M.Sc. Virology Course Syllabus

From Academic year 2023-24
(As per NEP 2020)

Conducted at the
ICMR-National Institute of Virology (NIV)
130/1, Pashan-Sus Road,
Pashan, Pune 411 021

Under the aegis of
Department of Biotechnology
Savitribai Phule Pune University

ICMR-National Institute of Virology,

Under the aegis of Department of Biotechnology, SPPU

M.Sc. Virology Syllabus Structure (As per NEP 2020)

Semester I		
Core Courses		
Major Core- 10 (T) + 4 (P)		
Course Code	**Course Title**	**Number of Credits**
VR-111MC(T)	A] Cell Biology B] Tissue Culture	**2**
VR-112MC(T)	A] Basic Virology B] Virological Methods	**2**
VR-113MC(T)	Immunology-I	**2**
VR-114MC(T)	Basic Epidemiology and Biostatistics	**2**
VR-115MC(T)	Analytical Techniques	**2**
VR-131MC(P)	A] Tissue Culture Techniques B] Analytical Methods	**2**
VR-132MC(P)	A] Propagation of Viruses B] Virus/Antigen Detection	**2**
Major Elective 2 (T) + 2 (T/P) (Any 2 Courses)		
VR-116ME(T)	A] Vector Biology B] General Biochemistry	**2**
VR-117ME(T)	Microbiology	**2**
VR-133ME(P)	A] Entomological Methods B] Statistical Methods	**2**
VR-150(RM)	**Research Methodology**	**4**
		Total Credit 22

Semester II		
Core Courses		
Major Core- 10 (T) + 4 (P)		
Course Code	**Course Title**	**Number of Credits**
VR-211MC(T)	Molecular Biology	**2**
VR-212MC(T)	A] Antivirals B] Viral Vaccines	**2**
VR-213MC(T)	A] Bioinformatics B] Applied Epidemiology	**2**
VR-214MC(T)	A] Virus Replication B] Virus Cell Interaction	**2**
VR-215MC(T)	Recombinant DNA technology	**2**
VR-231MC(P)	A] Serological Methods B] Immunological Techniques	**2**
VR-232MC(P)	A] Epidemiological Data Management and Analysis B] Practical Bioinformatics	**2**
Major Elective 2 (T) + 2 (T/P) (Any 2 Courses)		
VR-216ME(T)	Immunology-II	**2**
VR-217ME(T)	Mathematical Biology	**2**
VR-233ME(P)	Biosafety and Biosecurity	**2**
VR-250(OJT)	**Internship/ On job Training (OJT)** **DBC- OJT- After completion of Sem II exam**	**4**
		Total Credit 22

Exit option: Award PG Diploma in Virology on completion of 44 credits after Three Year UG degree **OR** continue with PG second year.

Semester III		
Core Courses		
Major Core- 6 (T) + 8 (P)		
Course Code	**Course Title**	**Number of Credits**
VR-311MC(T)	A] Viral Enteric Diseases and Cancers B] Viral Hepatitis	**2**
VR-312MC(T)	A] Viral Haemorrhagic Fevers B] Viral Encephalitis	**2**
VR-313MC(T)	A] Viral Respiratory Diseases B] Exanthematous Diseases	**2**
VR-331MC(P)	Viral Enteric Diseases	**2**
VR-332MC(P)	Viral Hepatitis	**2**
VR-333MC(P)	Viral Respiratory Diseases	**2**
VR-334MC(P)	A] Viral Haemorrhagic Fevers B] Viral Encephalitis	**2**
Major Elective 2 (T) + 2 (T/P) (Any 2 Courses)		
VR-314ME(T)	A] Veterinary and Agricultural Viruses B] HIV / AIDS	**2**
VR-335ME(P)	HIV / AIDS	**2**
VR-336ME(P)	Special Techniques in Virology	**2**
VR-350(RP)	**Research Project I**	**4**
		Total Credit 22

Note: As per the provision in the credit framework, we have assigned more credits to the practical courses in place of theory since virology requires more hands on training. Total number of credits in the semester remains 22.

Semester IV		
Core Courses		
Major Core- 8 (T) + 4 (P)		
Course Code	**Course Title**	**Number of Credits**
VR-411MC(T)	Quality Control, Bioethics and IPR	**2**
VR-412MC(T)	Applications of R and Python software in biological sciences	**2**
VR-413MC(T)	Genomics and Transcriptomics	**2**
VR-414MC(T)	One Health	**2**
VR-431MC(P)	Applications of R and Python software in biological sciences	**2**
VR-432MC(P)	A] Molecular Techniques B] Biochemical Methods	**2**
Major Elective 2 (T) + 2 (T/P) (Any 2 Courses)		
VR-415ME(T)	Proteomics and Metabolomics	**2**
VR-416ME(T)	Nanobiotechnology and Biosensor	**2**
VR-433ME(P)	Genomics and Transcriptomics	**2**
VR-450(RP)	**Research Project II**	**6**
		Total Credit 22

Total 4 Semesters	**Major Core**	**Major Elective**	**Research Methodology**	**Internship On Job Training (OJT)**	**Research Project (RP)**	**Total Credit**
	54	**16**	**4**	**4**	**10**	**88**

2 Years- 4 SEM. Award PG Degree in Virology on completion of 88 credits after Three years UG Degree or 1 Year-2 SEM PG Degree (44 Credits) after Four-Year UG Degree

Notes: Abbreviations: T- Theory, P- Practical

M.Sc Virology: Semester I

Major Core

VR-111MC(T):A] Cell Biology B] Tissue Culture (2 Credit) (Theory)

A] Cell Biology:

1. Microscopy: a) Simple, b) Compound, c) Phase contrast [1 hr]
2. Cell ultra-structure and electron microscopy [3 hrs]
3. Structure and function of cellular organelles, cytoskeleton, biomembranes, cell adhesion and junctions, extracellular matrix. [3 hrs]
4. Cell division and cell cycle: Mitosis and meiosis, steps in cell cycle, regulation and control of cell cycle. [2 hrs]
5. Cell signaling: Cell-cell interactions, Cell surface, receptors and signal transduction [2 hrs]
6. Cell growth—hyperplasia, hypertrophy, transformation, development and differentiation—cell lineages, growth and differentiation [2 hrs]
7. Stem cells -adult and embryonic [1 hr]
8. Cell dynamics, cell death [1 hr]

Recommended Books:

1. Essential Cell Biology. Bruce Alberts, Dennis Bray, Keith Roberts, Julian Lewis, Martin Raff. Latest edition / Pub. Date: October 2003. Publisher: Taylor & Francis, Inc.
2. Molecular Cell Biology. Harvey Lodish, James Darnell, Paul Matsudaira, Arnold Berk, S. Lawrence Zipursky. Latest edition / Pub. Date: August 2003. Publisher: W. H. Freeman Company.

B] Tissue Culture:

1. Introduction to tissue culture: Principles of tissue culture, applications, maintenance of sterility, use of antibiotics, mycoplasma and other contaminations [3hrs]
2. Cell environment—nutritional requirements, substrates. [3 hrs]
3. In vitro cultures—primary, diploid and established cell lines, organ culture, cell types in culture. [3 hrs]
4. Cell characterization—karyotyping, growth rates, isoenzymes [2 hrs]
5. Large scale production—suspension cultures, microcarriers, hollow fiber reactors, etc. [2 hrs]
6. Quality assurance in animal tissue culture. [1 hr]
7. Generating a new cell line [1 hr]

Recommended Books:

1. Culture of Animal Cells: A Manual of Basic Technique. R. Ian Freshney. Latest edition / Pub. Date: September 2005. Wiley.
2. Culture of Cells for Tissue Engineering. R. Ian Freshney. Pub.Date: March 2006. Wiley.
3. Invertebrate Tissue Culture Methods. Jun Mitsuhashi. Latest edition /Pub. Date: February 2002. Publisher: Springer-Verlag New York, LLC.

VR-112MC(T): A] Basic Virology B] Virological Methods (2 Credit) (Theory)

A] Basic Virology

1. History and principles of virology, virus taxonomy, introduction to replication strategies. [6 hrs]
2. Virus structure and morphology. [4 hrs]
3. Viruses of veterinary importance and zoonotic viruses. [6 hrs]
4. Principles of bio-safety, containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory. [4 hrs]
5. Plant viruses, plant virus propagation. [4 hrs]
6. Bacteriophages, bacteriophage propagation and viroids. [3 hrs]
7. Oncolytic viruses [3 hrs]

Recommended Books:

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.
2. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka. Latest edition / Pub. Date: December 2003 Publisher: American Society Microbiology---Chapters 3-13.
3. Laboratory Animal Medicine: Principles and Procedures. Margi Sirois. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.
4. Guides for the Care and Use of Laboratory Animals. National Research Council. Latest edition / Pub. Date: January 1996. Publisher: National Academy Press.
5. Laboratory Biosafety Manual, WHO, http://www.who.int/csr/resources/publications/biosafety/who_cds_csr_l yo_20034/en/
6. Virology: 1994. 3rd ed. FrankelConrat et al, Prentice Hall.
7. Introduction to Modern Virology. 2001. 5th ed. Dimmock et al., Blackwell Scientific Publ.
8. Basic Virology, 1999. By Waginer and M. Hewlett, Blackwell Science Publ.

B] Virological Methods

1. In vivo, in vitro and in ovo systems for virus growth, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods. [5 hrs]
2. Introduction to PCR, ELISA [4 hrs]

3. Immunodiagnosis, Immunofluorescence assay, haemagglutination and haemagglutination-inhibition tests, Complement fixation, neutralization, Radioimmunoprecipitation assay and immunohistochemistry. [6 hrs]
4. Fluorescence, confocal - principles and applications. [2 hrs]

Recommended Books:

1. Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Latest edition / Pub. Date: January 1996. Publisher: Elsevier Science & Technology Books.
2. Methods and Techniques in Virology. Pierre Payment, Trudel (Editor). Latest edition / Pub. Date: July 1993. Publisher: Marcel Dekker.
3. Diagnostic Virology Protocols: Methods in Molecular Medicine. John R. Stephenson (Editor), Alan Warnes Latest edition / Pub. Date: August 1998. Publisher: Humana Press.
4. Diagnostic Procedures for Viral, Rickettsial, and Chlamydial Infections. Edwin H. Lennette (Editor), David A. Lennette, Evelyne T. (Eds.) Lennette, Evelyne T. Lennette (Editor). Latest edition / Pub. Date: January 1995. Publisher: American Public Health Association Publications.

VR-113MC(T): Immunology-I (2 Credits) (Theory)

1. Introduction and history; Cells and organs of the immune system, [5 hrs]
2. Innate immune response & inflammation complement system. [3 hrs]
3. Hapten/antigen; antibody, structure & function, Immunoglobulin classes. Antigen & antibody interaction, Antibody diversity. [6 hrs]
4. Ontogeny of immune cells [2 hrs]
5. B and T cell receptors and signaling [4 hrs]
6. Major histocompatibility complex, Polymorphisms, Human leukocyte antigen association with disease. [4 hrs]
7. Antigen processing and presentation, Cytokines & Chemokines. [6 hrs]

Recommended Books:

1. Abbas AK & AH Lichtman (2006): Basic Immunology: Functions and Disorders of the Immune System. With Student Consult Online Access. Edn. 3. WB Saunders Co.
2. Delves PJ, SJ Martin, DR Burton & IM Roitt (2006): Roitt's Essential Immunology. Edn. 11. Blackwell Publishing.
3. Kindt TJ, RA Goldsby & BA Osborne (2007): Kuby Immunology. Edn. 6. WH Freeman & Co.
4. Paul W.B. (2012) Fundamental Immunology, Edn 7, Lippincott Williams & Wilkins
5. Mak TW, M Saunders & W Tamminen (2008): Primer to the Immune Response. Elsevier.
6. Male D, J Brostoff, D Roth & I Roitt (2007): Immunology: With Veterinary Consult Access. Edn. 7. CV Mosby & Co.
7. Roitt I, J Brostoff, D Male & D Roth (2006): Immunology. With Student Consult Online Access. Edn. 7. CV Mosby & Co.

8. Sompayrac L (2008): How the Immune System Works. Wiley- Blackwell.
9. Wood P (2006): Understanding Immunology. Edn. 2. Prentice Hall/ Pearson Education, Harlow, England.

VR-114MC(T): Basic Epidemiology and Biostatistics (2 Credits) (Theory)

1. Historical aspects and evolution of epidemiology, definitions and concepts in Epidemiology. [5 hrs]
2. Descriptive and analytical epidemiology, disease burden, natural history of diseases and measures of risk and death. [7 hrs]
3. Sample size estimation and introduction to study design in epidemiological investigations. [4 hrs]
4. Introduction, types of data, tabular and graphical presentation of data. [4 hrs]
5. Measures of central tendency. Mean, mode, median, GM, HM, quartiles, Measures of dispersion range, standard deviation, variance, coefficient of variation. Correlation, linear regression. [4 hrs]
6. Concept of probability distribution. Normal distribution—density curves, applications and statistical tables. Concept of significance tests, parametric and non-parametric tests, standard error and confidence intervals. [4 hrs]
7. Introduction to Sampling Methods: Simple Random sampling (with/without replacement), Systematic sampling, Stratified sampling, Cluster sampling [2 hrs]

Recommended Books:

1. Epidemiology: An Introduction. Kenneth J. J. Rothman. Latest edition / Pub. Date: May 2002. Publisher: Oxford University Press.
2. Epidemiology. Leon Gordis. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.
3. Diseases and Human Evolution. Ethne Barnes. Latest edition / Latest edition / Pub. Date: March 2005. Publisher: University of New Mexico Press.
4. Epidemiology: Beyond the Basics. F. Javier Nieto, Moyses Szklo. Latest edition / Pub. Date: November 2003. Publisher: Jones & Bartlett Publishers, Inc.
5. Basic and Clinical Biostatistics. Beth Dawson, Robert G. Trapp, Robert Trapp. Latest edition / Pub. Date: March 2004.
6. Discovering Statistics Using SPSS. Andy Field. Latest edition / Pub. Date: April 2005. Publisher: SAGE Publications.

VR-115MC(T): Analytical Techniques (2 Credits) (Theory)

1. Characterization of biomolecules: Introduction and various approaches for characterization of biomolecules. [2 hrs]
2. Electrophoresis (simple theory and applications): Types of electrophoresis paper, gel (starch, acrylamide and agarose) disc, vertical, horizontal submarine, gradient, 2D-

PAGE, pulse-field and capillary; isoelectrofocussing; isolation and analysis of molecules from gel and recovery of molecules from paper/gels; southern, northern and western blotting. [6 hrs]

3. Cell sorting and Flow cytometry: Principles and Applications. [3 hrs]
4. Radioisotope techniques: Nature and types of radioactivity, half life of isotopes; detection and measurement of radioactivity, GM counter, laboratory safety measures in handling isotopes; biological effects and uses of radioisotopes. Autoradiography. Biological effects of the radiations. [3 hrs]
5. Spectroscopy: Electromagnetic spectrum of light; simple theory of light absorption by biomolecules; Beers Lambert law; transmittance; extinction coefficient; light sources; monochromators; types of detectors; working principle and applications of visible, UV visible, IR, Raman, ESR, mass, plasma emission, atomic absorption, and NMR spectrophotometry; fluorimetry and flame photometry; isothermal colorimetry, ORD and CD; Xray diffraction and Xray crystallography, surface plasmon resonance. [10 hrs]
6. Introduction to Histological techniques [3 hrs]
7. Detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. [3 hrs]

Recommended Books

1. Practical Biochemistry: Principles and Techniques 1995, 4th ed. by K. Wilson and J. Walker, Cambridge University Press.
2. Modern Experimental Biochemistry. 1993. 2nd ed. by R.F. Boyer. The Benjamin Cummings Publ. Company.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 1982, 2nd ed. by David Freifelder. W.H. Freeman and Company.
4. Introduction to Practical Biochemistry. 2000. by S.K. Sawhney and Randhir Singh (eds.) Narosa Publ. House
5. Biochemical Methods for Agricultural Sciences. 1992 by S. Sadasivam and A. Manikam. Wiley Eastern Ltd.
6. Essentials of Nuclear Chemistry by Prof. Hari Jeevan Arnikar, University of Pune. ISBN: 978-81-224-3203-9.
7. Fluorescence In Situ Hybridization (FISH) – Application Guide (Kindle Edition 2010). Editor Thomas Liehr. Springer Publication. ISBN-10: 1607617889, ISBN-13: 978-1607617884.

VR-131MC(P):A] Tissue culture techniques B] Analytical methods (2 Credits)
(Practical)

A] Tissue culture techniques

1. Glassware decontamination, washing, sterilization, packing and sterile handling.
2. Media and reagents preparation, sterility checks

3. Maintenance of cell cultures
4. Growth studies. cell count, mitotic index.
5. Preparation of primary cell culture (CEC)

B] Analytical methods

1. Preparation of reagents and buffers
2. Protein estimation by Lowry method
3. DNA estimation (spectrophotometric)
4. Polyacrylamide gel electrophoresis
5. Confocal microscopy (Demonstration)
6. Gel Filtration chromatography (Demonstration)

VR-132MC(P):A] Propagation of viruses B] Virus / Antigen detection (2 Credit) (Practical)

A] Propagation of viruses:

1. Estimation of virus yields-- plaque assay & $TCID_{50}$
2. Preparation virus stocks and determination of mouse LD_{50}
3. Routes of inoculations in embryonated eggs
4. Handling of animals: Rules & Regulations

B] Virus / Antigen detection

1. ELISA
2. Immunoflourescence assay
3. Heamagglutination
4. Polymerase chain reaction
5. Electron microscopy (Demonstration)

Major Elective (Any 2):

VR-116ME(T): A] Vector Biology B] General Biochemistry (2 Credits) (Theory)

A] Vector Biology

1. Introduction to general entomology, insect morphology and classification. Insects and other arthropods of medical importance and their structures and functions. Methods for collecting these insects and arthropods, their preservation/ maintenance and transportation. [2 hrs]

2. Biology and life history of *Aedes*, *Culex* and *Anopheles* mosquitoes, their behavior and ecology with special reference to dengue, chikungunya, Japanese encephalitis and West Nile virus [3 hrs]
3. Biology, morphology and disease relationship of sandflies (sandfly fever and chandipura). Biology and morphology of fleas, lice, culicoides. Biology, ecology, life history of ticks with special reference to Kyasanur Forest Disease (KFD, CCHF). Biology and morphology of mites. [4 hrs]
4. Vector virus interactions: Virus dissemination & mechanism of virus transmission in vectors, natural cycle, maintenance of viruses in nature, basis of vector competence, mechanical transmission, virus dissemination, susceptibility-intrinsic and extrinsic factors. Xenodiagnosis- methods and application. [3 hrs]
5. Vector Control: Various control strategies and environmental management. Control in urban settings, control at aquatic stages, adult population, personal protection, insecticide resistance mechanism and control dynamics. [3 hrs]

Recommended Books:

1. Gordon RM, Lavoipierre MMJ (1962) *Entomology for students of Medicine*. Blackwell Scientific Publ.
2. Service MW (1996) *Medical entomology for students*. Chapman and Hall
3. Kettle DS (1984) Medical and veterinary entomology CAB international
4. Richard and Davies Imm's general Text book of Entomology, Vol I & II. Chapman and Hall
5. Roy DN and Brown AWA (1970) Entomology (Medical & veterinary) Bangalore printing and Publishing co.
6. Bates M (1949) Natural History of mosquitoes The Macmillan Co
7. Baker RH and Wharton R(1952) Introduction to Acarology The Macmillan Co

B] General Biochemistry

1. Carbohydrates: Classification of carbohydrates; outline structure and properties of important mono-, di-, and oligosaccharides and their identification and analysis; structure, occurrence and biological importance of structural polysaccharides (cellulose, chitin, agar, alginic acids, pectins, proteoglycans, sialic acids, ATP biosynthesis (Glycolysis, TCA and ETC) [2 hrs]
2. Lipids: Building blocks of lipids. Classification of lipids. Fatty acids- physico-chemical properties, separation, distribution in nature, characterization and saponification and iodine number. Nomenclature, outline structures, properties and functions of glycerides, neutral lipids (waxes, fats, oils), phospholipids, sphingolipids and glycolipids. Steroids- plant sterol, ergosterol, stigmasterol, cholesterol. Lipoproteins- classification, composition and importance. [2 hrs]
3. Amino acids: Classification, structures, physicochemical properties, acid-base behavior of amino acids. Peptides: Characteristics of peptide bond, peptides of non-protein origin,

properties and functions of peptides, determination of amino acid composition and sequence in peptides, peptides profiling. [2 hrs]

4. Proteins: Classification, properties and biological functions of proteins; structural organization of proteins primary, secondary, tertiary and quaternary. [2 hrs]
5. Protein metabolism: hydrolysis of proteins exo and endoproteinases, only outlines of biosynthesis and catabolism of amino acids (interlinking with carbohydrate and lipid metabolism) in microbes. [2 hrs]
6. Catalytic proteins (enzymes): Classification, nomenclature, composition and structures, enzymes as biocatalysts, outlines of purification and assay of enzymes, kinetics of enzyme catalyzed reactions, factors influencing enzyme catalyzed reactions, regulation of enzyme activity activators and inhibitors and mechanism of action of enzymes (chymotrypsin). Regulatory enzymes allosteric enzymes. Isoenzymes, coenzymes, ribozymes, abzymes. [2 hrs]
7. Nucleic acids: types and their composition, structures of purines, pyrimidines, modified bases, nucleosides, nucleotides and polynucleotides; properties of bases and functions of nucleotides; types and structural polymorphism of DNA and RNA; denaturation and renaturation of nucleic acids, factors influencing hybridization, cot curves [3 hrs]

Recommended Books:

1. Principles of Biochemistry, Lehninger, 3rd edition by Nelson and Cox (Worth) 2000.
2. Biochemistry, Stryer 5th edition, W.H. Freeman, 2001.
3. Review of Physiological Chemistry (Latest edition) by Harold A Harper. Lange Medical Publication.

VR-117ME(T): Microbiology (2 Credit) (Theory)

1. Origin and evolution of microorganisms. Distinguishing of different groups of microorganisms, Classification of microorganisms. [4 hrs]
2. Cultivation of microorganisms: Types of media- natural and synthetic; autotrophic, heterotrophic and phototrophic media; basal, defined, complex, enrichment, selective, differential, maintenance and transport media. [5 hrs]
3. Isolation from different natural samples. Approaches for obtaining pure cultures. Cultivation of aerobes and anaerobes. [5 hrs]
4. Enumeration / measurement of growth of microorganisms, Maintenance and preservation of microbial cultures: Repeated sub-culturing, sterile soil/sand preservation, glycerol-deep freezing, oil overlay, drying methods, freeze-drying. [4 hrs]
5. Fungi: Classification, structure, composition, reproduction and other characteristics of fungal divisions. [4 hrs]

6. Protozoan parasites: Classification, morphology and structure, reproduction and other characteristics of pathogenic protozoa like *Entamoeba, Plasmodium, Leishmania, Cryptosporidium, Trichomonas, Taxoplasma, Trypanosoma, Giardia*. [4 hrs]
7. Medical Microbiology: *Vibrio cholera, Salmonella typhii, S. pneumoniae*. [4 hrs]

Recommended Books:

1. Principles of Microbiology. 1997. 2nd ed. R.M. Atlas. Wm.C. Brown. Publ.
2. Foundations in Microbiology. 1996. 2nd ed. K. Talaro and A. Talaro. Wm.C. Brown Publ.
3. Microorganisms, Biotechnology and Disease: Students Book. 1997 by Pauline Lourie and Susanwells. Cambridge University Press.

VR-133ME(P):A] Entomological Method B] Statistical Methods (2 Credits) (Practical)

A] Entomological Methods

1. Mosquito collection & taxonomy
2. Taxonomy of ticks and sandflies
3. Processing of arthropods
4. Mosquito inoculation & immunoflourescence
5. Insecticide testing
6. Collection of rodents

B] Statistical Methods

1. Graphical presentation of data
2. Measures of central tendency and dispersion
3. Correlation and regression analysis
4. Significance tests
5. Statistical packages
6. Epidemiological exercise
7. Introduction to various available softwares (demo)

VR-150(RM): Research Methodology (4 Credits) [60 hrs]

1. Safety and Behavior at Workspace, Laboratoryand InstitutionalCampus:

General safety and accident prevention guidelines, Good personnel safety practices, Laboratory safety practices (Do's and Don'ts), Fire safety principles and fire handling, Care in handling chemicals, Understanding materials safety data sheet (MSDS), Storing and indexing of materials & chemicals, Disposal of materials, chemicals and biological wastes, First aid, Reporting accidents and requisitioning help, Combating

accidents. Awareness about members of the Institutional Safety Committee and emergency contact numbers. Lab bench co-operation with colleagues and co-workers, cultivating practice of collectivism, shared responsibilities and team-spirit among fellow researchers, Advancing culture of scientific sharing and discussion in campus and lab.

a) Concepts of biosafety and biosecurity I [Overview of microorganisms and types of viruses, bacteria, prions, Biosafety Levels and Risk group, Classification of pathogens based on risk, Containment.
b) Concepts of biosafety and biosecurity II [Risk & Hazard Assessment, Factors associated with a risk, Pre-requisites for assessing risk, Main parameters of Risk Assessment, Behavioral Elements, Primary Barriers, Respiratory protection (N95, PAPR), Laboratory specific requirement, Fitness test, Employee Health, Secondary Barriers, isolated zone, Double-door entry, negative pressure with different zoning, Biosafety cabinets].
c) Decontamination procedures: [Solid & Liquid & Biomedical waste, autoclaves principals and types, incinerators; Liquid: chemical kill tank, STP and BLED tanks, Disinfection: What is sterilization?, Methods of sterilization, What is Disinfection?, Maintenance of Records, Accident Reporting, Waste categories & Color coding, Label For Transport of Bio-Medical Waste Containers/Bags, Standards: for Incinerators, for Waste Autoclaving, for Liquid Waste, for Deep Burial, Local Government laws in safe disposal of waste i.e. PMC, BARC & BRIT for Gamma irradiation.
d) Safe laboratory Practices: Health & Medical surveillance, ABSL facilities, Safe shipment of specimens & infectious materials [IATA & ICMR rules for material movement] Safety rules for domestic & cleaning staff, Good microbiological practices, Good clinical and laboratory practices (GCLP), Good Laboratory practices (GLP)].
e) Medical surveillance: [Medical first aid, Requirements for certification of fitness, Vaccination requirements, Accident reporting and investigation, post-exposure assessments & management, Hospital infection control].

2. Research Problem Identification and Research Design/Plan:

Scientific methods, Types of reasoning (Logics) - Induction – Deduction – Abduction, Identifying a topic/area of research, Reviewing literature, Identifying a question to be answered/solution of a problem to be sought, Critically weighing investment (time, money and efforts) to reward (size and scale of answer/solution), Finalizing the research question/problem to be worked on, Cross-disciplinary thoughts and inter-disciplinary research approaches of addressing the question. Design of experiment/ research work process and its implementation, Serendipity research.

3. Good Experimental, Observational and Data Analysis including Computer Applications:

Maintenance of laboratory records & e-Note books, Management of data and self-navigation of research project and academic program progress (objectives, milestone as well as timeline compliance), Data integrity & archiving of observational data for re-tracing, Basic mathematical and statistical treatments of data for appropriate/rational interpretation, Reporting data in inference perspectives, Common computational tools like Process flow diagram, Chemical structure drawing, statistical analyses, Data tabulation and figure presentation (graph, bar diagram,Venn Diagram, heat maps etc.)

4. Writing & Communication ofResearch Results and Inferences:
Scientific writing (including Language proficiency), State-of-the-art scientific literature comprehension, Art and ethics of writing research report/paper, writing of an abstract for scientific community and general public, Skills of making powerpoint presentations, Art of web-meeting,Interactions & presentations using latest video-meeting modes, Letterwriting and official correspondence

Recommended Books:

1. Research Methodology: Methods and Techniques (New Age International).
2. Introduction to Biostatistics and Research Methods: P. S. S. Sundar Rao and J. Richard (PrenticeHall India).
3. Essentials of Research Design and Methodology: G. R. Marczyk, D. DeMatteo, D. Festinger(John Wiley & Sons).
4. Managing Science:Methodology and Organization of Research : Frederick Betz (Springer-Verlag).
5. Maths from Scratch for Biologists: A. J. Cann (Wiley).
6. Experimental Design and Data Analysis for Biologists: G. P. Quinn and M. J. Keough (Cambridge Research Methodology in the Social, Behavioural and Life Sciences - Designs, Models and
7. Methods: H. J. Ader and G. J. Mellenbergh (SAGE Publications)
8. Furr, A.K. ed. CRC Handdbook of Laboratory Safety.--3rd ed.-- Boca Raton, Florida: CRC Press, 1990.p. 704. ISBN 0849303532
9. Collins CH and Kennedy DA. Laboratory-acquired Infections: History, incidence, causes and preventions.--4th ed.--Oxford: Butterworth Heinemann, 1999. p. ix + 324 p. ISBN 9780750640237
10. World Health Organization. Laboratory Biosafety Manual.--3rd. ed.- Geneva: World Health Organization, 2004. p. viii + 178 p. ISBN 9241546506
11. Hawkins MD. Technician Safety and Laboratory Practice.- London: Cassell, 1980. p. xiii + 239 p. ISBN 0304305502

M.Sc Virology: Semester II

Major Core:

VR-211MC(T): Molecular Biology (2 Credits) (Theory)

1. Genomes: types, diversity in size, structure and organization in viruses, prokaryotes (nucleoid) and eukaryotes (chromosomes, ploidy, chromatin and nucleosomes). Chloroplast and mitochondrial genomes. Genome complexity and sequence components. Central dogma theory and flow of genetic information. [4 hrs]
2. Genes: The modern concept of the genes, gene structure and architecture, types of genes [1 hr]
3. Plasmids: detection, types, properties, purification, transfer, replication and curing, significance / importance. [1 hr]
4. Mobile genetic elements: Prokaryotes - types and structure of bacterial transposons, and molecular mechanism of transposition. Eukaryotes – types and their structure, and molecular mechanism of transposition. Exploitation of transposable elements in genetics [1 hr]
5. Gene transfer mechanisms and gene mapping in bacteria: Natural and artificial transformation. Conjugation and sexduction. Transductions (generalized; abortive, specialized and co-transduction). [1 hr]
6. Genetic recombination: Requirements for recombination. Molecular models / basis of recombination. [2 hrs]
7. Replication / perpetuation of nucleic acids: Concepts, definitions, and strategies / models for replication. Relation between cell cycle and DNA replication. Molecular mechanisms of DNA replication in prokaryotes and eukaryotes. Replication of single stranded DNA. Inhibitors of DNA replication [3 hrs]
8. DNA damage and repair: Classes / types of damage. Repair mechanisms – mismatch repair, short patch repair, nucleotide / base excision repair, recombination repair and SOS system. [1 hr]
9. Mutations: Types, causes and consequences of mutations. Mutagens and their mode of action. Isolation and analysis of bacterial / phage mutants. Importance of mutants in genetic analysis, point mutation [2 hrs]
10. Transcription (RNA biosynthesis): Types of RNA and their role. Organization of protein and RNA encoding transcription units and their transcription in prokaryotes and eukaryotes. Types of RNA polymerases. Protein binding sites on DNA - DNA foot printing. Promoters, enhancers, silencers, insulators. Transcription factors and characteristics of DNA binding proteins. Sigma factors. Events of transcription. Maturation and processing of different RNA transcripts- capping, methylation, polyadenylation, splicing, RNA editing and modification of nucleosides in tRNAs.

Regulation of transcription. *In vitro* transcription systems. Inhibitors of transcription. [4 hrs]

11. Translation (protein biosynthesis): Genetic code and its elucidation, structure and composition of prokaryotic and eukaryotic ribosomes, structural features of rRNA, mRNA and tRNAs in relation to function, steps of protein biosynthesis (activation of amino acids, initiation, elongation, termination) in prokaryotes and eukaryotes; post-translational modification of proteins and their sorting and targeting; regulation of translation; inhibitors of protein biosynthesis; in vitro translation systems. [4 hrs]
12. Regulation of gene expression: An overview on levels of regulation, terminology and operon concepts, enzyme induction and repression; positive and negative regulation in *E. coli*- lac, regulation by attenuation - trp operons; Eukaryotic Gene Regulation. Organization and regulation of nif and nod gene expression in bacteria; Global regulatory responses- heat shock response, stringent response and regulation by small molecules such as cAMP and PPGPP. [5 hrs]
13. Gene silencing mechanisms: Transcriptional and post-transcriptional silencing. RNA silencing, CRISPR/Cas9 technology and gene regulation. [1 hr]

Recommended Books

1. Molecular Biology of the Gene. 4th Edition. 2004. Pearson Education.
2. Molecular Cell Biology. 2003, by Lodish et al., Scientific american books, W.H. Freeman & Co.
3. Molecular Biology. 1995, by David Freifelder, Narosa Publ. House.
4. Text Book of Molecular Biology. 1994, by Sivarama Sastry et al, Macmillan India Ltd.
5. Advanced Molecular Biology: A Concise Reference. 1998, by R.M. Twyman. Viva Books Pvt. Ltd.
6. Microbial Genetics. 1995, by David Freifelder. Narosa Publ. House
7. Biology of the Gene. 1998, 5th ed. Watson et al, Addison Wesley Longman.

VR-212MC(T):A] Antivirals B] Viral Vaccines (2 Credit) (Theory)

A] Antivirals:

1. Antiviral Drug Classification [1 hr]
2. Designing / Screening of antivirals [1 hr]
3. Target identification & molecular modeling [1 hr]
4. Systems Biology approach & drug repurposing [1 hr]
5. Preclinical evaluation of antiviral agents [1 hr]
6. Clinical trial design [1 hr]
7. Mechanism of Antiviral drug resistance [1 hr]
8. Traditional & synthetic antivirals [1 hr]
9. Drug delivery approache [1 hr]
10. Pharmacogenomics [1 hr]
11. Pharmacokinetics & pharmacodynamics [1 hr]

12. Interferons [1 hr]
13. Anti-sense RNA, siRNA, miRNA, ribozymes [1 hr]
14. Antibody based therapeutics [1 hr]
15. Drug discovery to clinics [1 hr]

Recommended Books:

1. Antiviral Agents, Vaccines, and Immunotherapies. Stephen K. Tyring. Latest edition / Pub. Date: October 2004. Publisher: Marcel Dekker.
2. Antiviral Drug Discovery for Emerging Diseases and Bioterrorism Threats. Paul F. Torrence (Editor). Latest edition / Pub. Date: July 2005. Publisher: Wiley, John & Sons, Incorporated.
3. Chimeric Virus -like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor). Latest edition / Pub. Date: November 1996 Publisher: Karger, S. Inc.
4. Vaccines. Stanley A. Plotkin, Walter A. Orenstein. Latest edition / Pub. Date: September 2003. Publisher: Elsevier Health Sciences.

B] Viral Vaccines:

1. Conventional vaccines -killed and attenuated, [3 hrs]
2. Modern vaccines—recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines) [4 hrs]
3. Vaccine delivery and vaccination strategies, vaccine components- adjuvants, preservatives, large scale manufacturing-QA/QC issues. [4 hrs]
4. Animal models and vaccine potency testing. [2 hrs]
5. Clinical trial of vaccines [2 hrs]

Recommended Books:

1. Chimeric Virus -like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor). Latest edition / Pub. Date: November 1996 Publisher: Karger, S. Inc.
2. Vaccines. Stanley A. Plotkin, Walter A. Orenstein. Latest edition / Pub. Date: September 2003. Publisher: Elsevier Health Sciences.

VR-213MC(T): A] Bioinformatics B] Applied Epidemiology (2 Credit) (Theory)

A] Bioinformatics

1. Introduction and biological data bases: Nucleic acid, proteins, genomes, structure data bases, search engines, sequence data formats and submission tools, scoring matrices for

sequence alignments, algorithms—pairwise sequence alignments, database similarity searches - BLAST, FASTA. [3 hrs]

2. Methods for sequence analysis: Multiple sequence alignment, phylogenetic analysis and tree building methods, data mining tools and applications–secondary/ derived databases, motif & family searches, epitope prediction, etc [7 hrs]
3. Structure based approaches: Protein secondary structure prediction, threading approaches, homology based methods for protein tertiary structure prediction, visualization tools, structure evaluation and validation [3hrs]
4. Primer designing for PCR. [2hrs]

Recommended Books:

1. Introduction to Bioinformatics---Lesk, A.
2. Introduction to Bioinformatics--- Attwood.
3. Instant notes in Bioinformatics---Westhead, Parish &Twyman.
4. Bioinformatics: A practical guide to the analysis of genes and proteins-Baxevanis, Qoellette, John Wiley & Sons, NY.
5. Mount David: Bioinformatics

B] Applied Epidemiology:

1. Syndromic surveillance for viral diseases, ICD- codes, case reports and case series [2 hrs]
2. Outbreak investigations, special studies (surveys/case control and cohort studies) in viral diseases [3 hrs]
3. Assessment of viral disease burden, disease causality, mortality, morbidity aspects and quantification of risk indicators [3 hrs]
4. Public health strategies for prevention and control of viral diseases, Infectious diseases surveillance of viral diseases and its veterinary epidemiology [3 hrs]
5. Health Technology Assessment specific to viral diseases, evidence-based medicine, systematic review & meta-analysis, costing methods and economic evaluation of viral diseases and infectious diseases modeling [4 hrs]

Recommended Books:

1. Epidemiology: An Introduction. Kenneth J. J. Rothman. Latest edition / Pub. Date: May 2002. Publisher: Oxford University Press.
2. Epidemiology. Leon Gordis. Latest edition / Pub. Date: November 2004. Publisher: Elsevier Health Sciences.
3. Diseases and Human Evolution. Ethne Barnes. Latest edition / Pub. Date: March 2005. Publisher: University of New Mexico Press.
4. Epidemiology: Beyond the Basics. F. Javier Nieto, Moyses Szklo. Latest edition / Pub. Date: November 2003. Publisher: Jones & Bartlett Publishers, Inc.

5. Basic and Clinical Biostatistics. Beth Dawson, Robert G. Trapp, Robert Trapp. Latest edition / Pub. Date: March 2004.
6. Discovering Statistics Using SPSS. Andy Field. Latest edition / Pub. Date: April 2005. Publisher: SAGE Publications.

VR-214MC(T): A] Virus Replication B] Virus-cell Interaction (2 Credit) (Theory)

A] Virus Replication:

1. Replication of positive sense RNA virus (polio virus, any flavivirus), negative sense RNA viruses (VSV and influenza) [5 hrs]
2. Replication of double stranded RNA virus (Rotavirus), ambisense RNA (LCM) and retroviruses (HIV and HTLV). [5 hrs]
3. Replication of double stranded DNA viruses (SV40, pox), ssDNA virus (AAV) [3 hrs]
4. Prion proteins, replication of plant virus (Poty). [2 hrs]

Recommended Books:

1. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka Latest edition / Pub. Date: December 2003 Publisher: American Society Microbiology.
2. DNA Virus Replication. Alan J. Cann. Latest edition / Pub. Date: March 2000. Publisher: Oxford University Press.
3. Principles of Molecular Virology. Alan Cann J. Cann. Latest edition / Pub. Date: June 2005. Publisher: Elsevier Science & Technology Books.
4. Fields Virology. Vol. 1 and 2.

B] Virus-cell Interaction:

1. Definition, structure and methods of discovery of viral receptors (polio, herpes, VSV, HIV). Kinetics of receptor binding. Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms. Nuclear localization signals and nuclear pore transit, virus –cytoskeletal interactions, chaperons. [5 hrs]
2. Replication sites and their characterization, IRES, replicons, transport of viral proteins. [3 hrs]
3. Host cell 'shut off', apoptosis, necrosis, stress response, alteration of signaling pathways, cellular basis of transformation, types of cenotaphic effects, ultrastructural cytopathology [3 hrs]
4. Cellular injury associated markers, mechanism of viral persistence and latency—*in vivo* and *in vitro* models (JE, measles, LCM and HIV). [4 hrs]

Recommended Books:

1. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka Latest edition / Pub. Date: December 2003 Publisher: American Society Microbiology.
2. Virus Dynamics: Mathematical Principles of Immunology and Virology. Martin A. Nowak, Robert May.Latest edition / Pub. Date: January 2000. Publisher: Oxford University Press.
3. Molecular Aspects of Host-Pathogen Interactions. Malcolm A. McCrae (Editor), J. R. Saunders (Editor), C. J. Smyth (Editor), N. D. Stow (Editor) Latest edition / Pub. Date: September 1997. Publisher: Cambridge University Press.
4. Cell Biology of Virus Entry, Replication, and Pathogenesis. Richard W. Compans, Ari Helenius (Editor), Michael B. Oldstone (Editor). Latest edition / Pub. Date: December 1988. Publisher: Wiley, John & Sons, Incorporated.

VR-215MC(T): Recombinant DNA Technology (2 Credits) (Theory)

1. Scope and importance of recombinant DNA technology. [1 hr]
2. Tools for Recombinant DNA Technology: Gene vectors-Plasmid, transposon, bacterophage and plant and animal virus based vectors (retroviral, pox, rhabdo and adeno virus vectors) for manipulation of genes in bacteria, yeast, plant and animal cell systems. Enzymes–different nucleases, DNA and RNA polymerases, DNA joining enzymes (ligases, topoisomerase, recombinase) and other nucleic acid modifying enzymes. Oligonucleotides - linkers, adaptors, homopolymer tails, primers, promoters, reporter/ marker genes. Source DNA - genomic DNA, cDNA, PCR products and chemically synthesized oligonucleotides. [3 hrs]
3. Cutting and joining of DNA molecules-generation and joining of blunt and sticky ended DNA molecules using linkers, adaptors and homopolymer tails and PCR amplicons, TdT. [2 hrs]
4. Techniques for gene manipulation: DNA sequencing -Chemical, dideoxy chain termination, primer walking, automated sequencing, pyrosequencing, next generation sequencing methods [3 hrs]
5. Molecular diagnostics: Nucleic acid blotting and hybridization - Preparation of DNA and RNA probes, hybridization formats, factors influencing hybridization and applications of hybridization based tests. PCR- principles, Primer designing, factors affecting PCR, different types of PCR and Real time PCR, RT-PCR and their applications and limitations. DNA profiling - RFLP, AFLP, RAPD and DNA finger printing and their applications. [4 hrs]
6. Site directed mutagenesis and protein engineering: Different approaches for changing genes. Approaches for protein engineering to generate novel enzymes like subtulisin. [2 hrs]

7. Gene cloning strategies: Construction of genomic DNA and cDNA libraries and different strategies for selection, screening and analysis of recombinants. Recombinogenic engineering, Green Fluorescence protein, Fusion proteins—signals for protein secretion, purification of recombinant proteins. [3 hrs]
8. Gene cloning & Expression in bacteria, yeast, plant and animal cells-construction of cell specific recombinant vectors, introduction of them into targeted cells by different approaches and screening and isolation of recombinant cell clones. Insect cell system – Over expression of cloned genes using baculovirus based vectors. Production of recombinant molecules; Purification and analysis of generated recombinant molecules. Construction of vectors for over expression of genes, optimization of generation of recombinant molecules. In vitro translational systems like RBCs and Wheat Germ systems. [7 hrs]
9. Phage display libraries, reverse genetics, viral replicons (SFV and HCV) [3 hrs]
10. Functional genomics - transcriptome and gene expression profiling. In vitro mutagenesis and deletion techniques, genes knock out in bacterial and eukaryotic organisms. [2 hrs]

Recommended Books

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab *etc.*

VR-231MC(P): A] Serological methods B] Immunological techniques (2 Credits) (Practical)

A] Serological methods:

1. Heamagglutination inhibition test
2. Reagent preparation for ELISA
3. IgM capture ELISA,
4. IgG ELISA
5. Plaque reduction neutralization test

B] Immunological techniques:

1. Isolation of Peripheral Blood mononuclear cells (PBMCs) from human blood
2. Setting up of Macrophage culture
3. Phenotyping of immune cells using Flowcytometry
4. Lymphocyte proliferation assay
5. Cytokine assay
6. Elispot assay

VR-232MC(P): A] Epidemiological data management and analysis, B] Practical Bioinformatics (2 Credit) (Practical)

A] Epidemiological data management and analysis:

Statistical software (EPI-Info)

1: Introduction to the software
Design data entry form
Importing MS Excel data in Epi-Info

2: Basic commands in Epi-Info
Recoding/transforming a variable
Preparing frequency distributions/cross tables
Computing descriptive statistics and interpretation

3: Graphical presentation of data:
Bar diagram, Line diagram, Pie chart, Histogram, EpiCurve
Interpretations

4: Computing correlation coefficient
Comparing proportions using chi-square test
Comparing means using t test
Computing risk using univariate logistic regression
Interpretations

B] Practical Bioinformatics:

1. Biological data banks.
2. Pairwise sequence alignments.
3. Phylogeny & tree building 1.
4. Phylogeny & tree building 2.
5. Secondary structure prediction.
6. Secondary databases – Motif, family searches, Epitope prediction(B-cell).
7. Epitope predictions (T-cell).
8. Biomolecular Structure visualization 1.
9. Biomolecular Structure visualization 2.
10. Primer designing.

Major Elective: (Any 2)

VR-216ME(T): Immunology-II (2 Credit) (Theory)

1. Mucosal effector mechanisms. [4 hrs]
2. Cell mediated effector mechanisms: Phagocytosis, Cytotoxic and T helper response, Natural killer cells. [6 hrs]

3. Immunoregulation, Hypersensitivity. Autoimmunity; Immunodeficiency, Transplantation immunology. [10 hrs]
4. Immunity to viruses and modulation of immune responses by viruses. [5 hrs]
5. Vaccine induced immune response and immune correlates of protection. [5 hrs]

Recommended books:

1. Abbas AK & AH Lichtman (2005): Cellular & Molecular Immunology. Elsevier Health Sciences.
2. Kindt TJ, RA Goldsby & BA Osborne (2007): Kuby Immunology. Edn. 6. WH Freeman & Co., New York.
3. Johnson AG (2005): High-yield Immunology. Lippincott/ Williams & Wilkins.
4. Murphy K, P Travers & M Walport (2007): Janeway's Immunobiology. Edn. 7. Garland Science.

VR-217ME(T): Mathematical Biology (2 Credit) (Theory)

1. Fundamentals
   a) Introduction to Mathematical Biology [1 hr]
   b) Number systems and scientific notations. [1 hr]
   c) Elements of algebra, functions. [2 hrs]
   d) Understanding equations (Linear, simultaneous and quadratic) [2 hrs]
   e) Graph plotting [2 hrs]
   f) Matrices [1 hr]
   g) Basic Calculus - I: limits. [1 hr]
   h) Basic Calculus – II: differentiation [1 hr]
   i) Basic Calculus – III: integration [1 hr]
   j) Differential Equations [2 hrs]
2. Biological applications
   a) Beer-Lambart's Law, Enzyme kinetics. [1 hr]
   b) Radiation Biology & Radio-carbon dating [2 hrs]
   c) Newton's Law of cooling, Solutions-dilutions, estimation of cell viability, survival curves, apoptotic index, etc [1 hr]
   d) Tumor growth kinetics [1 hr]
   e) Electroporation techniques: cell and tissue electroporation [1 hr]
3. Population based studies
   a) Simple population growth models [2 hrs]
   b) Predator-Prey interactions: Lotka – Voltera interspecies competition logistics equation (theory, applications and problem set) [2 hrs]

4. Mathematical epidemiology:
   a) Time series analyses (surveillance & outbreak data), baseline data [2 hrs]
   b) Epidemics modelling: Data recording, concept of epidemic curve, Basic reproduction number. etc [1 hr]
   c) SIR Model & SEIR model (Basic concepts, calculations, graph plotting, data analyses) [2 hrs]
   d) Ronald-Ross malaria model [1hr]

References:

1. Schaum's Outlines College Mathematics. 4th Edition.
2. Mathematical Biology. JD Murray. Springer-Verlag. 1990.
3. Infectious Disease of Humans. RM Anderson & RM May. Oxford Scientific Publications.
4. Principles of mathematical modeling. CL Dym. Academic press. 2004.
5. Introduction to Analyses: Integral Calculus. Ghosh & Maity. New Central Bok Agency ltd. Pune, Kolkata
6. Problems in Mathematics. V Govorov, P Dybov, et al. Arihant Prakashan Meerat. 2019

VR-233ME(P): Biosafety and Biosecurity (2 Credit) (Practical)

1. Specimen collection from humans
2. Specimen collection from Animals
3. Vector collection
4. Specimen collection from birds, rodents & bats
5. Environmental samples
6. Introduction to Containment Laboratories: [Entry-exit protocols: Complete simulation of the facility with Delta suits/PAPR, Disposable and non-disposable sharps and other materials: Disposal, autoclaving, cleaning, segregation and precautions, Transport within the facility: dunk tanks, pass-boxes, etc., Transport outside the facility [Shipping of infectious material], Safety checks [daily, weekly, monthly and biannual checks], Specific SOPs for various processes & equipments]
7. Laboratory emergency response issues: [Spills: laboratory simulation on Splashes/spills CIP protocol, Needle stick injury, Cuts, & Medical emergencies etc. Air & surfaces decontaminations of the facility based on incidents/accidents, Safeguarding against accidents in the facility, Ventilation failure and emergency protocols, Fire and other emergencies, Simulation fire alarm system, immediate remedial measures, emergency exit protocol, Safety measures & preparedness for Natural disasters & Terrorist threats]
8. Engineering requirements for Containment laboratory (BSL- II, III): Construction (Civil, Plumbing, drain line), HVAC & BMS, Electrical system (UPS, DG set), Access control

system, Furniture, Communication, Fire alarm system, Definition of HEPA/ ULPA filter, Percentage (%) of penetration, In place testing, HEPA filters, Autoclave, BSC working & testing, Equipments use in waste management: Incinerator & Shredder]

9. Visit to health facility [Municipal health service structure, health care facilities]

VR-250(OJT): Internship/ On job Training (OJT) After completion of Sem II exam (4 Credits)

OJT plays a crucial role in preparing students for a successful career by bridging the gap between theoretical knowledge and practical skills. Students will get hands-on experience in industry / laboratories / pharmaceutical companies/ healthcare sector during this programme. Students will understand importance of compliance and maintaining high-quality standards and gain insights into the advancements taking place in the field. It would also help students to built-up network with industry professionals, potentially leading to future job opportunities or collaborations.

1. **OJT Program Structure:**

i. The duration of the OJT will be 2/4 weeks

ii. Students will be divided in groups and encourage to explore OJT opportunities with the help of teachers and alumni in reputable industry/ research/academic institute/companies or any other facility covering different health related aspects

iii. Student groups will be assigned mentors/ supervisors from NIV to provide guidance, monitor progress, and facilitate learning. Mentor will conduct periodic evaluations to track the students' progress during the OJT and maintain a detailed record of the tasks performed, skills learned, and achievements during the OJT.

2. **OJT Evaluation:**

i. Internal evaluation-50% weightage by mentor and supervisor based on
   a) Attendance
   b) Respect incoming and outgoing time
   c) Follow superior’s instructions
   d) Record keeping
   e) Respect for work assigned and interaction with other fellow members

ii. External evaluation-50% weightage based on
   a) Final report submission to the department
   b) Power point presentation based on final report
   c) Project evaluation-quality and out comes
   d) Presentation and communication skills

M.Sc. Virology: Semester III

Major Core:

VR-311MC(T): A] Viral Enteric Diseases and Cancers B] Viral Hepatitis (2 Credits) (Theory)

A] Viral Enteric Diseases and Cancers

1. Classification of enteric viruses, epidemiological scenario with respect to Viral Enteric Diseases at National and International level [1 hr]
2. Clinical course, disease burden, risk factors, prevention, and treatment. [2 hrs]
3. Rotavirus diversity, emerging strains, immune responses and immunopathogenesis of major viral agents associated with acute gastroenteritis [2 hrs]
4. Other Enteric viruses associated with acute gastroenteritis: Adenoviruses, astroviruses, Noro and Sapporo viruses [6 hrs]
5. Diagnostic methods and vaccines [1 hr]
6. Enterovirus diseases of public health concern (non-polio EVs) [1 hr]
7. Polioviruses [3 hrs]
8. Viral oncogenesis, oncogenic viruses HPV, HTLV, Epstein Barr virus [2 hrs]

Recommended books:

1. Fields Virology, 4th Ed., Vol 2 Ed by David M Knipe, and Peter M Howley Chapters: 24, 28, 34, 54, 55, 67 and 68.
2. Gastroenteritis Viruses, Vol. 238. Novartis Foundation Symposium, Mary Estes, Latest edition / Pub. Date: June 2001.
3. Viral Infections of the Gastrointestinal Tract, Vol. 10. Albert Z. Kapikian, Z. Kapikian A. 2nd ed., rev. and expanded. Latest edition / Pub. Date: March 1994.
4. Human Enterovirus Infections, Harley A. Rotbart (Editor), American Society Microbiology, January, 1995.
5. Viral Gastroenteritis, Edited By U. Desselberger, J. Gray. Elsevier Perspectives In Medical Virology. Series Editor: Arie J. Zuckerman, Uk Isa K. Mushahwar. 2003.

B] Viral Hepatitis

1. Physiology of Jaundice, clinical features and differential diagnosis, presentations of hepatitis caused by different hepatitis viruses, epidemiology of hepatitis viruses [3 hrs]
2. Structure & genomic organization, replication, genotypes, serotypes of HAV, HBV, HCV & HEV. [4 hrs]
3. Serological and molecular diagnosis of different hepatitis viruses. [3 hrs]
4. Immunopathogenisis of different hepatitis viruses. Animal models and their uses. [2 hrs]

5. Vaccines: historical aspects, types of hepatitis vaccines, vaccines presently used & vaccines of the future [2 hrs]
6. Antivirals against HBV and HCV [1 hr]

Recommended books:

1. Fields Virology, Volume 2, 4th edition:- (2001).
2. Clinical Virology, Second Edition (Richmans Hayden).
3. Hepatitis Viruses (Japan medical research forum).
4. Viral Hepatitis and Liver disease, A.J. Zuckerman.
5. Viral Infection of Humans (S. Svans & A Kaslow).
6. Viral Hepatitis Molecular Biology Diagnosis and Control, By Isa Mushahwar. Elsevier Perspectives In Medical Virology. Series Editor:Arie J. Zuckerman, Isa K. Mushahwar.2003.
7. Human Papilloma Viruses. Edited by D.J. McCance. Elsevier Perspectives In Medical Virology. Series Editor: Arie J. Zuckerman , Uk Isa K. Mushahwar. 2002.
8. Viruses and Liver Cancer. Edited by E. Tabor. Elsevier Perspectives In Medical Virology. Series Editor: Arie J. Zuckerman , Uk Isa K. Mushahwar. 2002.
9. Viruses, Cell Transformation, and Cancer. Edited by J.A. Grand. Elsevier Perspectives In Medical Virology. Series Editor: Arie J. Zuckerman, Uk Isa K. Mushahwar. 2001.

VR-312MC(T): A] Viral Haemorrhagic Fevers, B] Viral Encephalitis (2 Credits) (Theory)

A] Viral Haemorrhagic Fevers

1. Common clinical features of viral haemorrhagic fevers, history and disease burden, risk factors and geographical distribution of viruses associated with hemorrhagic fevers and their impact on global health. Clinical samples required, choice of laboratory diagnostic tests and their interpretation for differential diagnosis. [2 hrs]
2. Dengu: Epidemiology, virus replication, pathogenesis, prevention and treatment of dengue. Role of humoral and cell mediated immunity and viral factors in development of DHF, WHO based classification for dengue disease severity 1997 and 2009 [5 hrs]
3. Kyasanur forest disease, Crimean Congo hemorrhagic fever, Ebola, and Zika: Epidemiology, Virus replication strategy, Pathogenesis, Prevention and treatment of [3 hrs]
4. Chikungunya: Virus replication, pathogenesis, prevention and treatment [2 hrs]
5. Vaccine approaches for dengue, chikungunya and Ebola [2 hrs]
6. Animal models for studying dengue and chikungunya [1 hr]

Recommended books:

1. CRC Handbook of Viral and Rickettsial Hemorrhagic Feverby James H. S. Gear.
2. Viral Haemorrhagic Fevers. By C.R. Howard. Elsevier. Perspectives In Medical Virology. Series Editor:Arie J. Zuckerman , Uk Isa K. Mushahwar. 2004.

3. Dengue and Dengue Hemorrhagic Fever, D. J. Gubler (Editor), G. Kuno (Editor), Latest edition / Pub. Date: January 1998.
4. Bioterrorism Hemorrhagic Viruses Manual: For Healthcare Workers and Public Latest edition / Pub. Date: April 2004.

B] **Viral Encephalitis**

1. Global and national epidemiology of epidemic viral encephalitis with respect to Japanese encephalitis, West Nile and Chandipura virus infections. [3 hrs]
2. Genomic organization and molecular evolution of Japanese encephalitis, West Nile and Chandipura virus. [3 hrs]
3. Clinical and patho-physiological differentiation of human viral encephalitis, encephalopathy and meningitis and their causes. [1.5 hrs]
4. Role of non- human host and vectors in natural transmission of Japanese encephalitis, West Nile and Chandipura virus infections in India. [1.5 hrs]
5. Overview of sporadic viral encephalitis by human Herpes and rabies virus: clinical diagnosis and case management. [2 hrs]
6. Laboratory diagnosis of viral encephalitic agents, basic principles, preferred methods and problems. [2 hrs]
7. Central Nervous System invasion by encephalitic viruses: Host and viral factors governing disease outcome. [2 hrs]
8. Auto-immune encephalitis, causes, clinical outcome and diagnosis. [1.5 hrs]

Recommended books:

1. Viral Encephalitis in Humans. John Booss (Editor), Margaret M. Esin, Margaret Esiri (Editor). Latest edition / Pub. Date: June 2003. Publisher: ASM Press.
2. Encephalitis Protection. Qingshan Liang. Latest edition (January 2004), Publisher: Cozy Graphics Corporation.

VR-313MC(T): A] Viral Respiratory Diseases B] Exanthematous Diseases (2 Credits) (Theory)

A] Viral Respiratory Diseases

1. Epidemiological scenario with respect to respiratory diseases at National and International level [1hr]
2. History, clinical features, epidemiology of influenza, RSV and other respiratory viruses (Human Metapneumovirus, Human parainfluenza, Human Rhinovirus). [7 hrs]
3. Biology of Novel respiratory viruses (SARS, MERS CoV, SARS-CoV-2, H7N9, COVID-19). [2 hrs]
4. Differential diagnosis of different respiratory diseases. [2 hrs]
5. Vaccines against different viral respiratory diseases. [4 hrs]

Recommended books:

1. Viral Infections of Respiratory Tract by Raphael Dolin and Peter Wright. Mercel Dekker.
2. Clinical Virology Manual Ed: Specter, RL Hodinka, SA Young,. ASM Press.
3. Influenza. Edited by C.W. Potter. Elsevier Perspectives In Medical Virology. Series Editor:Arie J. Zuckerman , Isa K. Mushahwar. 2002.

B] Exanthematous Diseases

1. Epidemiological scenario with respect to exanthematous diseases at National and International level. [1hr]
2. Viruses associated with Exanthematous Diseases: Clinical features, disease burden, case definition and associated risk factor, strategies for prevention & treatment, biology and immunopathogenesis. [5 hrs]
3. Biology of Measles, mumps, rubella, Parvovirus B-19, Chicken pox and other viral pox diseases. Clinical complications of measles (i.e. SSPE) and rubella (i.e. CRS). Laboratory diagnosis of measles, mumps and rubella. [7 hrs]
4. Common features of viral pox diseases and case definitions. Paraspecific immunity due to pox vaccination, eradication and control programs. [3 hrs]

Recommended books:

1. Krugman's Infectious Diseases of children By Saul Krugman.
2. Immunization Safety Review: Vaccines and Autism Immunization Safety Review Committee (Editor) The National Academies Press, USA.
3. Measles and Rubella. Alvin Silverstein, Robert Silverstein, Virginia B. Silverstein, Virginia Silverstein. July 1997.
4. Immunization Safety Review: Measles-Mumps-Rubella Vaccine and Autism. Kathleen R. Stratton, Alicia R. Gable, Padma Shetty. June 2001.
5. Kingsbury DW. ed. The Paramyxoviruses.--New York: Springer Science + Business Media, 1991. p. xxi + 596 p.
6. Zuckerman AJ. ed. Principles and Practice of Clinical Virology.--Chichester: John Wiley and Sons, 1990. p. ix + 643 p.
7. World Health Organization. Global Measles and Rubella Strategic Plan: 2012-2020.--Geneva: World Health Organization, 2012. p. 42 p.

VR-331MC(P): Viral Enteric Diseases (2 Credits) (Practical)

1. Hospital visit- enrollment of acute gastroenteritis patients, recording of clinical information, collection of stool samples, determination of severity of Acute Diarrheal Disease.
2. Sample preparation and ELISA for detection of Group A Rotaviruses
3. RNA extraction by Trizol method
4. Electropherotyping of Rotavirus using RNA PAGE

5. Nested multiplex RT-PCR for G and P genotyping of group A rotavirus
6. Nested RT-PCR for detection of Enteroviruses from clinical samples/ isolates

VR-332MC(P): Viral Hepatitis (2 Credits) (Practical)

1. Liver function test (Serum alanine aminotransferase)
2. HBV-DNA PCR
3. Preparation of stool suspension and HAV/ HEV-RNA PCR
4. Real Time PCR quantitation for HBV DNA
5. HBV/ HCV genotype analysis
6. HBsAg, Anti-HBsAg, HEV and HAV IgM ELISA

VR-333MC(P): Viral Respiratory Diseases (2 Credits) (Practical)

1. Sample collection
2. Sample processing for virus isolation
3. Real Time PCR for Influenza virus
4. Virus isolation
5. Haemagglutination assay (HA)
6. Haemagglutination inhibition assay (HI)

VR-334MC(P): A] Viral Hemorrhagic Fevers B] Viral Encephalitis (2 Credits) (Practical)

A] Viral Hemorrhagic Fevers

1. MAC-ELISA for detection of dengue specific IgM antibodies
2. NS1 antigen capture ELISA
3. Immunofluorescence assay for detection of dengue virus in cell cultures
4. Focus forming unit assay for titration of chikungunya viruses
5. Multiplex real-time RT-PCR for simultaneous detection of dengue and chikungunya
6. Multiplex RT-PCR for serotyping of dengue virus: conventional and real-time RT-PCR based methods

B] Viral Encephalitis

1. Virus neutralization assay for differential diagnosis of encephalitic viruses.
2. Genome detection based diagnosis of encephalitic viruses.
3. Diagnosis of human viral encephalitis in specimens collected during acute phase of illness through detection of IgM antibodies.
4. Detection of viral antigen in clinical specimen using virus specific antibodies.

Major Elective: (Any 2) (2 Credits each)

VR-314ME(T): A] Veterinary & Agricultural Viruses B] HIV/AIDS (2 Credit) (Theory)

A] Veterinary & Agricultural Viruses

1. Introduction to viruses of veterinary importance [1 hr]
2. Cattle Diseases: Foot and mouth disease (FMD), Infectious Bovine rhinotracheitis (IBR), Lumpy Skin Disease (LSD), Bovine ephemeral Fever (BEF) [4 hrs]
3. Caprine Diseases: Blue Tongue (BT), Pestes des Petits Ruminant (PPR), Sheep/Goat pox, Rift Valley Fever (RVF), Nairobi Sheep Disease (NSD) [4 hrs]
4. Canine Diseases: Canine Distemper (CD), Rabies, Infectious Canine Hepatitis (ICH) [2 hrs]
5. Poultry Diseases: Newcastle disease (ND), Marek's disease (MD), Infectious bursal disease (IBD), Avian influenza (AI), Infectious laryngotracheitis (ILT), Infectious Bronchitis (IB), Egg drop syndrome, Chicken anaemia virus, Lymphoid leucosis and other retroviral infections. [6 hrs]
6. Equine Diseases: Equine influenza, Equine infectious anemia, Equine encephalomyelitis, African Horse Sickness, Hendra virus infection, Equine viral arteritis, Equine Herpesvirus infections [5 hrs]
7. Porcine Diseases: Swine influenza, Japanese Encephalitis, Classical Swine fever, African swine fever, Nipah virus encephalitis, Porcine reproductive and respiratory syndrome. [3 hrs]
8. Viral diseases of agricultural crops. Viral diseases of horticultural crops, Viral diseases of forest plants. Viral insecticides [3 hrs]

Reference Books:

1. Fenner's Veterinary Virology, Fifth Edition (2016)
2. Veterinary Virology by Murphy *et al*, 3rd Edition
3. Essentials of Veterinary Virology by Verma and Prajapati, 2018
4. Essentials of Laboratory Animal Science: Principles and Practices by Nagrajan, 2021.
5. Pathology of Laboratory Rodents and Rabbits by Barthold et al, 2016

B] HIV/AIDS

1. Epidemiology: Origin of HIV & molecular epidemiology; Epidemiology of HIV infection (including National and Global Statistics) & transmission of HIV among adults and children; National AIDS Control Program and Tracking the HIV Epidemic in India; Sexually transmitted diseases and their relation with HIV; Newer Methods of HIV Prevention (includes Antiretrovirals for prevention – TASP + PrEP + microbicides; Vaccines); Social and behavioural aspects of prevention. [6 hrs]
2. Pathogenesis: Life cycle of HIV, structure and replication; HIV characterization including HIV isolation; Immunopathogenesis of HIV infection [5 hrs]

3. Clinical Manifestation: Natural history, Clinical spectrum of HIV infection and complications in HIV: infectious, (bacterial, Fungal, viral), tumors, CNS involvement and Opportunistic infections. [3 hrs]
4. Diagnosis and monitoring of HIV infection: Serologic and virologic tests [2 hrs]
5. Anti-retroviral treatment: Classes of ARV drugs and treatment schedules, newer developments; ART drug resistance, complications and drug resistance monitoring and assessment. [2 hrs]
6. Historical perspective and present status of HIV Research: HIV vaccine and Clinical trials of drugs and vaccines. [2 hrs]

Recommended books:

1. HIV and Aids by Michael A. Palladino, David Wessner. Latest edition / Pub. Date: March 2005 Publisher: Benjamin Cummings.
2. HIV Libman, Harvey J. Makadon. Royal Society of Medicine Press Ltd. 2006.
3. Textbook of Aids Medicine. Thomas C. Merigan, John G. Bartlett (Editor), Dani Bolognesi (Editor). Latest edition / Pub. Date: September 1998 . Publisher: Lippincott Williams & Wilkins.
4. Aids Therapy. Raphael Dolin, Henry Masur (Editor), Michael S. Saag (Editor). Latest edition / Pub. Date: November 2002. Latest edition / Pub. Date: November 2002.
5. API Textbook. Chapter by DA Gadkari.

VR-335ME(P):HIV/AIDS (2 Credit) (Practical)

1. HIV Diagnosis
2. HIV subtyping
3. CD4, CD8 counts

VR-336ME(P):Special Techniques in Virology (2 Credit) (Practical)

1. Chick embryo fibroblast cultures
2. Complement fixation assay
3. Cytotoxicity Assays
4. Plaque reduction neutralization test
5. Agar gel diffusion for detection of antigens and antibodies
6. Microneutralization assay
7. Focus reduction neutralization test (FRNT)
8. Arbovirus inoculation in mosquito
9. Rabies diagnosis either by FAT or rapid fluorescent focus inhibition test (RFFIT)
10. Cell culture-based Immunocolorimetric assay (ICA)
11. ICA based focus reduction neutralization tests for MMR, JE & Rota viruses
12. Use of RT-PCR for detection of viruses with special emphasis on novel discovery platfoms

VR-350(RP): Research Project I (4 credits)

Research project I will mainly involve orientation of the students, assigning topic of research, literature search, writing a concept note on the proposed work including expected outcome, presentation by the student and learning of related techniques

1. Allotment of project and supervisor to the student
2. Literature search and writing a brief review on the topic of research
3. Work plan preparation, designing of experiments and enlisting material requirements including reagents and chemicals etc.
4. Learning of techniques and standardization of protocols
5. A brief presentation of the work done

M.Sc. Virology: Semester IV

Major Core:

VR-411MC(T) Quality Control , Bioethics and IPR (2 Credits) (Theory)

Quality Control:

1. Introduction to GLP, GCLP- Importance of GLP, GCLP , QA vs QC [2hrs]
2. Quality Control in Laboratory- Definition of Quality Control, Importance of QC in Laboratory, Types of Quality Control, Steps in Conducting Quality Control in Virology Laboratory [2 hrs]
3. Quality Assurance in Laboratory-Quality Assurance Cycle, Quality Management System, Interpretation of Laboratory Test Results, Reporting of Laboratory Test Results, Documentation of Laboratory Test Results, Corrective Action and Preventive Action [3 hrs]
4. Accreditation for laboratories-Accreditation Process and Benefits, Regulatory Frameworks and Requirements, Types of national and international accreditation agencies & their standards/ guidelines (ISO, NABL 15189, 17025 etc.), EQAS: What is EQAS, Importance of EQAS, How it is conducted [3 hrs]
5. Introduction to GMP for Biologicals- GMP guidelines & its importance, Different regulatory agencies [2 hrs]

Bioethics and IPR

1. Introduction to Ethics in Biomedical Research [1 hr]
2. Informed consent [1 hr]
3. Vulnerable and special groups as research participants [1 hr]
4. Responsible authorship and publication –RIPE, Research misconduct and policies for handling misconduct [1 hr]
5. Ethical review procedures [1 hr]
6. Clinical trials of drugs and other intervention [1 hr]
7. Public health research; Research during humanitarian emergencies and disasters [1 hr]
8. Biological materials, biobanking and datasets [1 hr]
9. Social and behavioural sciences research for health; Community Engagement [1 hr]
10. Group Discussion- on bioethics [3 hrs]
11. Basics of Intellectual Property Rights. [1 hr]
12. Indian patenting system. [1 hr]
13. Patenting in biotechnology. [1 hr]
14. Trade Related Intellectual Property Rights (TRIPS) and public health. [1 hr]

References:

1. ICMR-National Ethical Guidelines for Biomedical and Health Research involving Human Participants
2. WHO- Laboratory Quality Management System.

VR-412MC(T):Application of R and Python software in biological sciences (2 Credits) (Theory)

Module 1 [10 hrs]

Introduction to R, Basic data types in R, Basic data structures in R, Import and export data in R, Functions in R, Basic statistics in R, Simple data visualization in R, Install packages in R, Save data in R session, R markdown and R notebooks, Missing Values.

Module 2 [10 hrs]

Getting started with genomic data: Data files, GREIN (GEO RNA-seq Experiments Interactive Navigator), RNA-seq dataset, Tidyverse, Loading the data.

Getting to know the genomic data, formatting the genomic data.

Module 3 [10 hrs]

Application of Machine Learning Models using R. Classification and Regression.Types of Regression: Linear Regression and Logistic Regression, False Discovery Rate, Sensitivity, Specificity, ROC curve.

References:

1. Fundamentals of R for Biologists, Dillon Jones
2. https://cambiotraining.github.io/intro-r/03-tidyverse.html
3. R Bioinformatics Cookbook. Dan MacLean.
4. Biostatistics A Methodology for the Health Sciences Second Edition. Gerald Van Belle et al. John Wiley & Sons, Inc.
5. The Analysis of Biological Data. Michael Whitlock and Dolph Schluter

VR-413MC(T):Genomics and Transcriptomics (2 Credit) (Theory)

1. Structural Genomics: [6 hrs]
    a) Genome Organization (intron, exon, promotor, intergenic region, ORF)
    b) Virus evolution and adaptation, mechanisms of virus evolution - mutation, recombination and reassortment
    c) Genome Sequencing: MaxumGilbert Method, Sanger Methods, Pyro-sequencing.
    d) Next Generation sequencing methods (NGS)- Illumina sequencing, 454 sequencing, Ion Torrent. NGS-file formats.
    e) Genome Assembly and annotation
2. Introduction to Genomics: [6 hrs]
    a) Large fragment genomic libraries (Plasmid based and BAC libraries), physical mapping of genomes, whole genome sequencing approaches for prokaryotes and eukaryotic organisms (clone contig, shotgun sequencing), sequence assembly and annotation, concepts of contig and scaffolds, epigenetics.

3. Functional Genomics: [6 hrs]
    a) High throughput Biology and Microarrays, Analysis of Microarray Data, Sequence Polymorphisms, Promoter Analysis: Characterization and Prediction; Sequence Assembly and Finishing methods.
4. Comparative genomics [1 hr]
    a) Definition, significance and application of comparative genomics
5. Concepts of metagenomics, epigenomics and pharmacogenomics [1 hr]
6. Transcriptomics [2 hrs]
    a) Analysis of the transcriptome, Methods – RNA Seq, Microarrays, SAGE and Affymetrix Gene Chip arrays. Proteomics: Gel based - 2D PAGE
    b) Single-cell transcriptomics, spatial transcriptomics.
7. Impact of transcriptomic on biology and important repositories [3 hrs]
    a) Techniques used in transcriptomic: microarray and RNA-seq. DNA chips and their use in transcriptome analysis, qPCR, SAGE, MPSS, small RNA sequencing. Analysis of gene expression by Northen Blotting, RT-PCR, EST analysis, Promoters analysis, mapping transcriptional start sites.

References:

1. Genomes by T.A. Brown
2. Principles of Gene Manipulation and Genomics by Sandy B. Primrose and Richard Twyman
3. Introduction to Genomics. Third Edition. 2016. Arthur Lesk.
4. Transcriptomics and Gene Regulation. 2016. Springer. J Wu et al.
5. Genes IX. 2007. Benjamin Lewin.
6. The Dictionary of Genomics, Transcriptomics and Proteomics. 2015. Guenter Kahl.

VR-414MC(T): One Health (2 Credit) (Theory)

1. Introduction to One Health [1 hr]
2. History of One Health [1 hr]
3. One Health Policy, Framework, leadership, network [2 hrs]
4. Integrated human and animal disease surveillance systems: Emerging Infectious Diseases BSL4 [2 hrs]
5. Antimicrobial Resistance [2 hrs]
6. Zoonoses and types of zoonoses: [3 hrs]
    a. Food borne
    b. Waterborne
    c. Air borne
    d. Bat borne
    e. Vector borne
    f. Zoonotic spillover
    g. Mitigation, prevention of zoonotic diseases
    h. Field experiences for these diseases (human/animal)–lessons learnt
7. NTD in One health [1 hr]

8. Ecosystem and One Health [3 hrs]
    a. Environment, host and pathogen interaction
    b. Climate and climate change
    c. Climate of the Indian subcontinent
    d. Climate change impact on vectors and viral diseases
    e. Introduction to GIS systems (survey and outbreaks)
9. Socio cultural and behavioural practices in One Health [1 hr]
10. Bioterrorism and one health [1 hr]
11. Risk/Crisis Communication- Student seminar –on one health (group activity) [3 hrs]

VR-431MC(P): Application of R and Python software in biolocal sciences (2Credit) (Practical)

Module 1 [10 hrs]

An Overview of Descriptive Statistics, Hypothesis Testing and Statistical Inference.
Basic exploratory data analysis and summary functionality and outliers of a real data using R. Descriptives and Data Visualization (Bar chart, Pie chart, Histogram, Box Plot, Scatter Plot)

Module 2 [10 hrs]

Use R to apply classical statistical techniques on quantitative and qualitative data:
One and Two-Sample Inference, ANOVA, Chi square Test, Nonparametric Tests. Linear regression and Logistic regression, ROC Curve**,** Sample size calculation.

Module 3 [10 hrs]

Querying the NCBI Sequence Database via R, Searching for an accession number in the NCBI database, Analyzing Sequences: Quality assessment of raw sequencing reads and aligned reads using R**,** Sources of variation in RNA-seq data, Differential expression analysis**,** Annotation resources**,** Identifying over-represented gene sets amongst a list of differentially-expressed genes.

References:

1. Fundamentals of R for Biologists, Dillon Jones
2. https://cran.r-project.org/doc/contrib/Krijnen-IntroBioInfStatistics.pdf
3. https://cambiotraining.github.io/intro-r/03-tidyverse.html
4. R Bioinformatics Cookbook. Dan MacLean.
5. Biostatistics A Methodology for the Health Sciences Second Edition. Gerald Van Belle et al. John Wiley & Sons, Inc.
6. The Analysis of Biological Data. Michael Whitlock and Dolph Schluter.
7. https://compgenomr.github.io/book/data-filtering-and-exploratory-analysis.html

VR-432MC(P):A] Molecular Techniques B] Biochemical Methods (2 Credits) (Practical)

A] Molecular Techniques

1. Growth of bacterial cells & Preparation of competent cells
2. Transformation of bacterial cells
3. Purification of plasmid
4. Restriction endonuclease digestion and analysis

5. Cloning and screening of colonies
6. PCR and RT-PCR

B] Biochemical Methods

1. Protein estimation by Bradford method
2. Western Blot
3. Ultrafiltration
4. Ultracentrifugation
5. Affinity chromatography

Major Elective: (Any 2)

VR-415ME(T): Proteomics and Metabolomics (2 Credits) (Theory)

1. Introduction to Proteomics [2 hrs]
2. Recent Innovations in Proteomics [2 hrs]
3. Proteomics Resources [2 hrs]
4. Gel based proteomics [1 hr]
5. Mass spectrometry based proteomics: techniques in quantitative proteomics: ICAT labeling, SILAC, and iTRAQ [2 hrs]
6. In silico tools and databases involved in proteome analysis: UniProt, UniRef, UniParc, TrEMBL, PDB, SwissProt [2 hrs]
7. Basics of Metabolomics [2 hrs]
8. Protein Microarray [2 hrs]
9. Proteomics application in clinical/infectious diseases [2 hrs]
10. Assignment: Read and critically evaluate selected published papers in proteomics [6 hrs]

VR-416ME(T): Nanobiotechnology and Biosensors (2 Credits) (Theory)

1. History and concepts in nanotechnology [1 hr]
2. Nanomaterials and Nanoscale Phenomena [1 hr]
3. Types of Nanomaterials: Nanoparticles (Metallic, Carbon-based, Polymeric), Quantum Dots, Lipid-based nanoparticles (Solid Lipid Nano Particles, Nanostructured Lipid Carriers, Liposomes), Dendrimers, Nanolayers, Nanotubes or nanowires [3 hrs]
4. Properties of nanomaterials [1 hr]
5. Synthesis Methods: Chemical, Physical, Biological (Green Synthesis) [2 hrs]
6. Characterization of nanoparticles: methods of nanoparticle characterization (Spectroscopy, Transmission Electron Microscopy, Dynamic Light Scattering and Zeta potential/sizer), in-vitro/vivo evaluation of nanomaterial toxicity [2 hrs]
7. Introduction to Nanobiotechnology [1 hr]
8. Surface functionalization/conjugation of nanoparticles with biomolecules: Proteins (Antigens, Antibodies), Peptides, Nucleic Acids, Aptamers, Enzymes, Polymers, Ligands and Small Molecules [3 hrs]

9. Applications of Nanomaterials in medicine: Diagnostics, Delivery Systems (Gene therapy, Drugs), Therapeutics (antimicrobial agents), Imaging, vaccine carriers and adjuvants [3 hrs]
10. Introduction to Biosensors [1 hr]
11. Types of biosensors: electrochemical, optical, electronic, piezoelectric, pyroelectric, magnetic [4 hrs]
12. Lateral flow assays [1 hr]
13. Lab-on-a-Chip/Microfluidic Biosensors: Surface plasmon resonance (SPR) based biosensors [1 hr]
14. Application of biosensors in viral disease diagnosis: antigen, antibody and nucleic acid detection, limitations of biosensors [1 hr]

References/Books:

1. Viruses and Nanotechnology, Manchester M. Ed. 2009
2. Principles of nanotechnology: Molecular based study of condensed matter in small systems. 2005
3. Biosensors and biodetection: Methods and protocols, 2009
4. Micro and Nanotechnologies in bioanalysis: Methods and protocols, 2009
5. Nanobiomedicine Volume 5; Medical nanobiotechnology. 2015
6. Nano World. An Introduction to Nanoscience and Technology by CNR Rao.
7. Niemeyer CM, Mirkin CA, Nanobiotechnology: Concepts, Applications and Perspectives. John Wiley & Sons (2006).
8. Niemeyer CM, Mirkin CA. Nanobiotechnology II: More concepts and applications. John Wiley & Sons (2007).
9. Singh RP, Singh KRB, Singh J, Adetunji CO, editors. Nanotechnology for drug delivery and pharmaceuticals. Elsevier. (2023)
10. Gardner JW. Microsensors, Principles and Applications, John Wiley and Sons (1994).
11. Kovacs GTA. Micromachined Transducer Sourcebook, McGraw–Hill (2001).
12. Turner APF, Karube I, and Wilson GS. Biosensors–Fundamentals and Applications, Oxford University Press (2008).
13. Zhang X, Ju H and Wang J, Electrochemical Sensors, Biosensors and Their Biomedical Applications, Academic Press, 2008.
14. Grundler P. Chemical Sensors -An Introduction for Scientists and Engineers, Springer Verlag. (2007).
15. Rasooly A, & Herold KE, editors. Biosensors and Biodetection: Methods and Protocols, Volume 503: Optical-Based Detectors, Springer-Verlag, 2009.
16. Eggins BR. Biosensors: an Introduction. SpringerLink.
17. Blum LJ & Coulet PR, editors. Biosensors Principles and Applications, First edition, Marcel Dekker,Inc. (1991)
18. Buerk DG. Biosensors Theory and Applications. First Edition Technomic Publishing. Co, Inc, (1993)

VR-433ME(P): Genomics and Transcriptomics (2 Credits) (Practical)

1. DNA/ RNA Extraction and Quantification
2. Nanopore sequencing for viruses

3. Introduction to Linux and high-performance computation
4. Bioinformatics software introduction FASTA, FASTQ and SAM formats
5. QC: finding out the quality of generated NGS reads
6. Reference based and de-novo sequence assembly
7. Phylogeny maximum likelihood
8. Transcriptome data analysis
9. Omics facility demonstration

VR-450(RP): Research Project II (6 credits)

The student will continue working on the project assigned in semester III, carry out proposed work, submit final dissertation and defend it. The student will maintain a logbook during the entire project with all necessary details of the results/ data.

1) Optimization of protocols and conduct of experiments
2) Collection of data and analysis/interpretation of results
3) Writing of dissertation and submission
4) Final Presentation