Super secondary structure, Tertiary Structure, Quaternary Structure; Nucleic Acids: DNA polymorphism (A, B, Z forms) structure, helix parameters RNA secondary and tertiary structures.

Unit II: Structure determination of biomolecules: Introduction to atomic structures of proteins and nucleic acids, structure determination using different techniques such as X-ray crystallography, NMR and cryogenic electron microscopy

Unit III: Force Fields: Introduction to Force Fields and its components, Energy Minimization methods, Bonded and Non-bonded terms, Topological parameters,

Unit IV: Molecular Dynamics: Basic Theory, Introduction to the Molecular Dynamics and Monte Carlo simulation, software packages (AMBER & GROMACS), Applications of Molecular Dynamics in Protein folding and unfolding, Stability of drug/receptor complexes

Unit V: Structure-Based Drug Design (SBDD): Introduction to QSAR, Simple Structure Activity Relationships, Drug action and interactions with receptors

Textbooks

1. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
2. Jenny Gu and Philip E Bourne. Structural Bioinformatics, 2nd Edition 2009.
3. Stephen Neidle. Principle of nucleic acid structure. 2007.

LI404: Genetic Engineering **L3- T0-P0-CR3**

Course outcome

CO1: Ability to use techniques associated with engineering of animals and plants using molecular biology and genetic engineering.
CO2: Ability to express recombinant protein and characterize.
CO3: Ability to take up biotechnological research as well as placement in the relevant biotech industry.

Course content

Unit I: Introduction to genetic engineering: Brief history and overall impact of genetic engineering in modern society.

Unit II: Tools for genetic engineering experiments: restriction endonucleases, restriction mapping, restriction-modification methylases; DNA and RNA ligase,DNA ligation using: cohesive-ended and blunt-ended DNA fragments; linkers, adaptors; homopolymeric tailing, nucleic acids modifying enzymes;. Methods for protein-DNA, protein-RNA and protein-protein interactions (co-immunoprecipitation, pull-down assay, mammalian two-hybrid and yeast-two hybrid assay).

Unit III: Nucleic acid hybridisation methods: Radioactive and non-radioactive labelling of nucleic acids and proteins, southern, northern, western, south-western, far western, eastern, colony, fluorescence in situ hybridisation (FISH) and detection of chromosomal abnormalities.

Unit IV: Polymerase chain reaction and its application: Principles of PCR: primer design; fidelity of thermostable DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; site-specific mutagenesis *in vitro* and *in vivo*; methods of mutation detection (SSCP, DGGE, RFLP). PCR in molecular diagnostics (viral and bacterial detection).

Unit V: **Molecular vectors**: Plasmids; Bacteriophages; M13 vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Ti plasmid and Ri plasmid based vectors. Transformation, transduction and transfection methods.

Unit VI: DNA Libraries: Construction of cDNA and genomic DNA libraries; library screening methods.

Unit VII: Overexpression of recombinant protein: Expression vectors. Overexpression in bacteria system, Baculovirus, yeast and mammalian cells; Inclusion bodies formation and strategies to overcome; purification of recombinant proteins.

Unit VIII: Application of Genetic engineering: Gene silencing techniques: siRNA and miRNA construction of shRNA vectors; methods to generate transgenic animals and plants; DNA and protein microarrays genome editing technologies; ZFNs, TALEN, Cre-Lox and CRISPR/Cas9) system): Gene therapy.

Textbooks

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.

Suggested Reading:

1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

2. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science.
3. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

LI406: Applied Microbiology and Bioprocessing Engineering L3- T0- P0- CR3

Course outcome

CO1: Ability to identify industrially relevant microbe and use them various application
CO2: Ability to apply bioprocess engineering techniques for large scale production

Course content

Unit I: Kinetics of Substrate Utilization, Product Formation and Biomass Production in Cell Culture: Bioprocess Development an Interdisciplinary Challenges, Stoichiometry of microbial growth and chemical reaction and product formation. Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics ; Microbial growth in Batch culture, Specific growth rate, Monod equation, Growth in continuous culture, chemostat models, Turbidostate and Fed batch culture, Strain improvement for increased yield and other desirable characteristics.

Unit II: Energy and Material Balance in Bioprocess systems Energy and Material balance: System and process, steady state and equilibrium, Law of conservation of mass, Procedure for material balance calculation, calculation of hydraulic retention time of bioreactors.

Unit III: Transport Phenomena in Bioprocess systems :
Diffusion theory, Role of diffusion in bioprocessing, Film theory, Convective mass transfer: liquid solid mass transfer, liquid liquid mass transfer, Gas liquid mass transfer

Unit IV: Design of Biological Reactors , Scale up and Control:
Types of fermentation and fermenters; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization;

Unit V: **Upstream processing:**
Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Text books

1. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Butterworth Heinemann, 2nd Edition 2008. 2. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw- Hill
2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Pearson IN, 2015.
3. Pauline M Doran., Bioprocess Engineering Principles , 2nd Edition, Academic Press, 2016

Reference books

1. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo, 1973.
2. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.

LI 408: Computational Biology **L2-T0- P1- CR3**

Course outcome

CO 1: Ability use the knowledge of genomic, proteomic and metabolomics courses in drug design program.

CO 2: Ability to develop required database extraction, integration, coding for computational tools and methods necessary for all Omics

Course content

Unit I: Data search and Pair-wise Alignments: Dynamic Programming BLAST, FASTA.

Unit II: Algorithms: Multiple sequence alignments (CLUSTALW and CLUSTALX), Amino acid substitution matrix (BLOSUM, PAM), Nucleotide Substitution Patterns: Jukes Cantor Model, Kimura's model etc.

Unit III: **Phylogenetic Analysis:** Distance based methods and character based methods, Statistical approaches to Gene Prediction,

Unit IV: Molecular modeling: Protein structure prediction, *ab-initio*, Threading and Homology modeling, backbone construction and side chain addition; scoring method, evaluation

Unit V: Methods for comparison of 3D structure of proteins: Analysis and superimpose protein 3D structures, protein structure comparison

Unit VI: Docking of molecules: Protein-ligand interactions, Drug designing, buried and exposed residues; side chains and neighbors; fixed regions; hydrogen bonds; elements of *in silico* drug design; Virtual library.

Unit VII: Molecular interactions: Protein-protein, protein-DNA, protein-carbohydrate,
Unit VIII: Molecular Mechanics: Calculation of conformational energy for biomolecules, Molecular dynamics and quantum mechanics, Monte Carlo simulation,

Textbooks

1. Brown, T. A. *Genomes II* (2nd Edition, Wiley – Liss2002).
2. Primrose. *Principles of Genome Analysis and Genomics* (3rd Edition, Blackwell2003).
3. Baxevanis A. D *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, (Wiley-Interscience.2001).
4. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
5. Atkins and Friedman. Molecular quantum mechanics. Oxford University Press. 4th ed. 2005.
6. David C. Young. Computational Drug Design. A guide for Computational and Medicinal Chemists. Wiley. 2009

Suggested Reading

1. Krane, D. E,.Raymen, M. L. *Fundamental Concepts of Bioinformatics* (2002 Benjamin Cummings).
2. Mount, D. W. *Bioinformatics: Sequence and genome Analysis* (CHSL Press. 2001).
3. Bourne P. E. and Weissig, H. *Structural Bioinformatics* (2003, WILEY).
4. Ghosh Z. and Mallick B. *Bioinformatics Principles and Applications*, (Oxford University Press, (2010)

LI 410: Cell & Tissue Culture **L3-T0-P0- CR3**

Course outcome

CO1: Ability to perform plant and animal tissue culture experiments.
CO2: *Ability to generate explant from different plant parts. ill gain practical experience in doing plant tissue culture and animal tissue culture*
CO3: Ability to develop nurseries using tissue culture techniques

Course content

Unit I: Introduction: historical background, advantages and limitations of tissue culture, major differences in in vitro culture and types of tissue culture and the terminology, finite/infinite cell lines, immortalization of cells, genetic transitions in primary culture, monolayer cultures, immobilized cultures and suspension cultures.

Unit II: Techniques of plant tissue culture: media compositions, growth hormones and other organic compounds; gelling agents, culture environment, behavior of cells in culture conditions: division and growth pattern.

Unit III: **Techniques of animal cell culture**: Aseptic techniques, cell type, choice of materials - substrates-culture vessel/ treated surfaces, Development of media, physiochemical properties, complete media, serum, chemically defined basal and minimal essential media, serum and protein free media;

Unit IV: **Behaviour of animal cells in culture:** cell adhesion, cell proliferation, differentiation, energy metabolism. Initiation of culture, evolution of cell lines, development of continuous cell line and stem cells

Unit V: **Characterization, cell separation and maintenance of animal cell lines:** Cryopreservation, physical methods of cell separation, antibody based techniques, magnetic sorting, cell counting and cell proliferation. Common cell culture contaminants.

Unit VI: **Animal cell culture applications and products**: Cell products - antibodies and immuno-regulators, recombinant products, viral vaccines, cell and tissue therapy.

Unit VII: **Micro-propagation**: Techniques; multiplication by axillary buds and apical shoot; meristem, shoot tip and bud cultures; factors affecting micro-propagation; organogenesis- direct and indirect; somatic embryogenesis; elimination of viruses and other pathogen in plants. Somaclonal variation and production of disease free plants.

Unit VIII: **Haploid production**: Androgenesis; anther and pollen culture; factors affecting androgenesis; gynogenesis - ovary and ovulecultures; embryo culture and rescue.

Unit IX: **Protoplast culture and somatic hybridization**: Isolation, regeneration of protoplast; culture media and methods; cell wall formation, division and growth. Fusion of protoplasts and their culture; selection of hybrid cells and generation of hybrid plants and their characterization; symmetric and asymmetric hybrids; cybrids; applications and limitations of somatic hybridizations.

Unit X: Hardening, acclimatization and cultivation of tissue culture-derived plants: Exposure of tissue culture-derived plants to normal environment and their gradual acclimatization. Cultivation of the acclimatized plants in pots and filed.

Textbooks

1. Freshney R. I., Culture of Animal Cells, (5th Edition, Wiley-Liss, 2005).
2. Neumann K. H., Kumar A., Imani J. Plant Cell and Tissue Culture - A Tool in

Biotechnology: Basics and Application (Principles and Practice), (Springer; 1st edition 2009).
3. Satyanarayana U. Biotechnology, Books and Allied (P) Ltd.Kolkata

Suggested Readings

1. John R.W. Masters, Animal Cell Culture: Practical Approach, (3rd Edition, Oxford, 2000).
2. Clynes, M., Animal Cell Culture Techniques, 1st Edition, Springer, 1998.

LI412: Biology lab X (Genetic Engineering) **L0- T0- P3 CR3**

Course outcome

CO1: Ability to perform molecular biology techniques & genetic engineering.

CO2: *Ability to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.*

Course content

1. Amplification of gene of interest by Polymerase Chain Reaction and analysis by agarose gel electrophoresis
2. Restriction digestion of insert and vector; Ligation of digested insert and vector
3. Confirmation of the insert by Colony PCR and Restriction mapping
4. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli*, SDS-PAGE analysis
5. Purification of His-Tagged protein on Ni-NTA columns

Practical Book:

1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

LI 414: Biology lab XI (Applied Microbiology) **L0- T0- P3- CR3**

Course outcome

CO1: Ability to investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.
CO2: Ability in solving problems typical of bio industries and research.

Course content

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
6. Purification of amylase/protease/cellulase enzymes from microbes.
7. Comparative studies of Ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.

Semester IX

LI 501: Genomics and Proteomics **L3- T0- P0- CR3**

Course outcome

CO1: Ability to use the knowledge of genomics& proteomics in understanding biological systems.
CO2: Ability to apply the principles of genomics and proteomics, transcriptomics and metabolomics in various applied areas of biology.

Course content

Unit I: Basics of genomics and proteomics: Brief overview of prokaryotic and eukaryotic genome organization; transposons; telomeres; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast genome.

Unit II: Genome mapping: Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, comparative gene mapping.

Unit III: Genome sequencing techniques and genome sequencing projects: Sanger vs NGS; whole genome shotgun vs clone contig method of genome sequencing; contig assembly; genome sequencing projects for microbes (*Haemophilus influenzae*); Human Genome Project; genome annotation; databases of genomes; accessing and retrieving genome project information from the web.

Unit IV: Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; metagenomics; use of genomes to understand evolution of eukaryotes, track emerging diseases and; design new drugs (pharmacogenomics).

Unit V: Proteomics: Aims, strategies and challenges in proteomics; proteomics technologies: isoelectric focusing and 2D-PAGE, mass spectrometry (MALDI-TOF, and ESI-MS/MS), yeast 2-hybrid system, proteome databases; protein sequence alignments (local and global); quantitative proteomics.

Unit VI: **Functional genomics and proteomics**: Transcriptome analysis for identification and functional annotation of genes, RNAseq, mining functional genes in genome, gene function-forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics,

Unit VII: System Biology: Introduction and history of systems biology (including some examples), OMICs and Big data in biology, systems medicine.

Textbooks:

1. Brown T.A., Genomes 4, 4th Edition. Garland Science 2017.
2. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub. 2006.

Suggested Readings

2. Campbell, A. M., & Heyer, L. J., Discovering Genomics, Proteomics, and Bioinformatics. 2nd Edition. San Francisco: Benjamin Cummings 2006.

LI 503: Bioinformatics software and Algorithms **L3- T0- P0- CR3**

Course outcome

CO1: Ability to develop bioinformatics algorithms
CO2: Ability to develop biological problem specific algorithms.

Course content

Unit I: Computational Models: Introduction, Random Access Machine, Turing machine, circuit model, Parallel Random Access Machine, Bulk Synchronous Parallel model

Unit II: Basic Data Structures: Array, linked list, stack, Queue, set graph, tree and priority Queue.

Unit III: Introduction to Algorithms: Algorithms and Complexity: Biological algorithms versus computer algorithms, upper bound of polynomial form of time complexity, solution of some common recurrence relations, homogeneous and inhomogeneous recurrences, change of variable, generating functions, amortization

Unit IV: Types of Algorithms: correct versus incorrect algorithms, Fast versus slow algorithms, Simple Algorithms

Unit V: Testing and Efficiency of Algorithms: Analyzing Algorithms and Asymptotic Notations

Unit VI: Algorithm Design Techniques: Design Methods and applications: divide and conquer, Greedy Method, dynamic programming, Approximation algorithms, Randomized algorithms, Graph algorithms, Backtracking, branch and bound, lower bound techniques, genetic algorithms and parallel algorithms

Unit-VII: Bioinformatics Algorithms: Introduction, Computer and biological algorithms, matching algorithms: exact string matching algorithms, approximate string matching, comparing biological sequences, protein identification problem

Unit VIII: NP-Completeness: Easy and hard problems, Polynomial time, Hamiltonian cycles, non-deterministic polynomial time, problem reduction, NP-Complete problems and approximation algorithms.

Textbooks

1. Basu, S.K., Design Methods and Analysis of Algorithms (Prentice Hall of India (Pvt) Ltd, New Delhi. 2005).
2. Baxevanis A. D Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, (Wiley-Interscience.2001).

Suggested Readings

1. Krane, D. E.,Raymen, M. L. Fundamental Concepts of Bioinformatics (2002 Benjamin Cummings).
2. Mount, D. W. Bioinformatics: Sequence and genome Analysis (CHSL Press. 2001).
3. Bourne P. E. and Weissig, H. Structural Bioinformatics (2003, WILEY).
4. Ghosh Z. and Mallick B. Bioinformatics Principles and Applications, (Oxford University Press, 2010).

LI 505 Lab on advanced programming **L0 -T0 P2- CR2**

Course outcome

CO 1: Ability to use computer programming languages and algorithm.
CO 2: Ability to develop programmes using Unix, Perl, R studio and development of algorithm.

Course content

1. Unix

a. UNIX shell, I/O redirection- stdin, stdout, and stderr.
b. Introduction to text editors in unix.
c. Making interactive scripts and running external codes from unix shell.
d. Running codes in remote servers from local terminal.
e. Basic concept of job scheduling in High Performance Computing clusters.
f. Processes management in Unix
g. Variables (default variables), Mathematical expressions; conditional statements, regular expression & filters in UNIX

2. Perl

a. Getting and Installing Perl.
b. Writing Perl Programs.
c. Perl programming and applications to Bioinformatics.
d. Basic scripting in Perl, Regular expressions, File i/o & control statement, Subroutines & functions, Writing scripts for automation.

3. R

a. Introduction to R, The RStudio interface to R, R Package Repositories, Installation of R Packages.
b. Basic Syntax, Data Types, Data Objects, Object types in R.
c. Subsetting of data objects, Combining Objects (cbind, rbind), Merging Data Frames, Filtering Data, Operators and Calculations, Reading and Writing External Data**,** Control Structures, Operators-Comparison operators in R.
d. Using in-built functions in R for Statistical testing, manipulating data; executing bioinformatics data analysis workflows in R; Graphics in R.

Textbooks

1. Vince Buffalo (Author), "Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools", O'Reilly Media, 1st edition (1 July 2015)
2. Robert Gentleman, "R Programming for Bioinformatics", Chapman and Hall/CRC, July 14, 2008
3. William N. Venables, David M. Smith , "An Introduction to R", [https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf]
4. James Tisdall, "Beginning Perl for Bioinformatics An Introduction to Perl for Biologists", Publisher: O'Reilly Media

Suggested Readings

1. http://www.unix.org/what_is_unix.html
2. UNIX / Linux Tutorial - https://www.tutorialspoint.com/unix/index.htm
3. R: The R Project for Statistical Computing - https://www.r-project.org/
4. The Shell Scripting Tutorial https://www.shellscript.sh/
5. R Introduction | R Tutorial- http://www.r-tutor.com/r-introduction
6. R Tutorial for beginners - https://www.statmethods.net/r-tutorial/index.html
7. Bioconductor - https://www.bioconductor.org/
8. RStudio- https://www.rstudio.com/
9. The Perl Programming Language - www.perl.org

LI 507: Biosafety and IPR **L3-T0-P0-CR3**

Course outcome

CO1: Ability to establish the intellectual property rights of any material.
CO2: Ability to protect products derived from biotechnology research and issues related to application and obtaining patents.
CO3: Ability to assess the risk of products derived from recombinant DNA research.
CO4: Ability to release genetically modified organisms in the environment as per the guidelines.
CO5: Ability to compile as per the national and international regulations related to biological, biomedical, health care and biotechnology research

Course content

Unit I: Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

Unit II: Biosafety guidelines: Government of India biosafety guidelines; Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis: Risk Assessment; Risk management and communication.

Unit III: **Biosafety regulations**: Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

Unit IV: Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Unit V: Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & amendment rules 2016

Unit VI: Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"

Unit VII: Patents database and filling: Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENT Scope(WIPO), IPO, etc.) Patent filing procedures**:** National & PCT filing procedure; Time frame and cost;Status of the patent applications filed; Precautions while patenting –Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement meaning, scope, litigation, case studies

Text books

1. BAREACT, *Indian Patent Act 1970 Acts & Rules*, (Universal Law Publishing Co. Pvt.Ltd., 2007).
2. Kankanala C., *Genetic Patent Law & Strategy*, (1st Edition, Manupatra Information Solution Pvt. Ltd., 2007).

Important Links:

1. http://www.w3.org/IPR/
2. http://www.wipo.int/portal/index.html.en
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in
5. www.iprlawindia.org/ - 31k - Cached - Similar page
6. http://www.cbd.int/biosafety/background.shtml

Option I

LI 509: Plant Biotechnology **L3-T0-P0-CR3**

Course outcome

CO1: Ability to perform plant tissue culture, plant genomics, genetic transformation and molecular breeding of plants.

CO2: Ability to manipulate plant using recombinant tools.

Course content

Unit I: Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; tissue culture media- nutrients and plant hormones, sterilization techniques; initiation and maintenance of callus and suspension cultures; single cell clones, applications of tissue cultures micropropagation.

Unit II: **Somaclonal variation**: Androgenesis and embryogenesis, their applications. Protoplast culture and somatic hybridization - isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Synthetic seed production

Unit III: Genetic engineering: *Agrobacterium*-plant interaction; Ti and Ri plasmids: disarmed Ti plasmid, opines and their significance; Molecular mechanism of T-DNA transfer; Genetic transformation - *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; screenable and selectable markers; characterization of transgenic plants.

Unit V: Other methods of gene transfer into plants: Direct gene transfer - PEG-mediated, electroporation, particle bombardment, alternative methods, chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing (ZFN, CRISPR/Cas, TALEN)

Unit VI: Application of transgenics: Insect resistance, virus resistance, abiotic stress tolerance, longer shelf life (including strategies for suppression of endogenous genes), male sterility, enhanced nutrition (golden rice), edible vaccines, phytoremediation, synthetic biology- production of biochemicals for healthcare (Phytopharmaceuticals) and industry

Unit VII: Omics technologies: Genomics, Transriptomics, Metablomics; genome sequencing strategies, Bioinformatics tools and genome annotation, forward and reverse genetic strategies; gene, promoter and enhancer traps for gene discovery, differential gene expression analysis-microarray and RNAseq. VIGS and RNAi.

Textbooks

1. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
2. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.

Suggested Readings

1. Umesha, S. (2013). *Plant Biotechnology.* The Energy And Resources.
2. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.

LI 511 Economic Botany **L3- T0- P0- CR3**

Course outcome

CO 1: Ability to identify economically important plants, plant part.
CO 2: Ability to identify the required habitat of economically important plant and conserve.
CO 3: *Ability to use biotechnological approaches for production of disease free plants in line with biosafety concerns*

Course content

Unit I: Biosystematics: Concepts of biosystematics, evolution and differentiation of species; Biosystematic and taxonomic tools; Origin, evolution and biosystematics of selected crops (rice, wheat, rape seed & mustard, cotton).

Unit II: Economically important plants –I: Origin, history, domestication, botany, genetic resource activities, cultivation, production and use of selected Cereals (Wheat, rice and millets), Pulses (Pigeon pea, chickpea, soyabean, pea, lentil, French bean). Oilseeds: Groundnut, sesame, rape seed, mustard, sunflower, coconut).

Unit II: Economically important plants –II: Origin, distribution, cultivation, production and utilization of economic plants of following groups such as Fibres: cotton, silk cotton, jute etc; Sugars: sugarcane, sugarbeet, sugarpalm; Fodders and green manure crops: Plantation crops: coconut, cocoa, tea; root and tuber crops-: potato, sweet potato, tapioca, aroids etc.

Unit IV: Economically important plants –III: Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other indigenous fruits; apple, plum, pear, peach, cashewnut and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc.; Fumigatories and masticatories: tobacco, betelvine, areacanut; medicinal and aromatic plants: sarpagandha, belladonna, cinchona, nux-vomica, vinca, mentha and glycirrhiza, plantago etc.; Narcotics: cannabis, datura, gloriosa, pyrethrum and opium; Dye-, tannin-, gum- and resin- yielding plants; Plant of agro-forestory importance: multipurpose trees/shrubs, subabool, Acacia nilotica, poplar, sesbania, neem etc.; non-traditional economic plants: jojoba, guayule, jatropha, carcus etc.

Unit V: Biodiversity and Plant Genetic Resources (PGR): Biosphere and biodiversity; plant species richness and endemism; concept and importance of plant genetic resources and its increasing erosion; Centres of origin and diversity of crop plants, domestication, evaluation, bioprospecting; National and International organizations associated with PGR; Convention on Biological Diversity (CBD), recent issues related to access and ownership of PGR, IPR,. PBRs, farmers rights, sui-generis system etc.

Unit VI: Biotechnology in Plant Genetic Resources: Plant conservation biotechnology, biotechnology in plant germplasm acquisition; plant tissue culture in disease elimination, in vitro conservation and exchange; cryopreservation, transgenics – exchange and biosafety issues; biochemical and molecular approaches to assessing plant diversity.

Textbooks

1. Economic Botany- A comprehensive study by S L Kochhar, Fifth Edition(2016), Cambridge University Press, UK
2. A Text Book of Economic Botany by V Verma, (2009)Anne Books Pvt Ltd, New Delhi
3. Economic Botany: Principles and Practices by G.E. Wickens (2012) Kluwer Academic Publishers, New York

LI 513 Biology Lab XII (Plant Sciences) **L0- T0- P8- CR4**

Course outcome

CO1: Ability to isolate DNA from plant materials and characterize.
CO2: Ability to isolate plant organelles.
CO3: *Ability to perform experiments related to physiological system of plants*

Course content

1. Isolation of DNA from different plant sample and quantification.
2. Restriction digestion of plant DNA, separation in agarose gel electrophoresis and visualization.
3. Demonstration of plant sample preparation for SEM and TEM and their visualization and interpretation.
4. Study of different stages of mitosis and meiosis.
5. Morphological study of some representative species of algae, fungi, bryophyte and pteridophyte.
6. Extraction of chloroplast pigments from plant leaves and preparation of absorption spectrum of chloroplast and Carotinoids.
7. Extraction of seed proteins depending upon solubility.
8. Effect of gravity, unilateral light and plant growth regulators on the growth of young seedling.

Practical Books

1. Methods in Plant Molecular Biology and Biotechnology 1st Edition, by Bernard R. Glick (Author), John E. Thompson (Author) ISBN-13: 978-0849351648, ISBN-10: 0849351642. CRC Press; 1 edition (June 24, 1993).
2. Experimental Plant Physiology, Lucy. E. Cox, BiblioBazaar, 2016, ISBN 1359170111, 9781359170118.

Option II

LI 515: Animal Biotechnology **L3 -T0- P0-CR 3**

Course outcome

CO1: Ability to apply the principles and practices of animal genomics, genetic transformation and molecular breeding of animals.

CO2: Ability to apply the application of animal biotechnology for improvement of animals

Course content

Unit I: Animal Cell Culture: Brief history of animal cell culture; Basic requirement for animal cell culture; Cell culture media, serum and reagents; Culture of mammalian cells; tissue and organs; Primary and secondary cell culture; Continuous cell lines; Suspension culture; Common cell culture contaminants; Application of animal cell culture for toxicity study and production of vaccines and pharmaceutical proteins; Stem cells and their application.

Unit II: Animal Reproductive Biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; cryopreservation of embryos; embryo transfer technology.

Unit III: Diagnostic methods: Radio immunoassays; Immunoblotting; nucleic acid probe hybridization; PCR, Real time PCR; Nucleic acid sequencing; Molecular diagnostics of pathogen in animals.

Unit IV: Vaccinology: History of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

Unit V: Animal genomics: Different methods of characterization of animal genomes; SNP, STR, QTLs, RFLP, AFLP, RAPD; Genetic basis for disease resistance in animals.

Unit VI: Model system for genetic disorder: Gene knock out technology and Animal models for human genetic disorders.

Unit VII: DNA forensics: Immunological and nucleic acid based methods for identification of animal species; detection of adulteration in meat using DNA based methods; identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts of the confiscated by anti poaching agencies; Human forensics; bio-terror agents; Bio-crimes and Bio-terrorism.

Textbooks

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
2. Glick, B.R., & Pasternak, J.J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.; ASM Press.
3. Pinkert, C. (2006). Transgenic Animal Technology, Academic Press.

Suggested Readings

1. Masters, John R.W. (2000). Animal Cell Culture – A Practical Approach, Oxford University Press.
2. Gordon, I. (2005). Reproductive Technologies in Farm Animals. Oxford. CAB International.

LI 517 Economic Zoology **L3- T0- P0- CR3**

Course outcome

CO1: Ability to appreciate the commercial and industrial significance/value of animals.
CO2: Ability to rear Bee and manage for honey production.
CO3: Ability for self employment through pisciculture, diary, silk worm and poultry

Course content

Unit I Insect pests and its economic importance: Common Pests of paddy, Sugarcane, Tea, vegetables and Fruits (Distribution, food plants, life-history, damage caused, prevention and control measures of the Insect pests to be dealt)

Unit II: Apiculture: Introduction, species of honey bees, social organisation and life history of honey bees; selection of bees for apiculture, methods of bee keeping (indigenous and modern methods), products of bee keeping (honey and bee wax), bee keeping as an industry.

Unit III: Fish and Fisheries: Culture fisheries: - Introduction to fish culture, types of cultivable species. Freshwater fish culture technique and management of fish culture farm, harvesting and marketing. Capture fisheries: - Commercially important fisheries of Assam. Fishing tools-crafts and gears. Preservation and processing of fish and fisheries.

Unit IV: Poultry: Introduction, habitat of fowl: food and feeding of fowls- breeds of fowls (indigenous and exotic breeds); eggs and hatching, rearing of chickens; poultry products (eggs and meat); by-products of poultry.

Unit V: Dairy industry: Introduction- breeds of dairy animals (cow, buffalo, goat); Milk: processing of milk, marketing and distribution of milk, milk products (Curd, cream, Butter, Ghee, khoya, cheese).

VI: Sericulture: Origin and history of Sericulture Industry in India with special reference to Assam. Introduction to different silkworms with special reference to Assam and brief account of their food plants. Different species of silkworm of Assam, their habit and habitat. Types of Cocoon and silk produced by them.

Textbooks:

1. Yadav Manju (2003). Economic Zoology, Discovery Publishing House.
4. Shukla and Upadhyaya (2002). Economic Zoology, Rastogi Publishers
5. Jabde Pradip V (2005). Textbook of applied Zoology, Discovery Publishing House, New Delhi.

Suggested Readings

1. Ahsan Jawaid, Sinha Prasad S. (2000). A handbook on Economic Zoology. S. Chand and Co.

LI 519 Biology Lab XII (Animal Science) **L0 -T0- P4- CR4**

Course outcome

CO 1: Ability to prepare media and culture mammalian cells.
CO2: Ability to identify economically important animals and successful maintenance them.
CO3: Ability to apply the principles and practices of animal biotechnology and the culture techniques for rearing economically important animals

Course content

Practical

1. Preparation of cell culture media, culture of mammalian cells; Primary and secondary cell culture.
2. Diagnostic methods like immunoblotting; Real time PCR; RFLP, RAPD.
3. Morphological study of economically important fish species – *Labeo rohita* and *Catla catla*.
4. Isolation and mounting of the sting apparatus. Study of bees using charts.
5. Life cycle of mulberry silkworm, Bombyx mori/Antheria assama (model/chart/specimens)
6. External morphology and nomenclature of dairy animals. Determination of the specific gravity of milk by using a mercury lactometer.
7. External morphology of poultry birds (model). Test for good quality eggs (Floating test, cracking test) and for fertilized and unfertilized eggs (Light test, Cracking test).
8. Project report on visit to dairy farm/Poultry farm/Fishery.

Elective(s) for Option I

LI 522 Evolutionary Biology **L3- T0- P0-CR3**

Course outcome

CO1: Ability to understand molecular evolution.
CO2: Ability to identify and analyze mutation, variation, genome evolution.

Course content

Unit I: Evolutionary biology: Definition, scope and applications, Theories of evolution, selection vs. neutral theory, genome composition and complexity

Unit II: Base Substitution in evolution: Base substitutions in DNA, parity rules, mutation bias between the strands, AT and GC skews in DNA strands, transition and transversion bias, Gene distribution asymmetry, transcription induced mutation bias, Mutation is AT biased

Unit III: Genetic code and Evolution: Codon degeneracy, codon usage bias, measures of codon usage bias, selection on codon usage bias, ribosome profiling, tRNA modification role

Unit IV: Macromolecular evolution: Protein evolution, role of protein folding, intrinsically disordered proteins

Unit V: Genetic drift and Evolution: Mutation within and across genomes, genome wide association studies (GWAS), selection-mutation and drift theory, population genetics, disease causing mutations, selection, drift, cancer and evolution of tumor, artificial selection of recessive traits

Textbooks

1. Bergstrom C. T., Dugatkin L. A., (2012) Evolution, I S Edition, W. W. Norton & Company.
2. Griffiths A.J., Griffiths A.J.F., Miller J.H., Suzuki D.T. and Lewontin R.C. (2008) An Introduction to Genetic Analysis, W.H. Freeman.
3. Hartl (2011) Genetics: Analysis of Gene and Genomes, Jones & Bartlett Publisher.

LI 524 Ethnomedicine & Herbal Technology **L3- T0- P0- CR3**

Course outcome

CO1: Ability to identify and document traditional medicine and their scientific use.
CO2: Ability to document and practice classical and local health traditions.

Course content

Unit I: Herbs and healing: Historical perspectives: local, national and global level; Herbal cultures: origin and development of human civilizations; Ethnobotany and Ethnomedicine; Development of European, South and Central American, African, Indian, Chinese, and South East Asian Herbal Cultures

Unit II: Definition and concepts as per WHO guidelines for assessment of herbal medicines GMP and other regulatory and safety requirements as per schedule of drugs and cosmetics act and rules for herbal ayuervedic and other drugs of traditional origin. Preparation of documents for new drug application and export registration.

Unit II: General principles of formations including physico chemical properties like pH, solubility, distribution coefficient and the state of the individual component added and preparation of different doses forms of herbal formulations.

Unit II: Basic principles of treatment in Ayurvedic systems of medicine: Salient features of the techniques of preparation and standardization(including chromatographic methods) of some of the important class of formulations as per Ayurvedic pharmacopeia and text.

Unit IV: Herbal cosmetics: Historical background and present status of herbal cosmetics Technology resources and description of raw materials of herbal origin. used like fixed oils, waxes, gums hydrophilic colloids, colours, perfumes, protective agents, bleaching agents, preservatives antioxidants and other ancillary agents. Formulation aspects incorporating herbal extracts in various preparations like skin care, creams deodorant, antiperspirants etc. Utilisation of Industrial waste product aromatic products aromatherapy. Phytopharmaceutical isolation, characterization and estimation of caffeine, eugenol, pectine piperine, hesperidine, rutin etc

Unit V: Local health traditions: Symbiotic relationship between Classical health tradition and Local health tradition; Contemporary relevance of Local health traditions/Oral health traditions, primary health care and local health traditions, homestead level of medicinal plant garden for conservation and utilization of medicinal plants; Scientific documentation of traditional/indigenous knowledge related to plants used for healthcare

Unit VI: Concept of health and disease: A comparative account of (a) concept of health and disease (b) principles of prevention and treatment of disease and (c) health care in Ayurveda, Sidha, Unani and Homoeopathy

Unit VII: Cultural, Social and economic issues in health and disease: Causes for the decline and the current revival of interest in indigenous systems of medicine; a comparative evaluation of accessibility, benefits and costs of different systems of medicine; the relevance of herbal medicine as health care package for the masses in the 21st Century

Textbooks

1. Chancellor, P.M. 1971. Handbook of the Bach flower remedies. Saffron Waldon, Essex.
2. Cotton, C.M. 1996. Ethnobotany: principles and applications. John Wiley & Sons, New York.

Suggested Readings

1. Jayasurya, A. 1997. The Future of Complementary Medicines. Medicina Alternativa, Colombo

2. Ethnomedicinal Plants: Revitalizing of Traditional Knowledge of Herbs by Mahendra Rai, Deepak Acharya, José Luis Rios (2011) CRC Press, Taylor and Francis Group
3. Herbal Drugs: Ethnomedicine to Modern Medicine by Kishan Gopal Ramawat – (2008) Springer Verlag Berlin Heidelberg -

LI526 Plant metabolism & secondary metabolites **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to isolate and identify plant metabolites

CO2: Ability to isolate and identify secondary metabolite like terpenes phenolics and plant defense mechanism

Course content

Unit I: Secondary Metabolites: Secondary metabolites defend plants against herbivores and pathogens, three major groups.

Unit II: Terpenes: Isoprene units, terpene biosynthesis, IPP and its isomer, larger Terpenes, terpenes in growth and development, terpenes against herbivores.

Unit III: Phenolic Compounds: Phenylalanine, biosynthesis of phenolics, ultraviolet light and phenolics, release of phenolics into the soil, lignin, four major groups of flavonoids, anthocyanins attract animals, flavones and flavonols for ultraviolet protection, isofl avonoids, tannins.

Unit IV: Nitrogen-Containing Compounds: Alkaloids, cyanogenic glycosides , glucosinolates, nonprotein amino acids toxicity.

Unit V: Induced Plant Defenses against Insect Herbivores: Plants recognize insect saliva, jasmonic acid defensive responses, plant proteins inhibit herbivore digestion, insect herbivores and systemic defenses, volatiles and ecological functions, insects strategies against plant.

Unit VI: Plant Defenses against Pathogens: Pathogens invasion, antimicrobial compounds, infection induction, phytoalexins, interactions of plants with nonpathogenic bacteria can trigger induced systemic resistance.

Unit VII: Plant Defense Responses: Physical defense, chemical defense, plant protecting animals, systemic response to invader.

Textbooks:

1. Taiz, L. and Zeiger, E., Plant Physiology, 5th edition, Sinauer Associates, USA, 2012, ISBN-13: 978-0878938667.
2. Plant Secondary Metabolites: Occurrence, Structure and Role in the Human Diet, edited by Alan Crozier, Mike N. Clifford, Hiroshi Ashihara, John Wiley & Sons, 15-Apr-2008, ISBN 1-4051-2509-8.

Suggested Readings

1. Bioactive Compounds: Health Benefits and Potential Applications, edited by Maira Rubi Segura Campos, Woodhead Publishing, 01-Dec-2018, ISBN13 9780128147740.

LI 528 System Biology **L3- T0- P0- CR3**

Course outcome

CO1: Ability to understand and appreciate system biology and biological complexity
CO2: Ability to know complex biological system and its network, and bigdata in biology

Course content

Unit I: Systems Biology – Fundamentals: Concept of complex systems, systems theory, reductionism vs. holism, artificial systems vs. biological systems.

Unit II: Complexity in biological systems: Hierarchical organization in biological systems**,** central dogma and information flow in biological systems, top down and bottom up approaches in systems biology.

Unit III: Representations of Biological Systems: What is a model?, mathematical models in biology, Standards for systems biology, Systems Biology Markup Language (SBML), Systems Biology Graphical Notation (SBGN), basics of control theory, logical modelling, block diagram, enzyme kinetics, genome-scale metabolic networks, Basics of Metabolic control analysis (MCA) and Flux Balance Analysis (FBA), Basics of Biochemical Systems Theory (BST).

Unit IV: Basics of networks and graph theory: Network topology, nodes, edges, directed vs. undirected network, regular network, random network, small world network, scale free network and power law; centrality, degree centrality, betweenness centrality, clustering coefficient, network diameter, shortest path, identifying hubs, node failure and robustness.

Unit V: Examples of biological networks: Protein contact network, gene co-expression network, protein-protein interaction networks, gene regulatory networks, metabolic networks, neuronal networks (nervous system), species interaction network (plant-microbe interactions, host-pathogen interactions), ecological networks (food web).

Unit VI: Big data in biology: What is Big data?, Source of Big data in Biology**,** Big data integration in biology, challenges in heterogeneous data integration, Gene Ontology, Semantic Systems Biology.

Unit VII: Tools and methods: Basic modelling/simulation tools, R-bioconductor, cytoscape, MeV, galaxy, Cell Designer, COPASI, STRING, KEGG PATHWAY Database, Reactome Pathway Database, BioCyc, MetaCyc, Systems Biology Workbench, Pathway Commons.

Unit VIII: Systems biology examples from recent literature: in biology, medicine, agriculture.

Textbooks:

1. Alon, Uri. An introduction to systems biology: design principles of biological circuits. CRC press, 2006.
2. Newman, Mark. Networks: an introduction. Oxford university press, 2010.
3. Segel, L. A., Modeling Dynamic Phenomena in Molecular and Cellular Biology, Cambridge University Press, 1984
4. Foundations of Systems Biology (MIT Press) 1st Edition Edition by Hiroaki Kitano (Editor)

Elective(s) for Option II

LI530 Wild life & Animal Behavior **L3- T0- P0- CR3**

Course outcome

CO1: Ability to used the knowledge for biodiversity monitoring, conservation and management issues

CO2: Ability to apply the knowledge of wildlife ecology to solve local, regional and national conservation and management issues.

CO3: Ability to use the biological techniques used for improvement of fish culture and research

Course content

Unit I: Wildlife in India: Wildlife wealth of India & threatened wildlife. Reasons for wildlife depletion in India. Wildlife conservation approaches and limitations.

Unit II: Wild life Habitat: Characteristic, Fauna and Adaptation with special reference to su-btropical and tropical forests.

Unit III: Management of Wildlife: Red Data Book and Conservation status (endangered, vulnerable, rare, threatened and near threatened species)-definitions. Distribution, status. Habitat utilization pattern, threats to survival of endangered species of India with special reference to North East India. Concept of protected area, National Parks, Sanctuaries and Biosphere Reserves, cores and Buffers, Nodes and corridors. Community Reserve and conservation Reserves. Biodiversity Hot Spots in India.

Unit IV: National and International efforts for conservation: Wild life Trade & legislation: Assessment, documentation, Prevention of trade. Policies and laws in Wild life management (national) and ethics ; Wildlife (Protection) Act, 1972; Wild life (Protection) Amendment Act, 2002, Wildlife (Transaction and Taxidermy) Rules, 1974 ; Forest conservation Act, 1980 and Rules, 2003. Major International Agreements (CITES, CBE, ITTA, UNFCCC etc.)Convention on wetlands of International Importance (Ramsar convention). Important projects for the conservation of endangered species in India. Important projects for the conservation of endangered species in India. Economic value of biodiversity & legal, ethical and Conservation issues related to uses of biodiversity.

Unit V: Development of behavior: Concept of animal behaviour, significance of study of animal behaviour, influence of environment. Classification of behavioural patterns: Analysis of Behaviour (ethogram), Innate Behaviour, learned behaviour

Unit VI: Behavioural genetics: Genes and behavioural evolution, Hamilton's rule, kin selection, cost and benefits of social life, sex and sexual selection, Evolutional and phylogeny of behaviour, single gene effect, multiple gene effect, quantitative genetics, genetic techniques.

Unit VII: Control of behaviour: Neural, Hormonal and Pheromone control of behaviour; Chemical, Visual and Audio Communication. Social behaviour and types of social groups, advantages of grouping, Aggregation, Schooling in fishes, Flocking in birds, Group selection, kin selection, altruism, Social organization in insects and primates. Reproductive Behaviour: Mating systems, Courtship, Parental Care

Unit VIII: Biological Rhythms: Circadian and circeannual rhythms, Orientation and navigation, Migration of fishes & birds. Learning and memory: Types of learning, neural mechanism of learning

Textbooks:

1. Leveque C and Mounolou J (2003) Biodiversity, John Wiley and Sons, Ltd.: West Sussex, Englandd
2. Magurran A E and McGill B J (2011) Biological Diversity: Frontiers in Measurement and Assessment Oxford University Press: USA.
3. Shawn E. Nordell & Thomas J. Valone (2013) Animal Behavior: Concepts, Methods, and Applications. Oxford University Press
4. Lovejoy T E and Hannah L (2006) Climate change and biodiversity. The Energy and Resources Institute: Delhi)

Suggested Readings

1. Menon V 2003 A filed guide to Indian mammals, Dorling Kindersley Pvt. Ltd.: India
2. Nair S.C 1991 Southern Western Ghats: A biodiversity conservation plan, Indraprastha Press: NewDelhi.
3. Nair S M 1992 Endangered animals of India and their conservation, National Book Trust: Delhi
4. Primack R B 2010 Essentials of Conservation Biology, Bostan University: Sunderland, Massachussetts, USA
5. Zachos F.E. and Habel J.C. (Eds) (2011) Biodiversity Hotspots: Distribution and Protection of Conservation Priority Areas, Springer.
6. Slater P J B 1999 Essentials of Animal Behaviour (Cambridge Uni. Press)
7. Alcock (2001) Animal Behaviour- An Evolutionary Approach. (7th ed.) Sinaur Associates.

LI532 Fish Biology **L3- T0- P0- CR3**

Course outcome

CO1: Ability to classify fish based on morphological characters
CO2: Ability to develop aquaculture for rearing of economically important fish
CO3: Ability to use advance biological techniques for improvement of fish culture and research.

Course content

Unit I: Classification of fish; Principles of classification. Classification of major fish species of Assam. Study of major economic fish orders: Cypriniformes, Clupeiformes etc

Unit II: Structure and functions: Digestive systems and sensory organs of fishes, Osmoregulatory and Circulatory systems, Endocrine glands (Pituitary and Thyroid), Caudal neurosecretory organ. Acoustico -lateralis system. Internal transport and homeostasis- aquatic and aerial respiration, Structure and functions of reproductive organs, Types of reproduction, Breeding and Parental care. Fish migration – types and regulation

Unit III: Aquaculture: Inland fisheries resources in India with special emphasis on North East India and their principal species. Food fishes and their economic importance. Indian Major carps: Catla catla, Labeo rohita, Cirrhinus mrigala. Exotic carps: Hypophthalmicthys molitrix, Ctenopharyngodon idella, Cyprinus carpio Other groups: Clarias batrachus, Heteropneustes fossilis Anabas testudineus, Channa striatus, Etroplus suratensis

Unit IV: Fish culture practices: Collection of spawn, fries and fingerlings and their subsequent transport. Culture of air-breathing fishes, Integrated aquaculture: crop-livestock-fish farming, Paddy-cum-fish culture, Sewage-fed fish culture. Impact of invasive fish species. Marine fisheries Resources, Hilsa fishery

Unit V: Fish breeding Neuro-endocrine control of fish reproduction, Pond management for fish culture. Induced breeding in carps and catfishes. Composite culture of fishes (air breathing). Nutritional requirements, Feed types, composition, ingredients, formulation Feeding schedules, feed dispensing methods, Storage and quality control of feed

Unit VI: Maintenance of Fish Farm: Productivity of freshwater bodies Limnological methods and their application (oxygen and carbon-di-oxide), Pond fertilization Control of aquatic weeds, insects, predatory and weed fishes; Common diseases of fish: Causative organisms, effects and control

Unit VII: Ornamental fish culture and aquarium management. Ornamental fishes (native and exotic) species, breeding of aquarium fishes. Management of aquarium for different ornamental fishes.

Unit VIII: Fish biotechnology: Production of transgenic fish. Methods employed in phylogenetic studies and fish identification, fish barcoding. Fish as a research model

Textbooks:

1. Biology of Fishes, Bone, Q. and Moore, R.,(2008) Talyor and Francis Group, CRC Press, U.K.
2. Bardach, J. E. & Ryther, J. H. (1972). Aquaculture. John Wiley and Sons.
3. Beaumont, A. R. & Hoare, K. (2003). Biotechnology & Genetics in Fisheries and Aquaculture. Blackwell Publishing.
4. Pillay, T. V. R. (1993). Aquaculture. Fishing News Books.

Suggested Readings:

1. Evans, D. H. (1998). The Physiology of Fishes. CRC Press.

2. Jayaram, K. C. (1999). The Freshwater Fishes of the Indian Region. Narendra Publishing House, New Delhi.
3. Lowe, H. (2005). Beginner's Guide to Aquarium Fish and Fish Care. Abhishek Press, New Delhi.

LI 534 Cancer Biology **L3- T0- P0- CR3**

Course outcome

CO1: Ability identify cancerous cells.
CO2: Ability to identify the various causes of cancer, signalling, immune response and treatment regimen

Course content

Unit I: Biology and Genetics of Cancer Cell: Mendel rule of genetics, mutation in germ line and soma, gene expression and control of phenotype, regulation of gene expression, risk factors and mutagens responsible for human cancer

Unit II: Tumor viruses and cellular Oncogenes: Rous sarcoma virus (RSV) and cell transformation, multiple changes in cell phenotype, role *src* gene of RSV, proto-oncogene and activation by retroviruses, proto-oncogene activation affects protein expression or structure.

Unit III: Growth factors, receptors and signaling circuit: Src protein and EGF receptor functions as tyrosine kinase, transphosphorylation activates tyrosine kinase receptors, alteration in growth factor receptor activates oncogene, Ras proteins and downstream signaling cascade, Jak-STAT and Wnt-β catenin pathways, G-protein coupled receptors and signaling, other signaling pathways such as NF-kB, TGF-β, Notch and Patched.

Unit IV: Tumor suppressor genes: Retinoblastoma, loss of heterozygosity, promoter methylation, regulation diverse pathways such as pRB and cell cycle control, p53 and apoptosis

Unit V: Multi-step tumorigenesis and genome integrity: Evidences of multi-stage tumor formation, Darwinian model for clonal succession and tumor progression, role of toxic and mitogenic agents in tumor progression, chronic inflammation and tumor progression, genome integrity and cellular defence, DNA repair mechanisms such nucleotide excision repair, base excision repair, mismatch repair and cancer susceptibility

Unit VI: Heterotypic interactions and mechanism of angiogenesis, invasion and metastasis: Role of stromal cells in tumorigenesis, activation of tumor associated stroma by macrophages, modulation of complex angiogenic switch, anti-angiogenesis therapies for treating cancer, Epithelial mesenchymal transition, extracellular proteases and their role in invasion, small Ras like-GTPases controls adhesion, cell shape and motility, factors governing metastasis, metastasis suppressor genes and metastatic phenotype

Unit VII: Tumor immunology: Adaptive and Innate immune response, immune-surveillance, immune recognition of tumors, tumor-specific transplantation antigens, tumor associated transplantation antigens, NK cell and tumor, role of T-regulatory cells in immune invasion

Unit VIII: Current treatment regimen: Development and clinical use of effective therapies, anti-cancer drugs and attractive targets for drug development, Screening of new drugs, various clinical trial phases (Phase I, Phase II, Phase III), drug resistance and effective therapy.

Textbooks:

1. The biology of cancer, Robert A. Weingberg, Garland Sciences, Taylor and Francis Group.
2. The molecular biology of cancer, Stella Pelengaris and Michael Khan, Wiley-Blackwel

LI 536 Pyschoneuroimmunology **L3-T0- P0- CR3**

Course outcome

CO1: Ability to understand the aspects of psychoneuro-immunology

*CO2: Ability to establish the neuro and immunological response and related signaling networks in psychological behaviour***.**

Course content

Unit I: Introduction to Psychoneuroimmunology: Introduction and historical overview, Functional subdivisions of the immune system

Unit II: Basic Immunology: Structural components of the immune system ,Specific immune mechanisms and functions, Immunological methods, Immunomediators: Immune-specific (e.g., cytokines),Non-immune-specific (e.g., aging, sleep)

Unit III: Principles of Endocrinology: General principles, Hormone and Hormone receptors, Glands of the endocrine system

Unit IV: Concepts of Psychology: Classical conditioning and immune system, Stress, Definition, Acute versus chronic stress, the stress response and control

Unit V: The Immune- Neuroendocrine network: Neuroanatomy of the immune system**,**Lymphocyte neurohormonal receptors**,** Neuroendocrine influences on immunity**,** Neuroendocrine measurement, Neuroimmunomodulation of homeostasis and host defenses

Unit VI: Human stressor studies: Chronic/field stressor effects on immunity/methodologic issues, Laboratory acute stressor effects on immunity, Distress states, mood disturbances and immunity, Stress moderators in PNI

Text books:

1. Jorge H. Daruna(2007) Introduction to Psychoneuroimmunology ". Academic Press, New York, San Diego
2. Glaser, R. & Kiecolt-Glaser, J. (Eds) (1994) Handbook of Human Stress and Immunity. San Diego, CA: Academic Press.
3. Ader, R., Felten, D. & Cohen, N.(Eds.) (2000) Psychoneuroimmunology (3rd Edition). N.Y.: Academic Press.

LI 538 Insect vector and Diseases **L3-T0- P0- CR3**

Course outcome

CO1: Ability to identify types of disease vectors and the factors driving their spread.
CO2: Ability to use the methods to bring down their population for a better management
CO3: Ability to use the information about their life cycle to control and prevent disease spreaded by vector.

Course content

Unit I: Introduction to Insects: General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts w.r.t. feeding habits

Unit II: Concept of Vectors: Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity

Unit III: Insects as Vectors: Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera

Unit IV: Dipteran as Disease Vectors: Dipterans as important insect vectors – Mosquitoes, Sand fly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sand fly Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit V: Siphonaptera as Disease Vectors: Fleas as important insect vectors; Host-specificity, Study of Flea-borne diseases – Plague, Typhus fever; Control of fleas

Unit VI: Siphunculata as Disease Vectors: Human louse (Head, Body and Pubic louse) as important insect vectors; Study of louse-borne diseases –Typhus fever, Relapsing fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse

Unit VII: Hempitera as Disease Vectors: Bugs as insect vectors; Blood-sucking bugs; Chagas disease, Bed bugs as mechanical vectors, Control and prevention measures.

Text books

1. William Marquardt (2004) Biology of Disease Vectors 2nd Edition eBook ISBN: 9780080494067, Publisher: Academic Press
2. R. F. Chapman, Angela E. Douglas (2013) The Insects: Structure and Function. Cambridge University Press,
3. Pedigo L.P. (2002). Entomology and Pest Management. Prentice Hall Publication

LI 540 Immunotechnology **L3- T0- P0- CR3**

Course outcome

CO 1: Ability to corelate immune response in various cellular functions.
CO 2: Ability to use different immunological techniques in solving problems related to scientific research, health care and diagnosis.
CO 3: Ability to improve existing vaccines and design strategies in vaccine development.

Course content

Unit I: Introduction to Immunotechnology: Kinetics of immune response, memory; Principles of Immunization; Techniques for analysis of Immune response

Unit II Antibody Related Techniques: Immuno-chemistry of Antigens - immunogenecity, Antigenecity, haptens, Toxins-Toxiods, Hapten-carrier system; Genetic bases of immune response – Heterogenecity; Role and properties of adjuvants, Immune modulators; B cell epitopes; Hybridoma Rabbit, human.

Unit III: Antigen – Antibody interaction: affinity, cross reactivity, specificity, epitope mapping; Immuno assays RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, Surface plasmon resonance, Biosensor assays for assessing ligand – receptor interaction

Unit IV: New Generation Antibodies: Multigene organization of immunoglobulin genes, Ab diversity; Antibody engineering; Phage display libraries; Antibodies as in vitro and in vivo probes

Unit V: CMI and Imaging techniques: CD nomenclature, Identification of immune Cells; Principle of Immunofluorescence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications;

Unit VI: Cell Functional Assays: lymphoproliferation, Cell Cytotoxicity, mixed lymphocyte reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, In–situ gene expression techniques; Cell imaging Techniques -In vitro and In vivo; Immuno-electron microscopy; In vivo cell tracking techniques; Microarrays; Transgenic mice, gene knock outs

Unit VII: Vaccine technology: Rationale vaccine design based on clinical requirements: Hypersensitivity, Immunity to Infection, Autoimmunity, Transplantation, Tumor immunology, immunodeficiency; Active immunization, live, killed, attenuated, Sub unit vaccines; Recombinant DNA and protein based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines; Passive Immunization; Antibody, Transfusion of immuno-competent cells, Stem cell therapy; Cell based vaccines

Text ooks

1. Delves, P., Martin, S., Burton, D., Roitt, I. Roitt's Essential Immunology (WileyBlackwell, 11th Edition). 2002
2. Kuby Immunology Paperback by Thomas J. Kindt (Author), Barbara A. Osborne (Author), Richard Goldsby (Author). W. H. Freeman & Company; 6th edition

Suggested Readings

1. S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. P intar, L. Silberstein, Selected Methods for Antibody and Nucleic Acid probes, Volume1, Cold Spring Harbor Laboratory Press,1993.
2. Ed Harlow, David Lane, Antibodies Laboratory Manual, Cold Spring Harbor, Laboratory Press, 1988.
3. F.C. Hay, O.M.R. Westwood, Practical Immunology, 4 th Edition-, Blackwell Publishing,

LI 542 Computer aided drug designing **L3-T0-P0- CR3**

Course outcome

CO 1: Ability to use the state-of-the art methods and techniques for Insilco drug designing.
CO 2: Ability to carry out Molecular Modelling
CO 3: Ability to identify drug target and screen potential drug molecule using different date base.

Course content

Unit I: Concepts in Molecular Modelling: Introduction to Molecular Geometry, Coordinate systems, Molecular graphics, surfaces, Space for Optimization of Algorithm of Molecular Geometry, Z-Matrix, Molecular Vibrations, Electrostatic Charges, Multipole Moments, Fermi Contact Density, Electronic Spatial Extent and Molecular Volume, Electron Affinity and Ionization Potential, Hyperfine Coupling, Dielectric Constant, Force Field Customization. Equilibrium structures, potential energy surfaces, free energies, the standard tools of the molecular modelling: Molecular mechanics, force fields, types of force fields

Unit II: Molecular Dynamics: Introduction to Molecular Dynamics, Density Functional Theory, Linear Scaling Techniques, Ab initio Methods and Hartree-Fock Approximations.

Unit III: Drug Design: Introduction to drug designing, drug design to discovery and development, drug metabolism, toxicity and pharmacokinetics, toxicology considerations, problems and drawbacks on drug discovery and development.

Unit IV: Drug Target: Drug Target classification, identification and validation strategies, Design and development of combinatorial libraries for new lead generation Structure-based design – 'de novo' design methodologies 3D-database searching techniques, docking QSAR: Statistical techniques behind QSAR, classical QSAR, molecular descriptors 3D QSAR and COMFA.

Unit V: Molecular Docking: Introduction to molecular docking, Rigid docking, Flexible docking, manual docking, Advantage and disadvantage of Flex-X, Flex-S, AUTODOCK and other docking software, Scoring Functions, Simple Interaction Energies, GB/SA scoring (implicit solvation), CScore (consensus scoring algorithms).

Unit VI: Pharmacophore Models: Historical Perspective and Viewpoint of Pharmacophore, Functional Groups Considered as Pharmacophores, Ehrlich's "Magic Bullet", Fischer's "Lock and Key", Two-dimensional Pharmacophores, Three-dimensional Approach of Pharmacophores, Criteria for Pharmacophore Model, Pharmacophore Model Generation Software Tools, Molecular Alignments, Handling Flexibility, Alignment Techniques, Scoring and Optimization, Pharmacophores, Validation and Usage, Automated Pharmacophore Generation Methods, GRID-based Pharmacophore Models, Pharmacophores for Hit Identification, Pharmacophores for Human ADME/Tox-related Proteins.

Unit VII: Library and Database: Molecular and Structural Database, Protein Data Bank, Bioactivity Databases, Gene and Protein Sequence Databases, Cambridge Crystallographic Database, Compound Storage and Management.

Textbooks:

1. Andrew Leach. Molecular modeling: principles and applications. 2nd ed. Pearson Education. 2001.
2. Atkins and Friedman. Molecular quantum mechanics. Oxford University Press. 4th ed. 2005.
3. David C. Young. Computational Drug Design. A guide for Computational and Medicinal Chemists. Wiley. 2009.