Syllabus for M.Sc. in Virology and Immunology at Institute of Health Sciences, Presidency University

Course Code	Title	T/P/S	Credit	Marks
	SEMESTER I (Total credit: 20; Total mark: 250)			
VRIM0701	Biochemistry & Cell Biology	T	4	50*
VRIM0702	Microbiology & Recombinant DNA Technology	T	4	50*
VRIM0703	Introduction to Virology & Immunology	T	4	50*
VRIM0791	Biosafety & Practical on Biochemistry and Cell Biology	P	4	50
VRIM0792	Practical on Microbiology & Recombinant DNA Technology	P	4	50
	SEMESTER II (Total credit: 20; Total mark: 250)			
VRIM0801	Advanced Immunology	T	4	50*
VRIM0802	Advanced Virology	T	4	50*
VRIM0803	Bioinformatics & Genomics and Proteomics	T	4	50*
VRIM0891	Practical on Immunological Techniques	P	4	50
VRIM0892	Practical on Virological Techniques	P	4	50
	SEMESTER III (Total credit: 20; Total mark: 250)			
VRIM0901	Vector Biology & Vaccine	T	4	50*
VRIM0902	Medical Virology	T	4	50*
VRIM0903	Clinical Immunology and Neuroimmunology	T	4	50*
VRIM0991	Practical on Tissue Culture	P	4	50
VRIM0992	Practical on Immunology	P	4	50
	SEMESTER IV (Total credit: 20; Total mark: 250)			
VRIM1001	Biostatistics & Bioethics and Intellectual Property Right	T	4	50*
VRIM1091	Dissertation: Scientific writing and presentation	S	4	50
VRIM1092	Dissertation: Journal presentation and group discussion	S	4	50
VRIM1093	Dissertation: Thesis writing and defense	S	4	50
VRIM1094	Dissertation: Virus Research Laboratory Visit & Grand Viva	S	4	50
	Total credit and marks:		**80**	**1000**

Theory (T): Credit-4, Contact hour per week-4 h; Practical (P)/Sessional (S): Credit-4, Contact hour per week-8 h

*50 marks of theory paper are distributed as 35 marks for End semester exam and 15 marks for continuous assessment

Aims and Objectives:

The program aims to provide a basic and advanced level understanding about viruses and functioning of the immune system, to get acquainted with various techniques to study immunological and serological events and isolation and characterization of viruses with special emphasis on the different virus mediated pathogens of human, animal and plant origin. To get the knowledge about the importance of immune system in terms of homeostasis, defense against infectious disease, autoimmunity, and tolerance and for the overall exposure of the students towards various aspects of immunology and virology and to come up with a more rational and skilled approach in the field of biomedical research and academics.

Program outcomes (PO):

PO1: Fundamental knowledge development

Students should gain a comprehensive understanding of fundamental concepts in biochemistry, cell biology, virology, immunology, microbiology, and related fields, as well as their interrelationships.

PO2: Ability to critically analyze complex experiments and large data analysis

Analyze and interpret data from experiments and research projects using bioinformatics, genomics, proteomics, and statistical analysis.

PO2: Analytical skill development in research techniques

Students should be able to apply theoretical knowledge to develop analytical skills in recombinant DNA technology, immunological techniques, virological techniques, and other laboratory methodologies.

PO4: Effective communication and interpersonal skill development

Critically evaluate scientific literature and communicate findings effectively through scientific writing, presentations, and group discussions, primarily in English. If required, students should be able to communicate in any other language he/she feels comfortable with others.

PO5: Development of research ethics and biosafety practices

Demonstrate proficiency in biosafety practices and ethical considerations in scientific research, including intellectual property rights and bioethics.

Program specific outcomes

The overall exposure of students to modern bioinformatics tools, epidemiological characterization of infection and immunity will help the students pursue careers in public health and related areas along with biomedical research, academics, and industries.

PSO1: Understand the fundamental principles of biochemistry and cell biology and their applications in biotechnology and medical research through theoretical and laboratory-based knowledge

PSO2: Acquire knowledge of viral structure and replication of viruses, viral genomes, replication strategies, and mechanisms of viral transmission and persistence, viral pathogenesis, viral oncology, and antiviral drug development.

PSO3: Develop an in-depth understanding of basic and advanced topics in immunology, including antigen processing and presentation, immune regulation, host immune responses, immunological memory and immunotherapy strategies.

PSO4: Learn and apply bioinformatics tools and techniques for analyzing genomic and proteomic data, including sequence alignment, gene prediction, and protein structure prediction and relationships relevant to virology and immunology research.

PSO5: Understand the biology and ecology of vectors and vector-borne diseases, including transmission dynamics and vector control strategies, evaluate vaccine design and development strategies, viral disease epidemiology, diagnosis, and management,

PSO6: clinical applications of immunology, including diagnostic testing, immunodeficiency disorders, autoimmune diseases, and allergic reactions, principles of neuroimmunology

PSO7: Develop proficiency in biostatistics and data analysis techniques, understand ethical considerations in biomedical research, demonstration of research, science communications through various modes like writing, oral presentations and group discussions

Teaching-learning process

Teachers with expertise in a certain field will teach that module by having a proper idea of the curriculum, assessing learning needs, and establishing specific learning objectives. Teachers will be in continuous interaction with the students so that the various teaching and learning strategies can be implemented, while maintaining the students' motivation and curiosity about the subjects. Special care will be taken for underperforming students to make them feel confident about the subject.

Mode of assessment

Teaching will include lectures (online or offline), hands-on training, laboratory dissertation and research and diagnostic laboratory visit. Evaluations will be in two parts- internal assessment and final assessment/examination. Both time-bound written and oral examinations will be held. The presentations and interaction during presentations will be evaluated in an objective manner. Quizzes and group discussion will be conducted for continuous assessment. Regular performance for the laboratory courses will also be assessed in an objective manner.

SEMESTER I

VRIM0701

A. Biochemistry **32 h**

Unit I: Chemical basis of life

Enthalpy, entropy and free energy; Spontaneity and equilibrium; Colloids, Micelle; Phase diagram of water, buffers and pH, ionic strength, maintenance of blood pH; Ionic and covalent bonds, Van der Waals forces, hydrogen bonds; Polarity and dipole moment; Hydrophobicity; Principles of absorption spectroscopy- Beer-Lambert's law; Chemical kinetics- order, rates and rate constant, Arrhenius equation

Molecular conformations; Basic stereochemistry and its importance in biotechnology

Unit II: Introduction to Biomolecules

Carbohydrates, Lipids and Vitamins

Unit III: Structure and function of nucleic acids, and proteins

Structure and function of nucleic acids, difference in RNA and DNA structure; A, B and Z-DNA Structure of amino acids and peptides - Ramachandran plot, secondary and tertiary structures

Unit IV: Enzymology

Structure, classification and general properties of enzymes; Enzyme substrate complex; Enzyme kinetics and inhibition, Coenzyme and Cofactors, Mechanism of enzyme action and regulation.

Unit V: Bioenergetics

Respiration (aerobic and anaerobic)- glycolysis, fermentation, Krebs cycle, gluconeogenesis, Oxidative phosphorylation

B. Cell Biology **32 h**

Unit I: Cellular organization and cytoskeleton

Cellular organelles, cell wall, extracellular matrix; Prokaryotic cells and components; Structure of cell membrane, Cell-cell and Cell-matrix interaction; Cytoskeleton and motor proteins; Microscopic techniques to visualize cells and organelles

Unit II: Cell Cycle and Cellular activities

Mitosis and meiosis and their regulation; Cell cycle and its regulation, checkpoints, aneuploidy; Apoptosis, Necrosis and Autophagy; Proliferation and differentiation

Unit III: Cell signaling and communication

Signaling molecules; Receptors- G-protein coupled receptor, Receptor Tyrosine Kinase (RTK), cytokine receptors; Pathways of intracellular signal transduction; Regulation of hematopoiesis

Course Outcome (CO)

On completion of this course, students will be able to

- Understand the fundamental knowledge about the role of biomolecules as building blocks in cellular

processes, molecular basis of essential and major biochemical processes.

- Develop critical thinking abilities about the fundamental biochemical and cellular processes of life.
- Gain analytical skills to understand the cellular processes through chemical and biological perspectives.

VRIM0702

A. Microbiology **32 h**

Unit I: Microbes and their general characteristics

Origin of life: Miller–Urey experiment; Evolution of prokaryotes and eukaryotes, Endosymbiotic theory, Prokaryotic diversity and taxonomy. Culture dependent and independent approach; Polyphasic taxonomy, species concept.

Morphology and ultra-structure of Bacteria, cellular component, flagella, pili, fimbriae, extracellular layers, cell wall, cell membrane, plasmids and episomes, endospore, cysts, bacterial chromosome, inclusion bodies and pigment; Growth kinetics and bacteria cultivation: Aerobic and anaerobic cultures, different phases of growth. Batch, continuous and synchronous culture, Chemotaxis (signal transduction in microbes), quorum sensing, biofilm formation, Phototaxis, magnetotaxis.

Extremophiles, Archaeal diversity, and characters; Virus- Classification, capsid, envelope, and genetic material; General characteristics and importance of protozoa, algae, fungi

Unit II: Antimicrobial agents and chemotherapy

Discovery of Chemotherapy, Magic bullets

Antibiotics: Antibiotic resistance crisis, Multidrug resistance in microbes, Mechanism of action of antibiotics (Penicillin, Streptomycin, Rifampicin, cepahlosporin, fluroquinoline,isoniazid, etc) Antimicrobial spectrum, Antimicrobial resistance vs tolerance,

Methods of sterilization, disinfection, antimicrobial agent (antiseptics, sanitizer, germicide, antimicrobial agent), Chemical control- dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents. Assessment of chemical disinfectant, chemotherapeutic agents-sulphonamides.

B. Recombinant DNA technology **32 h**

Unit I: Recombinant DNA technology

Restriction endonucleases, restriction mapping, DNA and RNA modifying enzymes (viz. polymerase, reverse transcriptase, ligase, alkaline phosphatases, terminal transferase, nuclease) Vectors (viz. Plasmid, Cosmid, Fosmid, Phagemid, BAC, YAC, PAC, HAC, and shuttle vectors).

Cloning methods (directional and gateway), introducing engineered plasmids into a bacterial cell-transformation, conjugation, and transduction; Identification and analysis of recombinant DNA clones.

Expression vectors- bacterial, yeast, insect, mammalian and plant expression systems; Yeast two-hybrid systems; Phage display

Construction of cDNA and genomic DNA libraries; use of transposon in genetic analysis; Genetic manipulation of microorganisms and strain improvement – Knock-down and knock-in system.

Unit II: Techniques in genetic engineering

PCR- designing primers; Different types of PCR- Allele Specific, Assembly, Asymmetric, Colony, Helicase dependent, Hot-start, Inverse, Methylation specific, multiplex, nested, Quantitative/Real-Time, RT-PCR,

touchdown, touch up, VNTR etc. 5'-/3'-RACE, site-directed mutagenesis
Application of PCR in molecular diagnostics.
Methods of nucleic acid detection, Denaturing gradient gel electrophoresis (DGGE), DNA-protein interaction study - EMSA, DNA foot-printing; S1 nuclease mapping, RNase protection assay
Strategies of gene delivery - chemical, physical or mechanical method), Lentiviral/retroviral vectors and their usage in gene manipulation and delivery. Genome editing tools – CRISPR/Cas9, TALENs, ZFNs
Techniques in gene expression analyses - Reporter gene, Northern blot, Fluorescent in situ hybridization, Reverse transcription PCR, SAGE, DNA microarray, Tiling array, RNA-Sequencing

Course Outcome (CO)

On completion of this course, students will be able to-

- Gain a fundamental understanding of prokaryotic life, antimicrobial agents, chemotherapy to address the challenges posed by antimicrobial resistance and infectious diseases in various contexts.
- Gain critical thinking ability to understand different strategies of recombinant DNA technology (RDT) starting from restriction mapping of DNA to the most recent genome editing techniques, and genetic engineering in human health.
- Develop analytical skills to apply those continuously evolving RDT strategies such as PCR, real-time PCR, gene sequencing etc in emerging existing problems of human health and diseases.

VRIM0703

A. Introduction to Virology **32 h**

Unit I: Fundamental concepts in Virology

History and principles of virology, molecular biology of bacterial virus, viral classification, nomenclature, taxonomy; viral strategies for attachment and entry, different strategies for viral replication - the Baltimore Classification System; Basic immune response to viral infection, general virus pathogenesis; virus structure and morphology;

Unit II: Virological Methods

Cultivation and purification of viruses: Different *in vivo*, *in vitro* and *in ovo* growth systems for bacterial, plant and animal viruses, determination of yields; Purification of viruses using ultracentrifugation technique.
Immunological techniques: Immunodiagnosis, haemagglutination and haemagglutination inhibition assays, complement fixation, neutralization, western blot, radio-immunoprecipitation (RIPA) assay, single radial immunodiffusion (SRID) assay, flow-cytometry, immunohistochemistry (IHC), immunofluorescence assay (IFA).
Nucleic acid based techniques: Nucleic acid hybridization, PCR, microarray and sequencing.
Microscopic techniques: Fluorescence, confocal and electron microscopic techniques—principles and applications.
Analytical techniques: Chromatography techniques, membrane filtration, NMR, X-ray Crystallography. Emerging techniques in viral diagnostics

B. Introduction to Immunology **32 h**

Unit I: Components of the immune system

History of Immunology, innate immune response (PRRs, Neutrophils, Dendritic cells), complement system, humoral and cellular immunity and its components (T and B cell signaling)

Unit II: Cells and organs of the immune system

Overview of lymphoid system, cells of the immune system, primary and secondary lymphoid organs, tertiary lymphoid tissues

Unit III: Antigen and antibodies

Antigen concept, criteria of antigens, immunogen, antibodies (structure, specificity, diversity), antigen-antibody interactions.

Course Outcome (CO)

On completion of this course, students would be able to understand-

- Fundamental concepts of viruses, their origin, mode of replication, isolation, cultivation, characterization of viruses. Students will be able to understand the basis of immunology, antigens and antibodies structure and diversity
- Gain critical thinking skills in the area of virology and immunology related to human health
- Develop analytical thinking skills to analyze the problems related to viral and immunological diseases in human health.

VRIM0791

Biosafety and Practical on Biochemistry and Cell biology **128 h**

Unit-1: Principles and demonstration of Biosafety

Chemical and biohazard safety; Safety measurement for radioactive material; Social responsibility and Whistleblowing;

- Demonstration of biosafety and chemical safety, Use of PPE

Unit-2: Practical on Biochemistry and Cell biology

1. Aseptic techniques in biology- a) Preparation of bacterial growth medium and autoclaving and b) Preparation of buffer and sterile filtration
2. Determination of unknown protein concentration by absorption spectroscopy
3. Extraction of cellular protein, and quantitation using Bradford method
4. Quantitative analysis of amino acids, nucleic acids (DNA and RNA), carbohydrates and lipids
5. Separation of circular and linear DNA by agarose gel electrophoresis
6. Determination of pH optima, Km, Vmax and Kcat of an enzyme (viz. alkaline phosphatase)
7. Microscopic observation of subcellular structures/organelles

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with various lab safety protocols, basic laboratory instruments, their care and usage protocols, and measurement of the necessary parameters
- Utilize the basic knowledge in carefully and analytically conduct different experiments of biochemistry and cell biology

VRIM0792

Practical on Microbiology and Recombinant DNA Technology **128 h**

1. Preparation of competent *E. coli* cells
2. Transformation of competent *E. coli* cells with a plasmid to determine transformation efficiency
3. Determination of bacterial growth curve
4. Microbiological assay of antibiotics (MIC and Paper disc)
5. Bacterial culture preservation (-80°C glycerol stock) & revival
6. Plasmid isolation and restriction digestion – mapping
7. Gene cloning and recombinant screening
8. Genomic DNA extraction from mammalian cells
9. Primer designing using web-based tools for gene cloning and real-time PCR detection
10. RNA and cDNA preparation - Reverse Transcriptase PCR and Real-Time PCR (qPCR)
11. Molecular marker detection – RFLP
12. Concept of lac-operon: a) Lactose induction of b-galactosidase, b) Glucose Repression

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with laboratory instruments used to analyze macromolecules such as DNA and RNA
- Carefully and critically conduct different experiments utilizing various RDT techniques and concept of genetics to analyze those macromolecules

SEMESTER II

VRIM0801

Advanced Immunology **64 h**

Unit I: Receptors and Signaling

T-cell and B-cell receptors, receptor ligand interaction, signaling in T-cell and B-cell, Cytokines and chemokines

Unit II: Immunological memory

Development of T and B cells. T and B cell activation, differentiation and memory

Uni III: Antigen processing and presentation

Major histocompatibility complex, MHC restriction, Antigen processing and antigen presentation (endogenous and exogeneous processing pathways), Tolerance, Establishment and maintenance of tolerance, central and peripheral tolerance

Unit IV: Hypersensitivity, inflammation and transplantation immunology

Type I (Allergy), Type II (antibody mediated) and Type III (immune complex mediated) and Type IV (delayed type) hypersensitivity reaction, chronic inflammation, autoimmunity, transplantation immunology

Course Outcome (CO)

1. Understand T-cell and B-cell receptor structures and signaling pathways, as well as the development and function of immunological memory.
2. Explain antigen processing and presentation, including the role of MHC molecules and mechanisms of immune tolerance.
3. Identify and differentiate between hypersensitivity reactions and understand the principles of inflammation and autoimmunity.
4. Analyze transplantation immunology concepts, including graft rejection mechanisms and tolerance induction strategies.
5. Apply critical thinking skills to interpret immunological data and communicate findings effectively in both written and oral formats.
6. Collaborate with peers to explore and analyze complex immunological concepts and phenomena.

Demonstrate ethical awareness in the conduct of research and clinical practice in immunology-related contexts.

VRIM0802

Advanced Virology **64 h**

Unit I: Virus-cell interaction

Viral receptors, virus-cell interactions, receptor mediated endocytosis, virus uncoating mechanisms. Nuclear import of viral nucleic acids, replication sites and their characterization, IRES, replicons, transport of viral proteins.

Host cell response to viral infections - apoptosis, necrosis, stress response, alteration of different cell signaling pathways; cellular basis of transformation, types of cytopathic effects.

Mechanisms of viral persistence and latency-*in vivo* and *in vitro* models.

Unit II: Virus Replication

General strategies, replication of positive sense RNA virus (HCV and corona); replication of negative sense RNA viruses (VSV and influenza); replication of double stranded RNA virus (Rotavirus), replication of ambisense RNA virus (LCM); and replication of retroviruses (HIV and HTLV); replication of double stranded DNA viruses (SV40, herpes), ssDNA virus (AAV); Prion proteins.

Course Outcome (CO)

Upon completion of this course, students will be able to

1. Understand the intricate dynamics of virus-cell interactions.
2. Analyze host cell responses to viral infections.
3. Explore mechanisms of viral persistence and latency.
4. Comprehend the general strategies of virus replication and replication strategies of specific virus types.

Overall, students will gain a comprehensive understanding of advanced virology, including virus-cell interactions, host responses to viral infections, mechanisms of viral persistence and latency, and the replication strategies of various virus types. They will be equipped with the knowledge and analytical skills necessary to contribute to research in virology and related fields.

VRIM0803

A. Bioinformatics **32 h**

Unit I: Introduction to Bioinformatics

Scope and applications of bioinformatics, global bioinformatics scenario, definition of terms- orthology, paralogy, xenology and analogy; Similarity and identity

Introduction to databases- types of databases, information retrieval system (Entrez and SRS) and database collaboration, file formats, sequence, structure and pathway databases of nucleotides and proteins

Unit II: Application of bioinformatics

Multiple Sequence Alignment, progressive method, iterative method; data searching tools for homologous sequences analysis - BLAST & FASTA; Sequence editors - BioEdit, BoxShade etc

Prediction tools- profile, motifs, domains and feature identification

Phylogenetic prediction: Phylogenetic tree construction - distance based method and character-based methods; Gene prediction, protein structure & functions prediction, Phylogenetic analysis package – MEGA

Unit III: Protein modeling

Protein structure prediction: protein folding and model generation; secondary structure prediction; Homology modeling: potential applications; Protein function prediction, In silico drug design

B. Genomics and Proteomics **32 h**

Unit I: Genomics

Concept of Genomics, Genome mapping – Genetic and physical mapping, Genetic markers; methods and techniques used for gene mapping, molecular/genetic markers in genome analysis – RFLP, AFLP, RAPD, VNTR, Microsatellite polymorphism, SSR, SNP; molecular markers linked to disease resistant genes Application of

molecular markers in forensic, disease prognosis, genetic counseling and pedigree analyses; linkage analysis, cytogenetic techniques, Fluorescent In Situ Hybridization in gene mapping, somatic cell hybridization, and radiation hybrid maps

DNA-Sequencing – Maxam Gilbert and Sanger Dideoxy methods, Automated sequencing; Genome sequencing projects for microbes, plants and animals; Human Genome Project (HGP), Next-generation sequencing – Roche/454 pyrosequencing, Illumina (Solexa), SOLiD, Ion Torrent; Application of Next-Gen Sequencing technologies – Whole genome, Exome, 16S rRNA amplicon, RNA-Seq, ChIP-Seq, Methyl specific sequencing etc. Functional genomics, Application of genomics, Epigenomics, Proteogenomics, Structural genomics, Metagenomics, Viromics, Comparative genomics, Personal Genomics, Pharmacogenomics/pharmacogenetics, Pharmacodynamics.

Unit II: Proteomics

Concept of Proteomics; Sample preparation, Gel-based proteomics - isoelectric focusing and two-dimensional gel electrophoresis (2-DGE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), mass spectrometry – different types of mass spectrometers (MALDI-TOF Q-TOF, LC-MS), protein and peptide sequencing; Multidimensional proteomics: SELDI-TOF. Quantitative proteomics - stable isotope labelling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ); Label-free proteomics.

Course outcome (CO):

On completion of this course, students would be able to:

1) Efficiently access and analyze data from diverse biological databases
2) Comprehend the principles, algorithms, and software tools pertinent to sequence alignment and phylogeny analysis
3) Develop hands-on proficiency in predicting protein structure through diverse bioinformatics tools
4) Understand the concept of genome mapping techniques and familiarity with the application of molecular markers in various fields such as forensics and disease prognosis
5) Develop proficiency in DNA sequencing methods and their application in genome sequencing projects and next-generation sequencing technologies
6) Attain familiarity with gel-based proteomics methods including isoelectric focusing and two-dimensional gel electrophoresis (2-DGE), as well as advanced techniques such as two-dimensional fluorescence difference in-gel electrophoresis (DIGE)
7) Understand the concept of mass spectrometry and its various types (MALDI-TOF, Q-TOF, LC-MS), as well as protein and peptide sequencing methods for proteomic analysis

VRIM0891

Practical on Immunological Techniques **128 h**

1. Isolation and purification of IgG from serum
2. Precipitation reaction by double immunodiffusion (Ouchterlony method) and radial immunodiffusion (Mancini's method)
3. Detection of antigens or antibodies by ELISA – Indirect and Sandwich ELISA
4. Blood typing – A, B, AB and O
5. Immunoblotting assay for protein detection

6. Immunoprecipitation assay

Course Outcome (CO):

On completion of this course, students should be able to-

1. Learn the techniques for isolation and purification of antibodies.
2. Gain hands-on experience about the application of immunological techniques for diagnostic purposes such as immunodiffusion, ELISA, blood typing.
3. Understand the techniques for estimation and characterization of proteins.
4. Acquire knowledge about the study on interaction between molecules.

VRIM0892

Practical on Virological Techniques **128 h**

1. Phage titration
2. Latex agglutination
3. Transduction
4. Isolation and amplification of bacteriophages from sewage water
5. PCR based detection techniques

Course outcome (CO):

On completion of this course, students will be able to:

1. Gather hands on experience of measuring the concentration of bacteriophage particle in a solution
2. Learn the method of isolation and amplification of the unknown strain of bacteriophages from the sewage water
3. Understand the method of checking the presence of antibody against particular viral antigen in body fluids
4. Acquire the hands on knowledge about the viral genetic material transfer from one bacterium to another
5. Gain practical knowledge about the methods of virus detection in different clinical samples

SEMESTER III

VRIM0901

A. Vector Biology **32 h**

Unit I: Introduction to entomology

Introduction to the general entomology, morphology and classification of insects. Structure and function of other arthropods of medical importance. Methods for collecting arthropods and insects & their preservation, maintenance and transport.

Life cycle and biology of Aedes, Culex and Anopheles mosquitoes and their behavior & ecology with special reference to chikungunya, dengue, West Nile virus and Japanese encephalitis.

Biology, morphology and disease relationship of sandflies- sandfly fever and chandipura. Biology and morphology of lice, fleas and culicoides. Biology, ecology and life history of ticks -with special reference to Kyasanur Forest Disease (CCHF, KFD). Biology & morphology of mites. Zoonotic pathogens

Unit II: Vector-virus relationship and control of vector

Virus dissemination and mechanism of virus transmission in vectors. Natural cycle and maintenance of viruses in nature. Basis of vector competence, mechanical transmission and virus dissemination. Susceptibility-extrinsic and intrinsic factors. Xenodiagnosis (methods and application).

Various control strategies & environmental management, control in urban settings, at aquatic stages and of adult population, personal protection and insecticide resistance mechanism & control dynamics.

B. Vaccine **32 h**

Unit 1: Vaccinology

Types of Vaccine-recombinant DNA and protein-based vaccines; Peptide vaccines, conjugate vaccines, RNA Vaccines, Hybrid vaccine; role and properties of adjuvants, antibody engineering- chimeric and hybrid monoclonal antibodies.

Unit 2: Vaccine development and application

Biological basis of vaccine development, Novel strategies, Vaccine safety, Vaccine policy issues.

Unit 3: Vaccine trials and good clinical practice

Phases of vaccine trials, development of a vaccine protocol, product management, data collection and management, outreach and awareness

Course outcome (CO)

On completion of this course, students will be able to learn:

1. The mechanism of virus transmission via insect vectors.
2. How insect vectors propagate and grow in the environment?
3. The mechanism of entry of viral pathogens into corresponding vectors.
4. The various ways to prevent the growth of vectors and concomitant spreading of pathogens.
5. Principles of 'Immunization' to artificially develop immunity against infectious diseases.
6. Different types of vaccines, their formulation and excipients.
7. Commercialization of vaccines

VRIM0902

Medical Virology **64 h**

Unit I: Enteric virus diseases

Epidemiology of enteric viral diseases at National and International levels; enteric viral infections- Clinical course, disease burden, risk factors, prevention, and treatment.

Rotavirus diversity, emerging strains, immunopathogenesis and vaccines.

Other viruses associated with diarrhea and gastroenteritis: Adenoviruses, astroviruses, Norwalk and Sapporo-like viruses and other enteroviral diseases.

Polio & Non-polio Enteroviruses.

Unit II: Respiratory and Hepatic virus diseases

Epidemiology of different respiratory and hepatic viral diseases at National and International levels; History, clinical features, epidemiology of influenza, RSV and other respiratory diseases; Biology and pathogenesis of Coronavirus (SARS, MERS and SARS-CoV2), Metapneumovirus and human rhino virus.

Pathogenesis of different hepatitis viruses (HAB, HBV, HCV and HEV)

Differential diagnosis and vaccines against viral hepatic and respiratory diseases.

Unit III: Virus haemorrhagic fever and AIDS

Epidemiology of virus haemorrhagic fever and retroviral diseases at National and International level

Common clinical features of Viral Haemorrhagic Fevers, history and Disease burden, risk factors, replication strategy, pathogenesis, prevention and treatment of Dengue, Yellow Fever, Kyasanur forest disease, Chikungunya, Ebola.

Introduction to retroviruses; Origin of HIV-1, HIV-2, SIV, immunopathogenesis, diagnosis and prevention.

Unit IV: Oncogenic viruses and cancer

History of oncogenic viruses, viral oncogenesis, Different avian, animal and human oncogenic viruses; impact of oncogenic viruses in understanding cancer biology, cell transformation, proto-oncogene, oncogene and tumor suppressor genes; Metastasis.

Course Outcome (CO)

On completion of this course, students would be able to understand:

1. Understand the epidemiology of enteric viral diseases, including their prevalence, distribution, and modes of transmission, both nationally and globally.
2. Analyze the epidemiology of various respiratory and hepatic viral diseases, including the prevalence, transmission dynamics, and associated risk factors.
3. Understand the historical context and current challenges associated with viral pandemics, such as influenza outbreaks and coronavirus disease outbreaks.
4. Explore the epidemiology of virus hemorrhagic fevers and retroviral diseases, including their geographic distribution, transmission patterns, and risk factors for infection.
5. Evaluate the impact of viral hemorrhagic fevers and retroviral diseases on global health, including their potential for causing outbreaks and public health emergencies.
6. Analyze the epidemiology of virus-induced cancers, including their geographic distribution, risk factors, and preventive measures.
7. Understand the molecular mechanisms underlying viral oncogenesis, including viral integration into

the host genome, viral oncoprotein expression, and host immune evasion strategies.

VRIM0903

Clinical Immunology and Neuroimmunology **64 h**

Unit I: Host pathogen interaction

Mechanism of microbial pathogenesis (bacteria, virus, yeast, parasites), genetics of pathogenicity and virulence. Alteration of host cell behavior by pathogens, pathogen-induced diseases: bacterial (Tuberculosis, Helicobactor, Salmonella, Vibrio cholerae), Viral (Hepatitis, HIV, Ebola, Zika, Influenza and coronavirus). Hospital-acquired infections; Pathogenic fungi; Pathogenicity of parasites (Entamoeba, Naegleria, Leishmania, Trypanosoma, Plasmodium).

Unit II: Host-Microbiome Interaction

Microbial communities in the human body, role of Microbiota in human health; Microbial interactions with the host immune system; gut-brain axis; microbial diversity analysis; potential for microbiome directed therapeutics to impact human disease.

Unit III: Immunotherapies

Therapeutic interventions in human cancers

Unit IV: Neuroimmunology

Cells of the CNS, blood brain barrier, Encephalitis, encephalopathy and meningitis, Neurotropic viruses (Japanese encephalitis and West Nile viral infection, Chandipura virus, Encephalitis caused by Nipah and Hendra virus, Herpes virus encephalitis. HSV, West Nile Virus, Zika virus, etc), Neuroinflammation in diseases-Multiple sclerosis, dementia and other neurodegenerative diseases

Course Outcome (CO)

Upon completion of this course, students will:

1. Demonstrate comprehensive knowledge of the mechanisms underlying host-pathogen interactions, including the genetic basis of pathogenicity and virulence for various microbial agents such as bacteria, viruses, yeasts, and parasites.
2. Analyze the alterations in host cell behavior induced by pathogens, and understand the pathogenesis of diseases caused by bacterial, viral, fungal, and parasitic infections.
3. Evaluate the impact of hospital-acquired infections on public health and healthcare systems, and assess strategies for their prevention and management.
4. Assess the potential of microbiome-directed therapeutics.
5. Evaluate various immunotherapeutic interventions for human cancers, including the mechanisms of action and their clinical applications.
6. Analyze the pathogenesis, clinical manifestations, and management of neuroinflammatory diseases and critically assess the impact of neurotropic viruses.

VRIM0991

Practical on cell culture and viral infection **128 h**

1. Preparation of media, thawing of cells, maintaining cells and freezing cells.
2. Counting cell using hemocytometer
3. Imaging different mammalian cells
4. Cytotoxicity assay of mammalian cell lines through MTT assay
5. Isolation of PBMCs from fresh blood
6. Induction of EBV from HEK293T cells harboring BAC-EBV or B95.8 marmoset cell line
7. Infection of PBMCs with EBV and evaluation of infection using microscopy and qPCR techniques.
8. Propagation of virus
9. Plaque assay

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with mammalian cell culture and associated techniques to grow the cells, perform routine tests to detect cell viability.
- Detect viral infection in different diseases

VRIM0992

Practical on Immunology **128 h**

1. Phagocytosis induction and analysis by fluorescence microscopy
2. Macrophage activation with LPS and biochemical assays
3. Isolation of single cell suspension from spleen and staining of cells
4. Identification of T and B cell markers using flow cytometry
5. Immunohistochemistry of lymphoid tissues

Course Outcome (CO):

On completion of this course, students should be able to-

- Familiarize with laboratory instruments and techniques used to perform various immunological and immunodiagnostic studies

SEMESTER IV

VRIM1001

A. Biostatistics **32 h**

Unit I: Basics of Biostatistics

Principles and practice of statistical methods in biology; samples and populations; Data collection and graphical representation

Measures of central tendency- mean, median, mode; Measures of dispersion- range, mean deviation, coefficient of variation; standard deviation, standard error.

Unit II: Application of Biostatistics

Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, calculation of Karl-Pearson's coefficient of correlation; analysis of variance, factorial experiment design; Use of biostatistics software.

B. Bioethics and Intellectual Property Rights **32 h**

Unit I: Bioethics

Overview of research misconduct, rules and regulations in India; data management; privacy policies, institutional and professional code of ethics and standards of practice

Ethical use of bioresources- agricultural ethics and transgenic crops, animal subjects; Protection of human subjects; stem cell ethics; eco sourcing-code of practice

Mentor-mentee responsibilities; Collaboration, Bias, Conflicts of Interest; Publication- plagiarism

Cyber Security Awareness; understanding phishing attacks, malware, antivirus software.

Unit II: Intellectual Property Right (IPR)

Concept and provisions of IPR; Patents, Trademarks, Copyright, Conditional information, Breeder's right. Patent-types, scope, criteria, applying for a patent. Protection of Biotechnological inventions.

Unit III: Quality, Ethical and Legal Implications

International standards, Quality accreditation and certification – NABH standards

Quality checks - quality assurance samples, master sample, internal controls, techniques and concepts of statistical quality control and statistical process control; Operational aspects – calibration, accuracy checks of quality control; FDA and EPA regulations for clinical use of DNA tests and commercial release of chemical products.

Course Outcome (CO):

On completion of this course, students should be able to-

- Understand basic principles of Statistics and its application
- Familiarize with various ethical rules related to research activities in industry or academia
- Apply the essentials of product development in various industries
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents

VRIM1091

Dissertation: Scientific writing and presentation

Preparation of a hypothesis-driven research proposal on biomedical science, which should include a brief literature review, origin of proposal, significance and potential impact of the proposed research on ongoing scientific advancement, experimental design, pitfalls and alternative strategies (following the SERB format for three years of research funding); Both the written proposal, and an oral presentation with logical framework of the proposed research will be assessed

Course outcome:

On completion of the course, students will be able to:

1. Identify a specific research question, design a study and write a complete research proposal on their own
2. Learn the process of application of an extramural grant to the funding agencies
3. Learn how to present and defend their work that was proposed in the proposal in front of expert members

VRIM1092

Dissertation: Journal presentation and group discussion

Will learn to read, understand and present recent research articles in biomedical sciences or related to virology or immunology during the weekly departmental seminar

Course outcome (CO):

On completion of course students would be able to gain expertise on:

1. Understanding the highlights, strengths and weaknesses (if any) of a published article
2. Presentation of original research works from a published manuscript in front of a learned audience
3. Successfully facing the questions-and-answers session, preceded by presentation

VRIM1093

Dissertation: Thesis writing and defense

As part of an individual laboratory, students will be engaged in understanding the major research question of that lab, and will perform a project, which will train them in executing standard laboratory protocols, related techniques and technologies, data collection, data analysis, and ethical aspects of research. A written dissertation, and an oral presentation on the project will be assessed

VRIM1094

Dissertation- Virus Research Laboratory Visit and Grand Viva

A. Virus Research Laboratory Visit

In this module the students will visit the virus research laboratories to get the idea of laboratory facilities required for working with viruses and associated various safety measures.

B. Grand Viva

This module will cover all the topics that have been covered in the two years of the course and the students' performance will be evaluated both on their thinking and analytical abilities in front of an expert panel of both internal and external members.

Course Outcome (CO) of Dissertation (VRIM1091-4):

On completion of this course students should be able to-

- Apply all the acquired knowledge throughout the courses in understanding and executing one small topic of research of their own interest in their choice of lab
- Critically read, analyze and present a recently-published literature of related topic
- Build a novel hypothesis-driven research proposal with proper plan of experimental methods
- Generate a novel biotechnological entrepreneurship idea that may be readily implemented
- Acquire presentation skills and etiquette of gathered knowledge, journals, own research idea and data, and novel plans of research and entrepreneurship idea

Suggested Readings:

1. Voet, D., & Voet, J. G. Biochemistry (4th ed) Hoboken, NJ: J. Wiley & Sons.
2. Stryer, L. Biochemistry. (2019) New York: Freeman.
3. Lehninger, A. L. Principles of Biochemistry; New York, NY: Worth.
4. Ebbing, D. D., & Wrighton, M. S. (1990). General Chemistry. Boston: Houghton Mifflin.
5. Alberts, B. et al. Molecular Biology of the Cell (6th Ed.). New York: Garland Science.
6. Cooper, G.M., Hausman, R.E. The Cell: a Molecular Approach (5th edition). Sinauer Associates
7. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman
8. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl and Thomas Brock, Brock Biology of Microorganisms, 14th Edition; Pearson.
9. Willey J, Sherwood L and Woolverton CJ. Prescott's Microbiology, 10th Edition; McGraw-Hill.
10. Salle AJ, Fundamental Principles of Bacteriology, 7th edition, , Mc-Graw Hill Book Company Inc.
11. Black, J.G., Black, L.J. Microbiology Principles and Explorations (9th Ed.). Wiley
12. Primrose & Twyman. Principle of gene manipulation and genomics (7th Ed.); Wiley Blackwell
13. T. A. Brown. Gene cloning and DNA analysis: An introduction (6th Ed.); Wiley Blackwell
14. Clark DP, Pazdernik NJ, Biotechnology: Applying the Genetic Revolution, (2010), Elsevier Science.
15. Kurnaz IA, Techniques in Genetic Engineering, (2015), CRC Press.
16. Flint SJ, Racaniello VR, Rall GF, Skalka AM, Principles of Virology (Vol. 1-11) (4th Ed), ASM Press
17. Dimmock et al. Introduction to Modern Virology. (5th Ed). Blackwell Scientific Publication.
18. Punt J, Stranford S, Owen J, Jones P, Kuby Immunology (8th Ed). Macmillan Learning
19. Delves PJ, Martin SJ, Burton DR, Roitt IM, Roitt's essential Immunology (13th Ed.). WILEY Learning
20. Abbas AK, Lichtman AH, Pillai S, Cellular and Molecular Immunology (10th Edition), Elsevier Health Sciences.
21. Lorkin L, Virology: Molecular Biology and Pathogenesis, (ASM Press)
22. Freshney RI. Culture of Animal Cells: A Manual of Basic Technique.(7th Edition), Wiley.
23. Norkin LC, Virology: Molecular Biology and Pathogenesis, (2010), ASM Press,
24. Kennedy V, Fundamentals of Genomics, Larsen and Keller Education.
25. Brown TA. Genomes. 2nd edition. CRC Press.
26. Lesk, A.M. 2005, 2nd edition, Introduction to Bioinformatics. Oxford University Press.
27. Andreas D. Baxevanis, B. F. Francis Ouellette 2001 Bioinformatics: A Practical Guide to the Analysis of Genes, Wiley-Interscience
28. Durbin R., Eddy S., Krogh A. and Mithchison G. 2007 Biological Sequence Analysis, Cambridge University Press.
29. Clark DP, Pazdernik NJ. Biotechnology: Applying the Genetic Revolution; 2010, Elsevier Science.
30. Service MW, Service M, Medical Entomology for Students. (5th Edition), Cambridge University Press.
31. Eldridge BF, Edman JD, Medical Entomology, A Textbook on Public Health and Veterinary Problems Caused by Arthropods. (2nd Edition), Springer Netherlands.
32. Mullen GR, Durden LA, Medical and Veterinary Entomology. (2nd Edition), Elsevier Science.
33. Haller, D. The Gut Microbiome in Health and Disease, 2018, Springer
34. Kenneth J. J. Rothman. Epidemiology: An Introduction. (2nd Edition) Oxford University Press.
35. F. Javier Nieto FJ, Szklo M. Epidemiology: Beyond the Basics. (4th Edition) Jones & Bartlett Publishers.
36. Farkas DH, Wiedbrauk DL, Molecular Methods for Virus Detection, (Latest Edition). Elsevier Science.
37. Smyth CJ, Saunders JR, McCrae MA, Stow ND. Molecular Aspects of Host-Pathogen Interactions, (Latest Edition), Cambridge University Press.

38. Helenius A, Michael B. Oldstone A, Compans R W, Cell Biology of Virus Entry, Replication, and Pathogenesis. (Latest Edition). Wiley.
39. Cann A, Principles of Molecular Virology. (6th Edition), Elsevier Science.
40. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, (Vol. I, 8th Edn.). The World Press, Kolkata.
41. Chap T. Le and Lynn E. E. (2016): Introductory Biostatistics, Wiley
42. Goel. IPR Biosafety and Bioethics, (2013). Pearson
43. Furr A K, CRC Handbook of Laboratory Safety, (5th Edition), CRC Press.
44. Goel. IPR Biosafety And Bioethics, (2013 edition). Pearson