Curriculum for Master of Science (MSc) Inter-Disciplinary Bio Sciences

Semester	Course Code	Course Name	LTP	Credits	Course Instructor
Semester I	JBL 219	Fundamentals of Gene Regulation	3-1-0	4	Prof. Kushagra Bansal
	JCL 304	Bioorganic and Medicinal Chemistry	3-1-0	4	Prof. Jayanta Haldar
	JBL 204	Basics in Immunology	3-1-0	4	Prof. Ranga Udaykumar
	JCL 202	Organic Chemistry	3-0-0	3	Prof. Sarit Agasti
	JAL 201	Biostatistics & Bio-mathematics	2-1-0	3	Dr. Divyashri Baraniya
	JNL 202	Introduction to Neurobiology	3-1-0	4	Prof. Sheeba Vasu
	JAL 202	Principles of Biochemistry	2-1-0	3	Dr. Varuna H P
Semester II	JAL 205	Principles of Genetics	2-1-0	3	Dr. Lavanya Sivashanmugam
	JBL 220	Fundamentals of mechanobiology	2-1-0	3	Dr. Varun Bhaskar
	JAL 206	Developmental Biology	2-1-0	3	Dr. Megha Singhal
	JAL 207	Fundamental Computational Biology	2-1-0	3	Dr. Divyashri Baraniya
	JAL 301	Advanced Biochemistry	2-1-0	3	Dr. Varuna H P
	JBL 203	Gene Expression and Disease	3-1-0	4	Prof. Tapas K Kundu
	JBL 303	Intracellular Traffic, Transport and turnover	3-1-0	4	Prof. Ravi Manjithaya
	JBL 304	Principles of Virology	3-1-0	4	Dr. Shwetha Shivaprasad
	JAP 203	Laboratory I	0-1-3	4	Lab Coordinator
Semester III	JCL 312	Chemical Biology	3-0-0	3	Prof. Govindaraju T
	JBL 305	RNA Biology	3-1-0	4	Dr. Varun Bhaskar
	JAL 208	Fundamentals of Molecular Microbiology	2-1-0	3	Dr. Megha Singhal (Coordinator), Dr. Lavanya Sivashanmugam
		Elective I	3-1-0	4	----
		Elective II (May be credited either in 3rd or 4th Semester)	3-1-0	4	
	JAP 305	Laboratory II	0-1-3	4	Coordinator
Semester IV		Elective II (If it is not already credited in III Semester)	3-1-0	4	---
	JAD 209	Research Project (Dissertation)	0-2-6	8	Coordinator
	JAQ 210	Seminar	1-0-0	1	Coordinator
Total Credits				**87**	

Course curriculum and Credits are subject to changes

JBL 219 Fundamentals of Gene Regulation

Credit: 3

Objective of the course:

This major aim of this course is to make students understand the fundamental regulatory mechanisms of gene expression. The course will cover two major facets of gene regulation- transcriptional and post-transcriptional. This course will encompass both established as well as emerging concepts in the field of gene expression and its regulation. Students will also be briefly introduced to latest methodologies in the field which will help them to broaden their learning horizon. This course should be an effective exercise for the Integrated PhD and PhD students aiming to pursue their career at the liaison of molecular biology and other specialized themes such as immunology, oncology etc.

Syllabus:

A) Concepts of gene expression

- Genes and genomes
- RNA Polymerases and their function
- RNA-PolII pausing
- Transcription factors
- Regulatory elements

B) Role of epigenetic mechanisms in regulation of gene expression

- Chromatin modifications in regulation of eukaryotic transcription
- Concept of writer, reader and eraser
- Concept of promoter and conventional enhancers
- Latent enhancers
- Super-enhancers in gene regulation
- Open chromatin regions (OCRs)
- DNA-methylation in regulation of gene expression
- Long non-coding RNAs
- DNA topology and transcription

C) Genome organization and gene regulation

- Role of genome organization in regulation of transcription
- Control of genome organization by transcription elongation
- Concept of chromatin domains and transcription factories
- Role of Mediator, Cohesins and CTCF in genome organization and gene regulation
- Phase separation and gene regulation

D) Post transcriptional regulation of eukaryotic gene expression

- Small non-coding RNAs such as miRNA in gene regulation
- Basics of RNA editing

E) Gene regulation and diseases

- Dysregulation of gene expression in diseases
- Drug treatment in diseases to revert dysfunctional transcription

- Epigenome as a target for drug development

F) Emerging methodologies to evaluate the gene expression and its regulation

- Introduction to high-throughput sequencing methodologies to evaluate gene expression – Bulk RNA-seq, Single cell RNA-seq: How and why?
- Methods to evaluate chromatin state- ChIP-seq, Assay for transposase accessible chromatin (ATAC)-seq
- Method to analyze DNA methylation- Reduced representation bi-sulfite sequencing (RRBS)
- Chromatin architecture- Hi-C, HiChIP, ChIA-PET

JCL 304

Bioorganic & Medicinal Chemistry

Fatty acid, Essential Fatty Acids, Lipids classification, Energy-storage lipids (triacylglycerols), Chemical Reactions of Triacylglycerols, Triacylglycerols and diseases, Lipid absorption,Membrane lipids (phospholipids, sphingoglycolipids, and cholesterol), Cell Membrane, Apolipoproteins & Lipoproteins, transport of lipoproteins and diseases, Lipid-lowering drugs, Lipid aggregates (Liposome, Vesicle, micelle), Membrane dynamics, Prokaryotic cell membrane and envelope, Antimicrobial peptide targeting bacterial cell membrane, Transport Across Cell Membranes, drugs targeting transport mechanism and diseases, Emulsification lipids (bile acids) and diseases, Protective-coating lipids (biological waxes), Messenger lipids (steroid hormones and eicosanoids) and diseases-related drugs, Cationic synthetic lipids and use in gene delivery, membrane (lipids) as drug target (Antifungal drug, Antimicrobial peptides), lipids (liposome) use as drug delivery system; Carbohydrates, Classification of Carbohydrates, nomenclature of Carbohydrates, Reaction of Monosaccharide, Glucose testing and diabetes and drugs, Disaccharide (Maltose, Cellobiose, Lactose, and Sucrose), Lactose Intolerance, Galactosemia, Artificial Sweeteners, oligosaccharide, polysaccharide (Starch, glycogen, cellulose, chitin, hyaluronic acid and heparin), Glycogen, Glycogenesis, Glycogenolysis, Carbohydrate Digestion, Carbohydrate metabolism, Warburg effect, Targeting Glucose metabolism for Cancer therapy, Glycolipids and Glycoprotein, Cell Recognition, viral entry into host cells (Influenza virus, Herpes Simplex Virus), Bacterial Cell wall, Sugar based drugs and their mechanism (anti-flu, glycopeptides antibiotics, aminoglycosides, anti-cancer drugs like doxorubicin). Nucleic Acids, Primary and Secondary Structure of DNA, Replication of DNA, Transcription: RNA Synthesis, Genetic Code, Translation: Protein Synthesis, Recombinant DNA and Genetic Engineering, Polymerase Chain Reaction (PCR), Nucleic Acids as drug targets specially for cancer and infectious diseases, DNA-DNA crosslinker, Alkylating agents, DNA intercalator, Topoisomerase inhibitors, Chain cutters, Chain terminators (Acyclovir), Telomere and Telomerase inhibitors, Antisense Therapy, RNA Interference (micro- RNA or Si-RNA therapy)

Reference Books:

1. Biochemistry by D. Voet and J. G. Voet

2. Biochemistry by A. L. Lehninger

3. Medicinal Chemistry T. L. Lemke, D. A. Williams, V. F. Roche and S. W. Zito

4. An Introduction to Medicinal Chemistry by G. L. Patrick

JBL 204 Basics in Immunology

Syllabus: A history of immunobiology, basic concepts in immunology, immunologists' toolbox, the innate and the adaptive immune systems, cell-mediated immune responses to antigens, introduction to various classes of T-cells and MHC-molecules, antigen presentation to T-cells, the diversity of MHC molecules, B-cell responses to antigens, structure of antibodies, antigen-antibody interactions, B-cell development T-cell development, T-cell function, B-cell function, and the failure of the immune system.

JCL 202 Organic Chemistry

Chemical bonding and Molecular structure, Electronic effects, Resonance, Aromaticity, Acids and Bases, Weak bonding. Stereochemistry and conformational analysis: Stereoisomerism definitions, optical isomerism, Resolution of racemic mixture, Enantioselective synthesis, Effect of conformation on reaction. Basic organic reaction and their mechanism, nucleophilic, electrophilic addition to double bond.

Methods of deducing organic reaction mechanisms, Curtin-Hammett Principle, Organic Reaction Mechanism. Fundamental reactions of functional groups including amines, carboxylic acids, ethers, alcohols, aldehydes, ketones, and aromatic compounds; functional group transformation: retrosynthetic approach.

Organic Transformations/molecular rearrangements/ isomerizations/ reactions involving additions, eliminations, and substitutions.

Reactive Intermediates: carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals.

Concerted reactions, thermal pericyclic reactions-Organic photochemistry, Forward and backward approach in organic synthesis.

Reference Books:

1. Smith, M. B.; March, J. March's Advanced Organic Chemistry: Reactions, Mechanisms and

Structure, 6th ed. Wiley (2000)

2. Carey F. A.; Sundberg, R. J. Advanced Organic Chemistry, Part A. 5th ed. Harper & Row

(1986)

3. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. Organic Chemistry. Oxford University

Press, (2000)

4. Corey, E. J. Cheng, X. The Logic of Chemical Synthesis 1989

5. Warren, S. Organic Synthesis: The Disconnection Approach, 1982

JAL 201 Biostatistics & Bio-mathematics

I. Theory Component:

1. Introduction to Biostatistics: History of statistics, types of data, data representation, types of graphs, sampling, biases, frequency distributions.

2. Description of data and uncertainty: Measures of central tendency and measures of spread: mean, median, mode, standard deviation, standard error, interquartile range, proportions, confidence intervals, types of errors.

3. Hypothesis Testing: Basics of probability theory, the probability distribution, conditional probability and Bayes' theorem, the null hypothesis, the p-value, binomial distribution, Student's test, Analysis of Variance, post-hoc tests: Tukey, Bonferroni, Dunnet. Analysis of categorical data: Chi-Square tests, Fisher's exact test.

4. Correlation and Regression: Linear correlation coefficient, testing correlation, linear regression, regression towards the mean, R2 values.

5. Basics of Experimental Design: Confounding variables, artifacts, controls, blinding, replication.

II. Practical Component:

Using statistical tools on Microsoft Excel and GraphPad Prism for each module described in the theory classes.

III. Recommended Books:

Analysis of Biological Data by Michael Whitlock and Dolph Schluter,

Biostatistical Analysis by Jerrold Zar.

JNL 202 Introduction to Neurobiology – I

Topics:

1. Orientation; History of neuroscience

2. Structure and function of components of the nervous system; Evolutionary origins of the nervous system.

3. Basic neurodevelopment: introduction to neurulation; boundary formation and patterning of brain compartments, neurogenesis and astrogliogenesis – forebrain, hindbrain

4. Neural migration: Interneurons, axonal pathfinding

5. Defects in neurodevelopment: disorders, models & techniques

6. Origin of membrane potential; passive electrical properties of neuronal membranes; factors affecting ionic current, action potential generation and propagation; introduction to ion channels

7. Intercellular communication by neurons – chemical – synaptic properties; neurotransmitters; receptors; neuromodulation; neuromuscular junction; neuron-neuron signals Intercellular communication – electrical

8. Neuronal plasticity– synaptic networks, behaviour, learning, memory

9. Genetic Basis of Behaviour

10. Glia and the nervous system

Reference Books:

• **Principles of Neural Science**; Eric R. Kandel, James H. Schwartz, Thomas M. Jessell. McGraw-Hill Companies; 4th edition

• **Neuroscience**; Bear, M. et al (2006); 3rd Ed. Lippincott Williams & Wilkins

• **Neuroscience**; Purves, D. et al. (2008); 4th Ed. Sinauer Associates.

• **Neurobiology: Molecules, Cells and Systems**; Matthews G G; Wiley-Blackwell Smith.

• **Cellular Migration and Formation of Neuronal Connections: Comprehensive Developmental Neuroscience**, (2020). John Rubenstein and Pasko Rakic (Eds). Academic Press. ISBN: 978-0-12-397265-1

• **Patterning and cell type specification in the developing CNS and PNS**. (2020); John Rubenstein, Pasko Rakic, Bin Chen and Kenneth Y Kwan (Eds). ISBN: 9780128144053. Academic Press, xxiv, 1098 pages.

• **Neurodevelopmental disorders**. (2020); John Rubenstein, Pasko Rakic, Bin Chen and Kenneth Y Kwan, Wyns haw-Boris, and Anthony Joseph (Eds). ISBN: 9780128144091 ; 0128144092. Academic Press, xii, 414 pages.

JAL 202 Principles of Biochemistry

Part A

1. Chemical Basis of Life

2. Elixir of Life on Earth – Water, the medium of all Biochemical Processes. The physical and chemical properties of water at the root of life processes.

3. Cell – the unit of life where biochemical processes occur during birth, life and death of cell.

4. Physical and Chemical Principles underlying the Biochemistry in the cell

5. Introduction to the Chemistry of three major components of cell – Proteins, nucleic acids and carbohydrates.

6. Chemistry of small molecules necessary for the cell to survive and function

7. Chemistry of bio membranes in different classes of cells.

8. Types of Chemical Reactions occurring in the cell – redox, addition, substitution, hydrolysis and proteolysis, disproportionation and free radical. Concept of Free energy

coupling of different chemical pathways in cell.

Part B

1. Proteins - Composition and Structure

Primary, secondary, tertiary and quaternary structures.

Structure function correlation in proteins.

Experimental methods to find these structures and use of pymol and artificial

intelligence to predict the structure of the proteins.

Preliminary concepts of Enzymolgy and enzyme kinetics to understand a major

function of proteins in the cell.

Biochemical Basis of Immune Function

2. Nucleic acids, DNA and RNA – Chemistry and Structure

Chemical Synthesis of nucleic acids.

Chemical Basis of Genes and Genetic Code

3. Carbohydrates , structure and the role in the cell. Carbohydrate binding proteins.

4. Lipids and Cell Membranes

Part C

1. Metabolisms to keep the cells functional . Diseases related to faulty metabolism.

Part D

Basic introduction to Neurochemistry.

JAL 207 Fundamentals of Computational Biology

Unit 1. Working with sequences (basics I): In this unit students will understand biological sequences and details of the specification and representation of biological sequence data. Differences between different formats of sequences, different categories of databases and an overview of some important open source databases will be taught.

Unit 2: Working with sequences (basics II): Introduction to sequence alignment, its significance,

pairwise and multiple sequence alignments (MSA), different algorithms used for alignments, scoring matrices for amino acid substitution.

Unit 3. Introduction to Linux: basics of Linux, working on command line interface (CLI), performing various common operations including creating and opening folders, viewing lists, moving, copying and deleting files and folders, changing formats and renaming, use of important commands including grep, awk, echo, chmod etc. with examples.

Unit 4. Basics of R: Introduction to R and R studio. Fundamentals of R, creation and execution of R file, working with R scripts, importing data, data handling and restructuring, reading different formats of data files.

Unit 5: Computational analysis with examples: Performing various statistical analyses including measurement of central tendencies, hypothesis testing, Correlation and regression on data from lab experiments and plotting various types of graphs using R.

Unit 6. Biological and ecological diversity: Different components of alpha and beta diversities, parametric and non-parametric tests.

Suggested readings:

1. “Bioinformatics: Sequence and Genome Analysis” by David W. Mount

2. “Introduction to computational Biology” by Bernhard Haubold and Thomas Wiehe.

3. “R for data science” by Hadley Wickham and Garrett Grolemund

4. “Practical R for Biologists: An introduction” by Donald Quicke, Buntika A. Butcher, Rachel

Kruft Welton.

5. “The Linux command line: A complete Introduction” by William Shotts.

JAL 301 Advanced Biochemistry and Enzymology

Stereochemistry and Physical:

Stereochemistry of Carbon compounds: Optical isomerism, chirality, symmetry elements, enantiomers, diastereomers, DL and RS notations, racemization, stereoisomerism and geometrical isomerism, cis – trans and E – Z conventions.

Chemical equilibrium: Basic concepts of ionic equilibria in solution, hydrolysis of salts, pH, buffer, Henderson Hasselbalch equation and their applications. Equilibrium constants (Kc, Kp and Kx) for homogeneous reactions.

Thermodynamics: First law of thermodynamics, basic concepts of entropy and second law of thermodynamics, free energy changes, standard free energy change and its relation to equilibrium constant. Oxidation – reduction reactions in biological systems. Feasibility of reactions. ATP Structure, properties and energy currency of the cell, Importance of Coupled reactions, High energy compounds.

Biomolecules structure and function

Amino acids and Proteins: Nomenclature, classification and buffering properties, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids; the peptide bond and its properties. Primary structure and strategies for its determination, Secondary structure of protein and its prediction methods (Ramachandran Plot). Tertiary and quaternary structures. CD as a sensitive indicator in chain conformation of proteins. Overview of purification of proteins and criteria of purity. Protein folding with special emphasis on molecular chaperones.

Nucleic Acids: Structures of purine and pyrimidine bases, nucleosides, nucleotides, RNA, & DNA (differences), base pairing schemes, keto -enol tautomerism of bases and its consequences.

Structure and function: Types of DNA- A, B and Z. Supercoiling of the DNA molecule topoisomers and superhelixes. RNA Structure-types of RNA, structure of mRNA, tRNA, rRNA, siRNA, micro RNA with emphasis on importance of structure to its function; Denaturation of DNA , Spectroscopic properties of

DNA, hyperchromic and hypochromic shift. Sequencing of DNA and RNA. Structure determination of Nucleic acids by enzymatic, chemical and diffraction methods. Structure and Dynamics by NMR.

Techniques to study macromolecular structure.

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-

Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications

Protein analysis by mass spectrometry: Mass spectrometry (general and technical), Sample

preparation, Interpretation of mass spectra, Mass analysis of intact proteins and peptides.

Basic X ray crystallography and Cryo-electron microscopy

Carbohydrate metabolism and Plant Biochemistry.

Introduction to Metabolism– Basic concepts, Metabolism-Compartmentalization.

Carbohydrate Metabolism: Glycolysis, Gluconeogenesis and its regulation. TCA cycle - Regulation,

Glyoxylate cycle, amphibolic & anaplerotic reactions. Pentose phosphate pathway (HMP shunt) & its regulation, Glycogen metabolism and regulation. Oxidative phosphorylation.

Plant Biochemistry – i) Photosynthesis - Light harvesting complexes; mechanisms of electron transport; ii) Photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways. **'light' and 'dark'reactions**: photorespiration iii) Secondary metabolites - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

Enzymology:

Mechanisms of enzyme action: Enzyme definition and characteristics, mechanism of enzyme action, activation energy, collision & transition state theories, lock and key model, induced fit hypothesis, Proximity orientation effect, strain and distortion theory.

Enzyme kinetics: Derivation of Kinetics of single-substrate enzyme-catalysed reactions (Michelis Menten and Briggs-Haldane equation). Enzyme activity, specific activity, turnover number. Kinetics of bi-substrate reactions (elementary idea only).

Types of catalysis Acid-base catalysis, covalent catalysis, Techniques for studying the mechanism of enzyme action; chemical modification, site directed mutagenesis and substrate analogues.

Typical enzyme mechanisms and events at the active site: Mechanism of reaction catalyzed by serine proteases-trypsin and chymotrypsin, carboxypeptidase, lysozyme, triose phosphate isomerase, ribonuclease and rotational catalysis-ATPase.

Enzyme regulation: General mechanisms of enzyme regulation. Allosteric enzymes (ATCase). Cooperativity phenomenon. Hill plot for hemoglobin and myoglobin. Sigmoidal kinetics and their physiological significance. Reversible and irreversible covalent modification, feedback inhibition, control of enzyme by products, substrates and adenylate energy charge, monocyclic and multicyclic cascade systems.

Suggested readings:

1. Wilson and Walker. A biologist's guide to principles and techniques of practical biochemistry.

5th ed. Cambridge University Press 2000.

2. Friefelder and Friefelder. Physical Biochemistry – Applications to Biochemistry and Molecular

Biology. WH Freeman &Co. 1994

3. Upadhyay, Upadhyay and Nath. Biophysical Chemistry Principles and Techniques. Himalaya Publ. 1997.

4. Lehninger's Principles of Biochemistry - D. L. Nelson and M. M. Cox

5. Biochemistry – L. Stryer

6. Biochemistry, 2004, Donald Voet and Judith Voet, John Wiley and sons. ISBN – 047119350

7. David Sheehan (2009). Physical Biochemistry: Principles and Applicatons, John Wiley & Sons Ltd, Chichester, England

8. Biochemistry and Molecular Biology of Plants. Buchanan, Greussem and Jones, AAPS (2000)

9. Plant Biochemistry; Hans-Walter Heldt and Birgit Piechulla, Academic Press (2004)

10. Enzymes; Trevor Palmer, East – West Press Pvt. Ltd., Delhi (2004)

11. Streochemistry of organic compounds by D Nasipuri.

12. Molecular Cell Biology 8th EditionBy Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon and Kelsey C. Martin.

13. Nucleic acid structure, properties and function by Victor A Bloomfield, Donald M Crothers,Ignacio Tinoco Jr.

JBL 203 Gene Expression and Disease

Genome Organization: Organization of DNA elements, Evolution of genome Organization,Nucleography, Genome architecture, rearrangements, genomic disorders. Eukaryotic genome organization into chromatin.

Chromatin dynamics: Chromatin modifications and remodelling, Interaction of non-histone proteins with chromatin as a factor for dynamic chromatin structure, Chromatin structure and aging (E.g. Histone variants and aging process).

Transcriptional regulation: In Bacteria, Viruses, and Eukaryotes, Role of chromatin structure, Transcription, and disease. Translational control: in viruses, prokaryotes, and Eukaryotes, with particular emphasis on disease and therapeutics, Host-pathogen interaction to alter the gene expression (e.g. Epigenetic modulation)

Functional genomics and Epigenomics: In the context of gene function and disease.

Molecular cancer biology: Hallmarks of Cancer, Tumour cells, genetic basis of cancer, oncogene, a tumor suppressor and cancer manifestation, Epigenetic regulation of Cancer (histone modifications, DNA methylation, and non-coding RNA) and Cancer stem cells, DNA repair and cancer, chromatin and cancer, Epigenetic cancer therapeutics. Epigenetic Regulations of neurological disorders: Neurodevelopmental disorders (Autism)and neurogenerative Disorders (Alzheimer's, Huntington's, and Parkinson's disease) with special emphasis on underline epigenetic mechanisms.

JBL 303 Intracellular Traffic, transport and turnover

1 Intracellular Compartments and Protein Sorting

1.1 Beginnings of Cell Biology

1.2 Diversity of cell types, shapes and structures

1.3 The endo membrane system

1.4 Targeting molecules to specific location within the cell

2 Intracellular Vesicular Traffic

2.1 Exocytic pathway

2.2 Endocytic pathways

2.3 Intra-organelle trafficking

2.4 Cross-talk

3 Cellular degradative pathways

3.1 UPS

3.2 Autophagy

3.3 Others

Reference books:

1. Molecular Biology of the Cell by Alberts B, Johnson A, Lewis J, et al.
2. Molecular Cell Biology by Lodish H, Berk A, Zipursky SL, et al.
3. The Cell: A Molecular Approach by Cooper GM.
4. Trafficking Inside Cells: Pathways, Mechanisms and Regulation by Nava Segev

These topics will be dealt with discussions ranging from conceptualization to experimental approaches culminating in realization of current status and questions facing the said field. Further participation will be addressed through in-promptu quiz, paper/project presentations, model building and tests. Topics will also be taught by highlighting the landmark publications and the latest development in the field with an emphasis on experimental approach. There may be guest lectures by specialists in this field.

JBL 304 PRINCIPLES OF VIROLOGY

Course Overview:

Welcome to the “Principles of Virology” course! This course is intended for masters and graduate students who are interested in exploring the field of virology. It will include an overview of existing and emerging viruses, their replication strategies, immune evasion mechanisms, interactions with diverse hosts, pathogenesis and challenges in the development of vaccines and antiviral therapies. The course will also

discuss basic and high-throughput systems biology methods used to probe the viral life cycle and discover novel druggable virus-host interactions such as viral growth and titration assays, mutational analyses, genetic and proteomic screens with specific emphasis on the fundamental principles defining each technique. The course explores the past, present and future of Virology while promoting problem-solving and critical thinking skills through discussion of journal articles.

Learning goals:

By the end of the course,

1. Students will be able to explain the translation and replication strategies used by diverse viruses to establish infection in their hosts.

2. They will be able to communicate how viruses exploit host cellular machineries and evade host immune response mechanisms to establish infection.

3. They will be able to explain fundamental concepts underlying commonly used techniques in the field of virology and identify instances where these techniques have been applied to answer research questions in journal articles.

4. Students will be able to relate their learning to real-world challenges in the development of antiviral interventions.

Course material:

1.Principles of Virology – Jane Flint, Vincent Racaniello, Glenn Rall, Theodora Hatziioannou and Anna Marie Skalka

JCL 312 Chemical Biology

Introduction to the structural aspects of biomolecules: Periodic table of life, General Introduction

on structure and function of Proteins, nucleic acids, Carbohydrate, Lipids and their building blocks

and derived systems and materials; Structural forces in biological macromolecules.

Chemical and biological synthesis: Introduction to synthesis in chemical biology; Biological synthesis of biomolecules- proteins; nucleic acids, oligosaccharides and lipids; Chemical synthesis of peptides, proteins; nucleic acids; oligosaccharides; Chemical synthesis of lipids.

Manual to automated synthesis.

Protein engineering and in vitro evolution: General Introduction; Protein chemical ligation: Native Chemical ligation (NCL), Expressed protein ligation (EPL) and recent developments. Molecular biology as a toolset for chemical biology: Key concepts in molecular biology, tools and techniques in molecular biology, Cloning and identification of genes in DNA, Integrating cloning and expression, Site-directed mutagenesis. Molecular recognition and binding: Molecular recognition and binding in chemical biology, Theoretical models of binding, Analysing molecular recognition and binding, Biological molecular recognition studies.

Kinetics and catalysis: Catalysis in chemical biology, Steady state kinetic schemes, Pre-steady-state kinetics, Theories of biocatalysis.

Electron transfer Molecular selection and evolution: Chemical biology and the origins of life,

Molecular breeding; natural selection acting on self-organisation, Directed evolution of protein function, Directed evolution of nucleic acids, Catalytic antibodies. Molecular tools for imaging in chemical biology: Design and application of biological sensors.

Small molecular probes: chemical genetics: Chemical probes and tool compounds, diversity oriented synthesis (DOS), Biologically oriented organic synthesis (BIOS), Target discovery and validation: drug discovery, high throughput screening, Small molecule arrays, DNA arrays, protein arrays Chemical Biology in animal models: Genetic loss of function vs chemical perturbation, In vivo visualization of biological activities, Crossing the blood-brain barrier to engage targets in the brain, Chemical probes applied in tissues and living organisms.

Special topics: Activity based protein profiling and chemo proteomics; peptide-mimic-peptoid in drug discovery; Post-translational modifications; Bioconjugation (Bio-orthogonal conjugation chemistries, Labeling tools and methods etc.; Bioinformatics resources to aid chemical biology.

Reference Books:

1. Nucleic Acids in Chemistry and Biology- Blackburn, G. M. and Gait, M.

2. Introduction to Protein Structure. Garland- Branden, C. & Tooze, J.

3. Essentials of Chemical Biology: Structure and Dynamics of Biological Macromolecules-A.

D. Miller and J. Tanner.

4. The Organic Chemistry of Drug Design-Silverman, R. B.

5. Chemical Biology: From Small Molecules to System Biology and Drug Design - Stuart L.

Schreiber and others.

6. Chemical Biology: Approaches to Drug Discovery and Development to Targeting Disease –

Natanya Civjan

7. Posttranslational Modification of Proteins: Expanding Nature's Inventory - Christopher T.

Walsh

8. Primary literature, reviews will be used/referred extensively

JBL 305 RNA Biology Course

Unit 1- RNA and RNA-binding Proteins

Types of RNA; RNA editing and modifications; RNA structure; RNA folding; RBPs structure and function; RNA-RNA and RNA-RBP interactions; Principles of liquid-liquid phase separation; Dynamics of RNP granules formation and disassembly.

Unit 2- RNA synthesis and Processing

Mechanisms and dynamics of transcription initiation, elongation, and termination; Role of eRNA in transcription; Regulation of 5' capping, 3' end processing and polyadenylation; Splicing-spliceosome assembly, splicing mechanism, and alternative splicing; Cotranscrip zonal modifications.

Unit 3- RNA Transport and Localization

Mechanism and dynamics of nuclear RNA export; Role of nuclear pore; Modes of cytoplasmic RNA localization: selective entrapment, targeted decay and active transport.

Unit 4- Translation, Co-Translational Quality Control and RNA surveillance mechanisms Mechanism and dynamics of translation; Co-translational localization of RNA; Ribosome-associated quality control; Nonsense-mediated decay; Non-stop decay; No-Go decay; Modes of translational repression.

Unit 5- RNA Degradation

Nuclear and cytoplasmic degradation of mRNA; Deadenylation, Uridylation and readenylation; Decapping; Co-translational degradation; Targeted RNA decay; Lysosome mediated RNA decay.

Unit 6- RNA Homeostasis in Disease and RNA therapeutics Dysregulation of RNA homeostasis and its implications in diseases (cancer, neurodegenerative diseases), RNA-based therapeutic approaches and future directions.

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