RGCB

DISCOVERIES FOR A
BETTER TOMORROW

RAJIV GANDHI CENTRE FOR BIOTECHNOLOGY, THIRUVANANTHAPURAM 695014, KERALA STATE, INDIA

An Autonomous National Institute for Discovery, Innovation & Translation
In Biotechnology and Disease Biology,
Government of India,
Ministry of Science & Technology, Department of Biotechnology.

PROSPECTUS

MSc BIOTECHNOLOGY PROGRAM (WITH THREE STREAMS)

AFFILIATED TO UNESCO-REGIONAL CENTRE FOR BIOTECHNOLOGY, GOVERNMENT OF INDIA

MSc in Biotechnology Stream 1: **Disease Biology**

MSc in Biotechnology Stream 2: **Molecular Plant Sciences**

MSc in Biotechnology Stream 3: **Molecular Diagnostics & DNA Profiling**

The RGCB MSc BIOTECHNOLOGY PROGRAM WITH THREE STREAMS AFFILIATED TO UNESCO – REGIONAL CENTRE FOR BIOTECHNOLOGY (RCB)

Stream 1: Disease Biology
Stream 2: Molecular Plant Sciences
Stream 3: Molecular Diagnostics and DNA Profiling

Duration of the Course: Two years (four semesters)

The MSc Biotechnology Program at RGCB

Biotechnology harnesses the core principles of biology and engineering to generate controlled processes or products related to the biopharmaceutical, industrial, healthcare, food or agro-industries. It covers a broad range of subjects including cell and molecular biology, biochemistry, genetic & metabolic engineering, molecular cell biology, systems and synthetic biology.

The unique course structure is designed in consultation with clinical, agricultural and industrial experts to give you the cutting edge specialist knowledge and practical skills needed for a career in molecular biosciences. Students will gain extensive research experience through research based teaching in top notch laboratories, hands on computer modeling, internship in industry or medical institutions and carrying out a full semester research project, working under the mentorship and supervision of highly accomplished scientists. Students will graduate with specialist knowledge and employability skills for a career in further research (such as a PhD) or important placements in academic, clinical, industrial, agricultural or commercial sectors anywhere in the world.

The MSc program at RGCB will be unique, as it will cover the fundamental fields of theories in Biotechnology, while focusing on laboratory exercises and industrial as well as research applications. The students will be introduced to the concepts of “Enterprise and Entrepreneurship”. This allows students who wish for a career beyond the laboratory in an existing biotechnology industry or for those who dream of starting a new biotechnology enterprise. Students get trained in a real business & technology development bio-incubator where startup companies function. Every student will have a personal tutor who will constantly provide mentorship for course work as well as pastoral advice on living through the entire course.

We aim at developing and retaining a sustainable pipeline of biotechnology professionals across a range of related disciplines including fundamental science, technology development, translation, policy and outreach through efforts in education, training, and career development.

About RGCB

- Rajiv Gandhi Centre for Biotechnology (RGCB) located at Thiruvananthapuram, Kerala is an autonomous national institute of the Government of India, Department of Biotechnology, Ministry of Science and Technology.

- The mandate of the institute is discovery, innovation and translation in biotechnology and disease biology.

- India's engagement with biotechnology, life sciences and medicines is dynamic and constantly evolving. RGCB sees itself as key player in this developmental process. Our research is focused on understanding disease biology and processing this knowledge for better management and design of potential therapeutics.

- RGCB currently functions from three campuses. The main campus is located at Thiruvananthapuram where the bulk of our discovery research programs are implemented.

- The second campus located at the Film & Video Park in Thiruvananthapuram functions as the transit facility for the Bio-Innovation Center where RGCB's core Bio-Imaging, Genomics and Laboratory Medicine & Molecular Diagnostic core facilities are located in addition to laboratories for Chemical Biology, and Tropical Disease Biology.

- BioNest, the third campus located at Kochi is a unique facility, designed to provide infrastructure and scientific support to enable, researchers, investors and entrepreneurs. It offers incubation space for individual companies backed up by a state of the art "plug and play" laboratory.

- The trademark feature of RGCB is the collaborative and interdisciplinary approach we bring to everything we do.

- We are also special being an institute that translates Biotechnology for the society where we provide services to the judiciary and criminal justice systems with DNA fingerprinting & DNA Barcoding for identification of plants, animals, unidentified bodies and paternity disputes. RGCB also provides state of the art molecular diagnostics for viral diseases, cancer markers and risk markers for cardiovascular & genetic-diseases.

- This unique facet and energetic atmosphere of the institute is our success. It also creates an ideal and fertile teaching atmosphere for graduate students and postdoctoral trainees. RGCB is truly of the people, by the people and for the people.

The Affiliating University: UNESCO - RCB

- For this MSc program, RGCB will be affiliated to the Regional Centre for Biotechnology (RCB: www. rcb.res.in) an **"Institution of National Importance"** providing education, training and research established by the Government of India through an Act of Parliament and under the auspices of the United Nations Educational, Scientific and Cultural Organization or UNESCO, a specialized agency of the United Nations (UN) based in Paris. RCB is thus equivalent to a Central University for all degree granting purposes.

- The declared purpose of UNESCO is to contribute to peace and security by promoting international collaboration through educational, scientific, and cultural reforms. UNESCO pursues its objectives through five major programs: education, natural sciences, social sciences, culture and communication/information.

- RCB is focused on cooperatively working towards shared biotechnology growth in the Asia-Pacific Region. Regional interactions in biotechnology will promote co-operation amongst the countries to develop necessary infrastructure and capacity building for economic benefit of our societies.

- Students studying the MSc course at RGCB will get their degrees from UNESCO-RCB

What is special about the MSc Program in Biotechnology at RGCB?

- **RGCB's** Master of Science or MSc is a two-year post baccalaureate degree.

- **RGCB's** MSc Biotechnology is a research based teaching program that combines disciplines of biochemistry, cell biology molecular biology, genomics, proteomics, microbiology and immunology as well as application of computer science to biology (bioinformatics) along with principles of design and engineering in biological systems.

- **RGCB's** MSc Biotechnology students will have a personal tutor who will constantly provide mentorship for course work as well as pastoral advice on living through the entire course. Student residences will be made available for all students.

- **RGCB's** MSc Biotechnology program will introduce students to the concepts of "Enterprise and Entrepreneurship". This allows students who wish for a career beyond the laboratory in an existing biotechnology industry or for those who dream of starting a new biotechnology enterprise. Students get trained in a real business & technology development bio-incubator where start up companies function.

- **RGCB's** MSc Biotechnology program extends over four semesters. This includes didactic lectures, seminars and laboratory-based teaching by scientists who do exciting and high-end research, the best of teachers from the medical & scientific education system and professionals from the biotechnology & pharmaceutical industry.

- **RGCB's** MSc Biotechnology program will also have dry lab exercises where students learn on their own computer, design of experiments in molecular biology as well as fundamentals of computational modeling, structural biology, data analysis from proteomics platforms, genomic sequencing & genomic analysis and microarray analysis as well principles of statistical analysis on software platforms.

- **RGCB's** MSc Biotechnology program includes foundation courses in ethical, legal and regulatory aspects of biotechnology applications.

- **RGCB's** MSc Biotechnology students will give regular seminars and journal clubs. They will learn the importance of correct reading & scrutiny of scientific publications, critical analysis of manuscripts rejected for publications to realize the reasons behind this and the art of writing manuscripts and grant proposals.

- **RGCB's** MSc Biotechnology students, once in 6 months students will get to go on a scientific retreat where there will be invited talks and a one to one formal interactions between students and faculty.

Structure of the RGCB MSc Biotechnology Program

Three specialized post graduate streams

MASTER OF SCIENCE IN BIOTECHNOLOGY:
Specialization in Disease Biology

MASTER OF SCIENCE IN BIOTECHNOLOGY:
Specialization in Molecular Plant Sciences

MASTER OF SCIENCE IN BIOTECHNOLOGY:
Specialization in Molecular Diagnostics and DNA Profiling

Semesters 1 and 2 (YEAR 1)

All students from the three streams will have a common syllabus to study in the first two semesters (Year 1), where there is comprehensive teaching and laboratory training in the fundamental sciences associated with cell & molecular biology, genetic engineering, biochemistry, microbiology, immunology bioinformatics, genomics and proteomics.

The detailed syllabus and number of credits for the different subjects and courses are elaborated in the detail syllabus provided in this prospectus.

Semesters 3 and 4 (YEAR 2)

After successfully completing the first two semesters, students would move into the specialized stream they have selected in Semester 3 and 4.

MASTER OF SCIENCE IN BIOTECHNOLOGY (Specialization in Disease Biology)

Biosciences research has huge impact in helping people live longer and healthier lives. With the World Economic Forum identifying healthcare as one of the top 10 Global Challenges for 2030, there is a growing demand for specialists in this field. This course provides you with an understanding of the molecular basis of biological systems and focuses on applying this knowledge to improve human health and disease, food biosecurity and sustainable technology based application.

- RGCB's MSc Biotechnology program with specialization in disease biology is unique and one of a kind in India.

- In the third semester there are intensive courses for understanding of human diseases and the potential use of such knowledge for preservation of human health. A detailed understanding of the molecular mechanisms of disease biology will form a rational basis for improved disease prevention.

- This is carried out by theory and laboratory teaching through the third and fourth semesters that will also include a carefully selected 8-month duration dissertation done with one of the many accomplished scientists at RGCB. There will be continuous seminars, quiz programs and debates on contemporary topics by the students during the 3rd and 4th semesters.

- This goal can only be reached by performing high-quality scientific research that is based on the most advanced methodology available. While medical students develop a very good background in structure and function of the human body and methods of diagnosis & treatment, they often face difficulty in formulating research questions in the context of modern biology on a structured hands-on laboratory platform to tackle molecular research questions. RGCB's MSc Biotechnology students specializing in disease biology will become ideally positioned by their training to take up this research challenge. This will therefore make them in high demand for the best of PhD programs in biomedical research as well as attractive jobs in the biotechnology, pharmaceutical and health industry.

MASTER OF SCIENCE IN BIOTECHNOLOGY (Specialization in Molecular Plant Sciences

Life on Earth depends on solar energy captured by plants - they are the base of most food webs and the platform for functioning of all major ecosystems. Plants release the oxygen that we breathe. Plants convert solar energy into chemical energy, providing us with food and renewable energy sources as well as raw materials for many industries. Plants use intricate systems for growth, development, transport and metabolism to cope with adverse environmental conditions, but also have considerable capacity to adapt genetically to both biotic and abiotic factors. An understanding of the mechanisms that underlie these features is of fundamental importance for all biological disciplines.

- RGCB's MSc Biotechnology program with specialization in molecular plant sciences is unique and one of a kind in India.

- The Molecular Plant Science program extends over four semesters. This includes didactic lectures, seminars and laboratory-based teaching by scientists who do exciting and high-end research, the best of teachers from the agriculture education system and professionals from the plant biotechnology industry.

- There will also have dry lab exercises where students learn on their own computer, design of experiments in molecular biology as well as fundamentals of computational modeling, structural biology, data analysis from proteomics platforms, genomic sequencing & genomic analysis and microarray analysis as well principles of statistical analysis on software platforms.

- The program includes foundation courses in ethical, legal and regulatory aspects of biotechnology applications.

- Students will give regular seminars and journal clubs. They will learn the importance of correct reading & scrutiny of scientific publications, critical analysis of manuscripts rejected for publications to realize the reasons behind this and the art of writing manuscripts and grant proposals.

- Students, once in 6 months students will get to go on a scientific retreat where there will be invited talks and a one to one formal interactions between students and faculty.

- In the third semester there are intensive courses for understanding of molecular plant sciences designed to address some critical global challenges of the 21st century including crop improvement, food security, renewable energy, climate change, protecting biodiversity and improving global health.

- This is carried out by theory and laboratory teaching through the third and fourth semesters that will also include a carefully selected 8-month duration dissertation done with one of the many accomplished scientists at RGCB. There will be

continuous seminars, quiz programs and debates on contemporary topics by the students during the 3rd and 4th semesters.

- RGCB's MSc Molecular Plant Science graduates can continue towards the best of PhD programs in India and abroad or move directly into a career.

- MSc Plant Science graduates can take on a wide variety of possible jobs including positions in horticulture & plant breeding, nurseries, biotech & seed industry, greenhouses, plant research & development, food & plant production, plant based biotechnology, phytomedicines and nutraceuticals and much more.

MASTER OF SCIENCE IN BIOTECHNOLOGY (Specialization in Molecular Diagnostics and DNA Profiling)

Molecular Diagnostics is an emerging platform gaining wide acceptance attributed to the outcome of the fruitful interplay among laboratory medicine, genomics knowledge and emerging genetic engineering technology, resulting in faster and accurate diagnostic support. Strict adherence to evidence based medical practice has opened new avenues in molecular medicine-based diagnostics in both infectious and non-infectious diseases. Similarly the use of DNA profiling in paternity disputes, identifying disaster victims and solving criminal cases is now standard procedure. This course will create ready to deploy, highly trained molecular diagnostic professionals for the betterment of human kind.

- RGCB's MSc Biotechnology program with specialization in Molecular Diagnostics and DNA Profiling is unique and one of a kind in India.

- The third and fourth semester will empower the students with advanced knowledge in various diagnostic platforms, using molecular techniques and provides an opportunity to understand molecular diagnostics for viral and chronic diseases or DNA profiling for solving human identification, resolving paternity disputes, use of DNA barcodes to identify protected wild life and in the identification of different plant species Hands-on training using state-of-the art machinery and latest techniques used in diagnostics and DNA fingerprinting will be the highlight of these semesters

- The fourth semester will in addition have a dissertation work, to be carried out at the diagnostic and DNA fingerprinting facilities of RGCB under the direct supervision of senior scientists. This is supplementary to regular seminars, presentations, and problem-based learning (PBL) sessions.

- There often cannot be a definitive clinical diagnosis without the assistance of molecular diagnostic tests or a criminal case or missing person or paternity disputes resolved without DNA fingerprinting. DNA based testing is therefore acknowledged as the gold standard in molecular based testing for disease and molecular forensics. Having adequate exposure and theoretical background, will

generate professionals capable of planning, executing and troubleshooting advanced molecular diagnostic aids in health care system.

- A Post-graduate Degree in MSc Biotechnology program with specialization in Molecular Diagnostics and DNA Profiling will generate immediately employable work force who will then need minimal on job training. This will make the degree holders highly desirable for employment by any institute catering to quality molecular diagnostic services, diagnostic kit manufacturers and function as technical support executives in the diagnostic marketing field as well as in molecular forensics laboratories in the government sector. Additionally, further research opportunities leading to a PhD in various domains of molecular based diagnostics will pave the way for applying for academic and research jobs as well as generating academic entrepreneurs in the field of medical diagnostics.

Number of seats per year: 15 seats for Disease Biology and Molecular Diagnostics & DNA profiling per stream; ten seats for the Molecular Plant Science Stream.

Eligibility criteria

Students with 60% aggregate marks (or an equivalent grade point average) in Bachelor's degree in any branch of Science, Engineering, Medicine (including Dentistry, Ayurveda and Homeopathy from approved Universities), are eligible to be apply for admission. Students from the SC, ST, OBC (non-creamy layer), and PWD categories shall be given a relaxation of 5% aggregate marks. Students in the final year of their qualifying degree program are also eligible to apply provided that they produce a proof of having secured the required marks in their undergraduate degree program at the time of admission.

Admission Procedure

Eligible students are required to appear for the RGCB Entrance Examination. The examination in 2019 will be held at 16 cities in the country (provided a minimum of 50 applications must be received for taking the test in the particular city). Up to 15 students per stream (total 45), who meet the desired criteria for selection, may be admitted. Allotment of students to particular specialties will be based on the choice of the candidate at the time of application submission. Students will have to give three preferences (three specialties) and final allotment will be based on the marks scored in the entrance examination.

Reservation

There shall be reservation of seats for students from the SC, ST, OBC, PWD and Economically backward categories as per the rules and regulations of the Government of India.

Foreign national students

Foreign national students with 60% aggregate marks (or an equivalent grade point average) in Bachelor's degree in any branch of Science, Engineering, or Medicine are eligible to apply for admission. Students in the final year of their qualifying degree program are also eligible to apply. Eligible students are required to apply online for admission and fellowship to the program. Additional of approved intake, 2 (15%) students per stream, who meet the desired criteria for selection, may be admitted. Admission of foreign students is subject to them getting the student visa from the Government of India and will have a higher fee structure.

Stipend

Indian and foreign students admitted to the program shall receive the RGCB-DBT stipend of Rupees 6000 per month for the first year and Rupees 8000/- for the second year of the MSc program.

CORE COURSES (for all three streams)

ONE CREDIT = 12 TEACHING HOURS

SEMESTER I

CODE	COURSE	CREDIT (S)
RGC 301	**BIOCHEMISTRY AND BIOPHYSICS** *This course is designed to provide students a broad understanding of basic macromolecules of life. This course will also cover a wide range of topics applying physical principles and techniques to different problems in biology.* **Unit I: Basic principles and role of water** Basic chemistry, Elements, Functional groups, pH, Mole concept, Bonding and chirality, Non-covalent interactions, Water, interactions in aqueous systems, Ionization state of biomolecules, Water as reactant, Laws of thermodynamics, Gibbs free energy, Statistical thermodynamics, and maintenance of equilibrium. **Unit II: Proteins** Amino acids – structure and functional group properties; pH and properties of amino acids, Peptides and covalent structure of proteins; peptide bond, polypeptide, protein structure-secondary, tertiary and quaternary, protein structure & function, protein folding and chaperones, Protein-Ligand interactions and function, Post-translational modification of proteins. **Unit III: Enzymes** General principles of enzyme catalysis, Activation energy and stereo-specificity, Quantitation of enzyme activity and efficiency, Enzyme characterization and Michaelis-Menten kinetics, Regulation and Inhibition of enzymes, Enzymes and Metabolic pathways, Study of model enzymes such as proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase. Production of industrial enzymes, enzyme immobilization **Unit IV: Carbohydrates, Lipids and Nucleic Acids** Carbohydrates: Monosaccharides and Disaccharides, Polysaccharides, Nucleic Acids: Nucleotides, Nucleic Acid composition, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material. Lipids: Storage lipids, Structural lipids in membranes, Lipoproteins. Lipids as signals, cofactors and pigments **Unit V: Biological Membranes** Composition and architecture, Membrane dynamics, Anchoring of proteins in membranes, Organization of proteins on membranes, Solute Transport across membranes, Membrane vesicles. **Unit VI: Bioenergetics & Metabolism** Principles of bioenergetics, Glycolysis, Citric acid cycle, Oxidative phosphorylation, Photosynthesis, Biosynthesis of amino acids, lipids, nucleotides.	3

RGC 302	**MICROBIOLOGY** *This course is designed to cover fundamental aspects of the microbial world (pathogenic and non- pathogenic) with special emphasis on how microbes live, divide, cause diseases and understanding the contribution of their genomes.* **Unit I: Microbial characteristics and diversity** Introduction to microbiology and microbes. General organization of a microbial cell morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; Gram staining and microbial typing, Cell wall and cell organelle structure and organization of various microbes. Microbial taxonomy: classification of microorganisms, criteria for classification. Prokaryotes, Eukaryotes and Archaea. Microbial evolution of diversity. **Unit II: Microbial Metabolism and genetics** Metabolic pathways of microbes, Photophosphorylation; nitrogen metabolism, symbiotic microbes, nitrogen fixation and its regulation; sulphate-metabolism; putrefaction, methane oxidizing and methanogenic bacteria. Bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance. Pasteur experiment and Griffith's experiment, Modes of genetic exchange in microbes. **Unit III: Microbes and Health** Pathogenic bacteria and viruses, Human microbiota and their role in human health, Drug-resistant bacteria, biofilms, antibiotics and antimicrobial agents, Protozoan parasites and human diseases. Antibiotics, antiviral and antifungal drugs, biological control of microorganisms. Virus and bacteriophages **Unit IV: Host-Microbe interaction** Host-pathogen interaction, ecological impact of microbes; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics. **Unit V: Tools and techniques in Microbiology** High-throughput screening assays, drug screening, molecular barcoding methods, PCR and next-generation sequencing based techniques in microbiology, Microbes in biotechnology, microbes in brewery and biotechnological applications including recombinant DNA methodologies **Unit VI: Virology** Viruses and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles –viroids and prions. Viruses, bacteriophages and their applications. **Unit VII: Fermentation technology** Bioreactors, biochemistry of fermentation, Downstream processing for product recovery, Production of different Bio-products involving microbes.	**3**

RGC 303	**IMMUNOLOGY** *This course will provide information regarding the immune system involving different molecules, cells and processes.* **Unit I: Introduction to Immunology and innate immunity** Fundamental concepts and overview of the immune system Components of innate and acquired immunity; Innate immune cells and functions; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Major Histocompatibility Complex Organs of immune system, primary and secondary lymphoid organs. **Unit II: Adaptive immune system** Immunoglobulins, B-cell receptor, B cell and T cell maturation, activation and differentiation; cell-mediated immune responses, antigen processing and presentation, Adaptive immune system and response, antigen-antibody interactions, immunological techniques **Unit III:Immunotechnology** Principles of immunization, Vaccine development, Immunotherapy, Development of monoclonal antibodies, Gene editing technology in designing antibody, Designing antibody library for immunotherapy. **Unit IV: Immunogenetics** Major histocompatibility complex genes, HLA typing, Complement genes, implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV complex.	**2**
RGC 304	**CELL AND MOLECULAR BIOLOGY** *The objectives of this course are to introduce students to fundamental concepts of cell biology. The course will also cover various biological and molecular processes associated with DNA, RNA and proteins.* **Unit I: Introduction to Cell Biology** Fundamental aspects of cell biology, Understanding the basic cell, visualizing cells, Evolution of the cell, Internal organization of the cell membrane structure, Intracellular traffic, Proteins sorting, Compartmental diversity, Endocytosis, Exocytosis, Secretory pathway, Mechanisms that maintain compartmental identity and crosstalk. **Unit II: Cytoskeleton, molecular motors and dynamics** Basic elements of the cytoskeleton of a cell, Mechanisms of assembly, Dynamic structure and regulation of actin and microtubules, Cytoskeleton-based molecular motors and their varieties, Intracellular transport of cargo and its regulation. **Unit III: Cell cycle and regulation** The cell cycle and its control system, Interphase, Mitosis, Cytokinesis and molecular regulation, cell transformation, cell death and apoptosis. **Unit IV: Intercellular communication** Transport mechanisms across membrane, Cell signaling, Cell junctions, Cell adhesion and the extracellular matrix, Specialized cells, tissues, stem cells and tissue renewal.	**3**

	Unit V: Genome, DNA Replication, Repair & Recombination Genome: Composition and Structure of DNA, Supercoiling, Epigenetic modification, Replication of single stranded circular DNA. Homologous and non-homologous recombination, Site specific recombination; Genetic Alterations and Mutation: Types and causes, Transposition in prokaryotes and eukaryotes; DNA repair: Direct reversal, DNA mismatch repair, Base excision repair, Nucleotide excision repair, Recombination repair, DNA damage tolerance. **Unit VI: Chromatin structure and dynamics** Chromatin and chromatin control, Transcriptional control, post-transcriptional control, miRNAs and siRNAs, protein translation machinery, ribosomes, universal genetic codes, degeneracy of codons, Wobble hypothesis, co- and post-translational modifications **Unit VII: Transcription and Translation** Prokaryotic Transcription: Transcription unit, Promoters - Constitutive and Inducible, Operators, Regulatory elements, Initiation, Attenuation, Termination, Anti-termination; Transcriptional regulation: Positive and negative, Operon concept; Eukaryotic transcription: RNA polymerase structure and assembly, Eukaryotic promoters and enhancers, Transcription factors, Role of Nucleosomes, Epigenetic regulation; Processing of RNA: Transcript processing, Processing of tRNA and rRNA, Splicing and role of introns and exons, RNA editing, mRNA stability, Transcriptional and post-transcriptional gene silencing. Translation: Mechanism of initiation, Elongation and termination, Regulatory factors, Genetic Code, Differences and similarities in eukaryotic and prokaryotic translational process and machinery, Translational regulation of gene expression.	
RGC 305	**LABORATORY COURSE 1: METHODS IN BIOCHEMICAL TECHNIQUES** ***Practical 1***: Preparation and assessment of quality of buffers. ***Practical 2***: Estimation of protein concentration by plotting a standard graph of BSA using UV spectrophotometer. ***Practical 3***: Estimation of total carbohydrates and free amino acids in cereals. ***Practical 4***: Estimation of protein molecular weight using standard markers and SDS - Polyacrylamide Gel Electrophoresis. ***Practical 5***: Gel Filtration Chromatography. ***Practical 6***: Affinity purification of a recombinant protein and assessment of purity. ***Practical 7***: Identification of proteins using immunoblotting. ***Practical 8***: Determination of the catalytic efficiency of a standard enzyme. ***Practical 9***: Binding assay to quantitate interaction between biological macromolecules.	**4**
RGC 306	**LABORATORY COURSE 2: METHODS IN MICROBIOLOGY AND CELL BIOLOGY** ***Practical 1***: Media preparation, microbial culture (bacterial and fungal). ***Practical 2***: Growth curves, preservation of the bacteria, plating, dilution plating. ***Practical 3***: Effect of temperature, pH, salts and other stress factors on bacterial growth. ***Practical 4***: Isolation of bacteria from various surroundings, Identification of bacteria by biochemical assays and Gram staining. ***Practical 5***: Antibiotic or drug inhibition assays. ***Practical 6***: Mammalian cell culture, counting, and cryopreservation. ***Practical 7***: Staining of various cellular compartments. ***Practical 8***: Expression of foreign protein in mammalian cells. ***Practical 9***: Mammalian virus culture and titration.	**4**

RGC 307	**LABORATORY COURSE 3: METHODS IN IMMUNOLOGY** ***Practical 1*:** Immunization of mice and methods of bleeding, serum separation, storage. ***Practical 2*:** Antibody titre determination by ELISA method. ***Practical 3*:** Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion. ***Practical 4*:** Complement fixation test. ***Practical 5*:** Isolation and purification of IgG from serum. ***Practical 6*:** Blood smear identification of leucocytes by Giemsa stain. ***Practical 7*:** Separation of leucocytes by dextran method. ***Practical 8*:** Separation of mononuclear cells by Ficoll-Hypaque. ***Practical 9:*** Flow cytometry, identification of T cells and their subsets. ***Practical 10***: Lympho-proliferation by mitogen antigen induction.	**4**
RGC 308	**SCIENTIFIC ENGAGEMENT - I** Each student will be required to choose a recent high quality primary research publication and make a power point presentation to the class. The presentation should cover all the background literature of the chosen research area. Stress should be given to the objectives of the paper, logic of each experiment and the data analyses. In addition, they will be expected to highlight shortcomings and alternate approaches as appropriate. This endeavor would give them the exposure of what it takes to defend a scientific concept in an open audience. Additionally, students of this course will mandatorily attend all seminars conducted at the institute.	**1**
	Total Credits	**24**

PRESCRIBED READING

RGC 301	**Biochemistry and Biophysics** 1. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. Macmillan. 2. Tymoczko, J. L., Berg, J. M., & Stryer, L. (2011). *Biochemistry: a short course*. Macmillan. 3. Cornish-Bowden, A. (2014). *Principles of enzyme kinetics*. Elsevier. 4. Haynie, D. T. (2001). *Biological thermodynamics*. Cambridge University Press. 5. Voet, D., & Voet, J. G. (2016). *Fundamentals of Biochemistry*. *5th Edition*. Wiley & Sons 6.
RGC 302	**Microbiology** 1. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (2001). Textbook of microbiology. *MC Graw-Hill publications, 5th edn, New York*, *1193*, 504-508. 2. Sherwood, L., Willey, J. M., & Woolverton, C. (2011). *Prescott's microbiology*. McGraw-Hill. 3. Black, J. G. (2005). *Microbiology: principles and explorations* (Vol. 1). John Wiley & Sons Incorporated. 4. Hogg, S. (2013). *Essential microbiology*. John Wiley & Sons. 5. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.

RGC 303	**Immunology** 1. Janeway Jr, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2001). The complement system and innate immunity. In *Immunobiology: The Immune System in Health and Disease. 5th edition*. Garland Science. 2. Virella, G. (2001). *Medical immunology*. CRC Press. 3. Abbas, A. K., Lichtman, A. H., &Pillai, S. (2014). *Cellular and molecular immunology E-book*. Elsevier Health Sciences. 4. Khan, F. A. (2014). *Biotechnology in medical sciences*. CRC Press. 5. Pongracz, J., & Keen, M. (Eds.). (2009). *Medical biotechnology*. Elsevier Health Sciences. 6. Goldsby, R. A., Kindt, T. J., Osborne, B. A., &Kuby, J. (2003). Immunology New York.
RGC 304	**Cell and Molecular Biology** 1. Alberts, B., Johnson, A., Walter, P., Lewis, J., Raff, M., & Roberts, K. (2008). Molecular cell biology. *New York: Garland Science*. 2. Lodish, H., Berk, A., Darnell, J. E., Kaiser, C. A., Krieger, M., Scott, M. P. &Matsudaira, P. (2008). *Molecular cell biology*. Macmillan. 3. Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2014). *Lewin's Genes XI*. Jones & Bartlett Publishers. 4. Cooper, G. M., Hausman, R. E., &Hausman, R. E. (2000). *The cell: a molecular approach* (Vol. 2). Washington, DC: ASM press.. 5. Hardin, J., Bertoni, G. P., &Kleinsmith, L. J. (2017). *Becker's World of the Cell*. Pearson Higher Ed. 6. Baker, T. A., Watson, J. D., & Bell, S. P. (2003). *Molecular biology of the gene*. Benjamin-Cummings Publishing Company.

SEMESTER 2

CODE	COURSE	CREDIT (S)
RGC 309	**GENETICS AND GENETIC ENGINEERING** *This course is designed to familiarize students with the basic principles of genetics and genomics and their applications in the life sciences. The topics covered include fundamentals of genetics and inheritance, cytogenetics, genetic tools, developmental genetics and genetic disorders.* **Unit I: Principles of Genetics** Principles of genetics and inheritance, cytogenetics, developmental and human molecular genetics and associated genetic disorders, Mendelian and non-Mendelian modes of inheritance, linkage and crossing over, complementation, epistasis, quantitative genetics, population and evolutionary genetics **Unit II: Chromosomes and inheritance** Chromosomes and their role in inheritance, chromosomal aberrations, sex determination and transposable elements, Genetics in animal development. **Unit III: Human Genetics** Recent advances in human molecular genetics, introduction to the human genome, pedigree analysis, gene mapping and linkage analysis, Diagnosis and genetic counselling in genetic and metabolic disorders. **Unit IV: Methods and Tools for genetic engineering** Isolation and quantification of nucleic acids, Gel electrophoresis, Enzymes such as restriction endonucleases, ligases etc., Different types of vectors for gene cloning and protein expression, cohesive and blunt end ligation, linkers, adaptors, homopolymeric tailing, Hybridization techniques, gene synthesis, **Unit V: PCR techniques** Principles of PCR, Primer design, Types of PCR, T-vectors, proof reading enzymes; Site specific mutagenesis; PCR in molecular diagnostics, sequencing methods; mutation detection: SSCP, DGGE, RFLP **Unit VI: Gene manipulation and protein-DNA interaction** Insertion of foreign DNA into host cells; construction of libraries; isolation of RNA, reverse transcriptase and cDNA synthesis; cDNA and genomic libraries, study of protein-DNA interactions, Gene silencing technologies, genome editing by CRISPR-Cas.	3

RGC 310	**PROTEOMICS AND GENOMICS** *The objective of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.* **Unit I: Introduction to Genomics** Organization of genome in Prokaryotes and Eukaryotes; C-value paradox, Organelle DNA; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis- physical and genetic mapping **Unit II: Genome sequencing projects** Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs, ENCODE project, exome sequencing and Databases **Unit III: Proteomics** Protein analysis (includes measurement of concentration, amino-acid composition, N- terminal sequencing);2-D electrophoresis of proteins; Micro-scale solution iso-electric focusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; Differential display proteomics, Yeast/Bacterial two hybrid system **Unit IV: Functional genomics and proteomics** Analysis of microarray data; Protein and peptide microarray-based technology; SAGE, RNA-Seq & Transcriptomics, Chip-Seq; PCR- directed protein *in situ* arrays; RNAi screens, Protein-protein interactions & Interactome studies.	**2**
RGC 311	**BIOINFORMATICS AND STRUCTURAL BIOLOGY** *The course will provide an overview on the databases and methods available to exploit genomics data. Also, the function of the majority of biological macromolecules is governed by their three dimensional structure. This course will introduce basic concepts regarding macromolecule structure and the computational/experimental methods utilized to obtain structural information.* **Unit I: Tools for Bioinformatics** Introduction to UNIX environment, Unix file system; Installing & executing programs in LINUX environment; Web-Based & Command-Line Software culture, Basic command line operations; Fundamentals of computer programming & Biostatistics – Python and R package. Introduction to common text editors. **Unit II: Biological data resources** Biological data resources, access & management–Genomes across the tree of life, Major sequencing projects, Major centralized bioinformatics databases to store DNA, RNA, protein sequences & 3-D structures. Navigating through major resources and services at NCBI, Web based and command- line access to information. Overview of major web resources for the study of genomes.	**2**

	Unit III: Biological sequence analysis Scoring matrices; Evaluation of significance of results using E-value and Bit score; Sequence alignment programs, Molecular Phylogenetics, Web resources available for Plants. **Unit IV: Structure and function of Macromolecules and complexes** Principles of protein structure and function, Structure and function of enzymes, Structure and function of Nucleic Acids, Structure and function of Lipids and Carbohydrates, Structure of Complexes and Macromolecular Assemblies, Virus Structures and Assembly, Protein Folding. **Unit V: Structure determination of Macromolecules** Basic concepts and methods in Macromolecular Crystallography, Nuclear Magnetic Resonance, Cryo-Electron Microscopy, Circular dichroism, Forster Energy, Resonance Transfer, Small Angle X-ray Scattering, Mass Spectrometry, Dynamic Light Scattering, Analytical Ultracentrifugation, Computational Methods for determination of structure, Molecular Dynamics Simulations.	
RGC 312	**BIOSTATISTICS AND DATA ANALYSIS** *The course will provide information regarding basic concepts and common practices for the analysis of biological data using statistical tools and provide opportunity to students to apply these methods on available data sets.* **Unit 1: Scope of Statistics in Biological Research** Applications of statistics in biology, definitions (populations, samples), Basic concepts, type of data, various data collection methods, Diagrams and graphs; Measures of averages and location; Measures of dispersion; Probability and probability theory, Use of statistical packages on biological data. **Unit II: Statistical Methods** Descriptive: Graphical representation on various type of data, Use of each measure of location; Measures of spread: Variance and Standard Deviation, Standard Error; Skewness, Kurtosis; Quantiles, Outliers; Inferential: Framing hypothesis, Hypothetico- deductive method, Definition & Concept of types of hypothesis, types of errors, Power, Level; Storing Data in public repositories; Applications of NGS. **Unit III: Transcriptomics and Proteomics Data Analysis** Next generation sequence analysis – RNA Introduction to Microarrays and RNA-Seq: Data acquisition & Analysis. Microarray data analysis using TopHat and Cuffflinks, Functional annotation of microarray/Rna-seq data. Proteomics: Protein analysis & prediction using different Protein Data Bank (PDB); Basics of Protein Structure Prediction (Homology Modeling, Fold Recognition, Ab-Initio Prediction); Proteomic resources; Fundamentals of molecular docking, Chip-Seq data analysis.	**2**

RGC 313	**RESEARCH METHODOLOGY** *This course is designed to enable the student to understand the basic principles and practices of common methods used for research in Life Science & Biotechnology. The course deals with contemporary research methodologies, experimental design, data analysis and presentation.* **Unit I: Research Design, Conduct, Regulation, Recording & Presentation** Formulation of a research problem, Ethics and code of conduct in research, Data falsification, Plagiarism, Data security, Laboratory behavior, Biosafety and IT usage policy, Regulatory issues in Biotechnology, Maintenance of laboratory notebooks, Grant/Fellowship/Report writing, Manuscript Writing, Seminar Presentation. **Unit II: Literature Search, Use of Databases and Experimental Design** Databases for literature search, Bibliometrics, Citation, Impact factor, Hypothesis as a framework for scientific projects, Experimental design, taking measurements, Data Analysis, sampling, statistical tests with excel, handling data, hypothesis testing **Unit II: Good Laboratory Practices** Responsibilities of a researcher, handling and storage of biological material, laboratory waste disposal, management of personnel, facilities, buildings and equipment. **Unit III: Bio-entrepreneurship and IP management in Biotechnology** Bio-entrepreneurship, Funding options, Introduction to Intellectual Property Rights, Types of IP, Patent search, IP management, Technology transfer.	**2**
RGC 314	**LABORATORY COURSE 4: METHODS IN GENETIC ENGINEERING** ***Practical 1***: Agarose gel electrophoresis of DNA. ***Practical 2***: Isolation of genomic DNA, quantitation and characterization. ***Practical 3***: Isolation of RNA and assessment of quality. ***Practical 4*:** Isolation of Plasmid DNA, assessment of quality and characterization. ***Practical 5*:** Preparation of competent E. coli cells and genetic transformation. ***Practical 6***: Polymerase chain reaction and assessment. ***Practical 7***: Restriction digestion of plasmid DNA and assessment of quality. ***Practical 8***: DNA ligation and transformation. ***Practical 9***: Confirmation of DNA cloning through PCR and restriction digestion.	**4**
RGC 315	**LABORATORY COURSE 5: METHODS IN BIOINFORMATICS** ***Practical 1***: Basic UNIX commands for routine tasks ***Practical 2:*** Running NCBI-BLAST for protein, DNA and RNA sequences. ***Practical 3*:** Installation of NCBI SRA toolkit and to download raw sequencing data (DNA-seq, RNA-seq, ChIP-seq etc). ***Practical 4*:** Simple applications of UCSC Genome Browser like Quality Check of raw sequencing data and estimation of number of SNPs per	**4**

	exon in human chromosome 22. ***Practical 5***: Processing of raw sequencing data like adapter trimming, removal of bad quality reads and trimming bad quality tails of reads etc. ***Practical 6***: Alignment of reads against reference genome using bowtie or bwa or/and tophat, STAR aligner etc including analysis of output files. *Practical 7*: Visualization of protein structures using Pymol, Rasmol & UCSF Chimera etc. ***Practical 8***: Homology modelling using Swiss Model and/or Modeller. ***Practical 9***: Calculation of binding affinity (K_d) for protein-ligand interactions using Autodock and/or DOCK.	
RGC 316	**LABORATORY COURSE 6: METHODS IN PROTEOMICS** ***Practical 1***: Protein isolation from cells and protein estimation for proteomics analyses. ***Practical 2:*** Gel based proteomics (all steps in two-dimensional gel electrophoresis). ***Practical 3:*** Demonstration of biological mass spectrometry & soft ionizations (MALDI- TOF & ESI-Q-TOF). ***Practical 4:*** In-gel and in-solution trypsin digestion of protein. ***Practical 5:*** Sample preparations for MALDI & Electro Spray Ionization. ***Practical 6:*** Protein identification by peptide mass fingerprinting & database search. ***Practical 7:*** Protein identification by MS/MS sequencing & database search. ***Practical 8:*** High throughput proteomic protein profiling, data pre-processing, quality control and post-MS data analyses. ***Practical 9:*** Analyses of protein post-translational modifications. ***Practical 10:*** Label-free protein relative quantification or protein expression	**4**
RGC 317	**SCIENTIFIC COMMUNICATION** For a successful scientist, it is very important to effectively convey his work to both the technical and non-technical audience. This may be in the form of verbal and visual communication in the form of seminars and presentations, and written communication in the form of reports, manuscripts, and grant proposals. This course aims to encourage the students to inculcate these attributes by making presentations.	**1**
	Total Credits	**24**

PRESCRIBED READING

RGC 309	**Genetics and Genetic Engineering** 1. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2015). *Concepts of Genetics*. 11th Edition. Pearson Higher Ed. 2. Snustad, D. P. & Simmons, M. J., (2015). *Principles of genetics*. 7th Edition. John Wiley & Sons. 3. Pierce, B. A. (2017). *Genetics: A conceptual approach*. 6th Edition Macmillan. 4. Green, M. R., & Sambrook, J. (2012). Molecular cloning. *A Laboratory Manual,* 4th Edition, CSHL Press. 5. Watson, J. D, Baker, T. A., Bell, S. P., Gann, A., Levine, M. & Losick, R.M. (2013). *Molecular biology of the gene*. 7th Edition. Pearson. 6. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). *Lewin's Genes XII*. 12th Edition Jones & Bartlett Learning.
RGC 310	**Proteomics and Genomics** 1. Voet, D., Voet, J. G., & Pratt, C. W. (2016). *Fundamentals of biochemistry: life at the molecular level*. 5th Edition. John Wiley & Sons. 2. Campbell, A. M., & Heyer, L. J. (2006). *Discovering genomics, proteomics, and bioinformatics*. 2nd Edition. Pearson. 3. Primrose, S. B., & Twyman, R. (2013). *Principles of gene manipulation and genomics*. John Wiley & Sons. 4. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). *Molecular biotechnology: principles and applications of recombinant DNA*. Washington, DC: ASM Press.
RGC 311	**Bioinformatics and Structural Biology** 1. Schulz, G. E., & Schirmer, R. H. (2013). *Principles of protein structure*. Springer Science & Business Media. 2. Liljas, A., Liljas, L., Piskur, J., Nissen, P., & Kjeldgaard, M. (2009). *Textbook of structural biology*. World Scientific Publishing Company. 3. Lesk, A. (2014). *Introduction to bioinformatics*. Oxford University Press. 4. Tramontano, A. (2006). Protein structure prediction: concepts and applications. In *Protein Structure Prediction: concepts and applications.*
RGC 312	**Biostatistics and Data Analysis** 1. Mann, P. S. (2007). *Introductory statistics*. John Wiley & Sons. 2. Rice, J. A. (2006). *Mathematical statistics and data analysis*. Cengage Learning. 3. Campbell, A. M., & Heyer, L. J. (2003). *Discovering genomics, proteomics, and bioinformatics* (No. QH447 C35 2007). San Francisco: Benjamin Cummings.
RGC 313	**Research Methodology** 1. Katz, M. J. (2009). *From research to manuscript: a guide to scientific writing*. Springer Science & Business Media. 2. Holmes, D. , Moody, P., Dine, D. and Trueman, L. (2016). Research Methods for the Biosciences. Oxford University Press. 3. Glass, D.J. (2014). Experimental Design for Biologists, Cold Spring Harbor Laboratory. 4. Ruxton, G.D. and Colegrave, N. (2016). Experimental design for the Life Sciences 4th Edition Oxford University Press. 5. https://www.who.int/tdr/publications/documents/glp-trainer.pdf 6. http://www.w3.org/IPR/http://www.wipo.int/portal/index.html 7. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html 8. http://www.cbd.int/biosafety/background.shtml 9. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

STREAM SPECIFIC COURSES

SEMESTER III

STREAM 1: DISEASE BIOLOGY

ONE CREDIT = 12 TEACHING HOURS

Code	Course	Credit (s)
RGC 401	**HUMAN ANATOMY AND PHYSIOLOGY** *This course covers all major organs and systems of human body, including basic anatomy, cellular structure and function, integration, organization and control of the body systems.* **Unit I: Cellular and tissue level of organization** Chemical and Cellular levels of organization, cell division, cellular diversity and cell ageing. Tissue level of organization, epithelial and connective tissues, muscular tissue, nervous tissue and tissue repair. **Unit II: Bone, skeletal and muscular systems** Overview of the skeletal and muscular systems, skeletal muscle tissue, contraction and relaxation of skeletal muscle fibers, muscle metabolism, cardiac muscle tissue, smooth muscle tissue regeneration of muscle tissue, ageing and muscle tissue, structure and functions of the bone, bone formation, fracture and repair of the bone, role of bone in calcium homeostasis; ageing and bone tissue. **Unit III: Nervous tissue** Overview of the nervous system, histology of nervous tissue, electrical signals in neurons, signal transmission at synapses, neurotransmitters, neural circuits, central nervous system, brain organization, blood supply to brain and spinal cord, cerebrospinal fluid, somatic and autonomic nervous systems **Unit IV: Endocrine system** Overview of the endocrine system, endocrine glands, hormones and their function, mechanisms of hormone action, hormone-producing glands (hypothalamus, pituitary, pineal gland, thyroid, parathyroid, adrenals, pancreas, ovaries and testis). **Unit V: Blood, Cardiovascular and Lymphatic systems** Overview of blood, cardiovascular and lymphatic systems, anatomy of the heart, blood circulation to heart, heart valves, cardiac muscle tissue and contraction, cardiac cycle, anatomy and function of blood vessels, capillary exchange, hemodynamics, regulation of blood pressure, circulatory routes, shock and homoeostasis, anatomy and function of lymphatic system, development of lymphatic tissues.	**3**

	Unit VI: Respiratory system Overview of the respiratory system, anatomy of the respiratory system, pulmonary ventilation, exchange of oxygen and carbon dioxide, transport of oxygen and carbon dioxide, control of respiration. **Unit VII: Digestive and Gastro-intestinal systems** Overview of the digestive system: peritoneum, mouth, pharynx, esophagus, stomach, pancreas, liver, gall bladder, small intestine and large intestine; and phases of digestion. Fluid compartments, electrolytes and acid-base homeostasis. **Unit VIII: Urinary system** Overview of urinary system, structure and function of kidney, glomerular filtration, tubular reabsorption and secretion. **Unit IX: Reproductive system** Overview of male and female reproductive systems, hormones, female reproductive cycle.	
RGC 402	**HUMAN DISEASES AND HEALTH CARE POLICY** *Over the last decade, there has been increasing recognition of the value of epidemiological analysis in aiding the design and interpretation of diseases from a population perspective. This course will provide a study based understanding of epidemiology, pathophysiology and treatment of common human diseases as well as the healthcare policy of India.* **Unit I: Epidemiology.** Overview of epidemiology, epidemiology tools, definition and natural history of diseases, quantifying disease in population, comparing disease rate, outbreaks of disease, epidemiological aspects of infections and chronic diseases of national importance. **Unit II: Basics of Pathophysiology.** Introduction to the basics of pathophysiology, altered cellular and tissue biology, cellular adaptation, atrophy, hypertrophy, hyperplasia, dysplasia, metaplasia, cell injury, immunological & inflammatory injury, manifestations of cellular injury, cell death: apoptosis, necrosis and autophagy. **Unit III: Pathophysiology of Organ Dysfunction and Disorders.** *Diseases of nervous system:* definition of pain, neuro anantomy of pain, sleep disorders, alteration of cognitive systems, seizure disorders, alterations in cerebral hemodynamics, alterations in neuromotor functions, disorders of the central and peripheral nervous systems and neuromuscular junctions. *Diseases of the endocrine system*: alterations of the hypothalamic and pituitary systems and diseases, thyroid dysfunction and diseases, endocrine pancreas dysfunction and diseases, metabolic syndriome & diabetes, adrenal dysfunction and diseases. *Diseases of the cardiovascular system*: Disorders of perfusion, alterations of hemostasis, vascular disorders, coronary circulation disorders, cardiac disorders and heart failure. *Diseases of the reproductive system*: Reproductive dysfunctions, female and male reproductive disorders, sexually transmitted diseases.	**2**

	Unit IV: Public Heath Policy. Overview of public health policy, overview of WHO and global health policies, overview of Indian public health policies, Indian public health policies for infections and chronic diseases, concept of one health, design and implementation of public health policy, impact of socioeconomic and political factors on public health care policy. **Unit V: Health Care Management** Overview of public health care management in India and other countries. Strategic health care management to major health care challenges in India. Health care management for major diseases in India. Organizational performance of hospitals, physician practices and community health care centers for treating above diseases.	
RGC 403	**INTRODUCTION TO DRUG DISCOVERY AND DEVELOPMENT** *In this course, students will gain a comprehensive understanding of the principles of Drug Discovery and Development.* **Unit I: Drug Discovery and Development**. An Overview of Modern Methods and Principles; Different domains and steps in drug discovery and development; Challenges in modern drug discovery **Unit II: Classical Targets in Drug Discovery** Protein Structure, Enzymes, Inhibition of Enzymes, G-Protein-Coupled Receptors (GPCRs), Ion Channels, Membrane Transport Proteins (Transporters), Emerging Targets **Unit III: In vitro Screening Systems.** The Language of Screening: IC50, EC50, GI50 values. Biochemical versus Cellular Assays; Assay Systems and Methods of Detection; Radio ligand Assay Systems; Enzyme-Linked Immunosorbent Assay (ELISA); Fluorescence-Based Assay Systems; Reporter Gene Assays; Kinetic Fluorescent Measurement Systems; Label-Free Assay Systems; Electrophysiological Patch Clamp Assays; Application of Streptavidin and Biotin affinity assays. **Unit IV: Medicinal Chemistry, Safety and Toxicology** Basic understanding of the medicinal chemistry & Structure Activity Relationship, hit identification to lead development process; Basic principal of Pharmacokinetics and Pharmacodynamics; Ligand and Target based Toxicity; Acute versus Chronic Toxicity; Carcinogenicity, Genotoxicity, and Mutagenicity; Drug–Drug Interactions; Cardiovascular Safety and Toxicology Studies; Central Nervous System Safety and Toxicology Studies **Unit V: Basics of Clinical Trials and Biomarkers** Phases of Clinical Trails (I-IV), Translational Medicine and Biomarkers; Definition of a Biomarker and Their Classification; Characteristics and Impact of Biomarkers; the Practical Application of Biomarkers.	**2**

RGC 404	HUMAN DISEASE BIOLOGY	4

This course will provide detailed understanding of cancer, diabetes and cardiovascular disorders, and also infectious diseases and stem cell disorders.

Cancer

Unit I: Fundamentals of cancer
Overview of cancer biology, nature of cancer, classification of cancers and tumors, cancer epidemiology.

Unit II: Etiology of cancer
Tobacco and cancer development, cancer susceptibility syndromes, viruses and cancer (RNA and DNA viruses), inflammation and cancer, chemical & physical carcinogens, carcinogenesis, types of carcinogenesis, diet and cancer.

Unit III: Molecular Biology of Cancer
Cellular Oncogenes, tumor suppressor genes, signaling, cell cycle regulation, programmed cell death, telomeres.

Unit IV: Invasion and Metastasis
Angiogenesis and its implication in tumor progression, evolution and pathogenesis of metastasis, models for metastasis, cancer stem cells.

Unit V: Tumor Immunology and Immunotherapy
Anti-tumor immune response of regulatory T cells, NK cells, immune surveillance theory, tumor associated antigens, evasion of immune surveillance by cancer cells, principles of immunotherapy, CART cells.

Unit VII: Cancer treatment and management
Cancer treatment – radiation, chemotherapy and surgery, use of cell kinetics to optimize cancer treatment, principles of drug trials for new cancer treatment, monoclonal antibodies as anti cancer agents, new modalities in cancer treatment.

Diabetes and Cardiovascular Diseases

Unit I: Diabetes
Overview of diabetes, types of diabetes (Type I, II diabetes mellitus and MODY), pathophysiology of diabetes, clinical symptoms of diabetes, hyperglycemia, insulin resistance, alteration in blood lipid signatures, vascular clot formation, atherosclerotic clot formation, activation of vascular endothelium, vascular complications, treatment and management.

Unit II: Cardiovascular Diseases
Overview of cardiovascular diseases, pathophysiology and changes in circulation of heart, cardiac electrophysiology, diagnosis of altered coronary arteries and veins, risk factors, coronary artery disease, congenital heart defects; heart failure, venous diseases, pulmonary vascular disease, rheumatic heart disease, pericardial diseases and endocarditis; diagnostic/prognostic methods of cardiovascular diseases. Recent advances in cardiovascular disease therapeutics, experimental models of cardiovascular diseases.

Infectious Diseases

Unit I: Viral Infections
Overview of viral infection, structure and classification of viruses, viral diseases, epidemiology, pathogenesis and clinical symptoms, vaccines and antiviral strategies, treatment and management.

Unit II: Bacterial Infections.
Overview of bacterial infections, structure and classification of bacteria, molecular biology of pathogen-host interaction, human microbiota and their role in human health, gut microbiom, chronic microbial infections and their long-term consequences, drug-resistant bacteria, biofilms, antibiotics and antimicrobial agents, treatment and management.

Unit III. Protozoan infections.
Overview of protozoan infections, classification, diseases, epidemiology, pathogenesis, treatment and management.

Stem Cell and Developmental Disorders

Unit I: Stem Cells
Overview of stem cell biology, culture, derivation, differentiation of embryonic/adult/fetal stem cells, differentiation to different lineages, clinical applications, stem cell niches, organoids; and cancer stem cells.

Unit II: Stem Cell Disorders
Overview of stem cell dysfunctions and disorders, stem cell aplasia (aplastic anemia), monoclonal hematopoietic stem cell proliferative syndrome (leukemia and myelodysplastic syndrome), and polyclonal hematopoietic stem cell proliferative syndrome (systemic and organ-specific autoimmune diseases), mesenchymal stem cell disorders (Alzheimer's disease, osteoporosis, and lung fibrosis) and organ-specific stem cell disorders (carcinosarcoma in the lung and adeno-endocrine cell carcinoma in the stomach), pathogenesis and treatment.

Unit III: Therapeutic applications of stem cells
Clinical and experimental applications of stem cells, tissue engineering approaches for stem cells, ethical issues of using these cells, clinical facilities required for human stem cell transplantation. Current therapeutic use of stem cells in disease: neural disorders, hematopoietic disorders and cardio vascular diseases, use of embryonic stem cells, derivation of induced pluripotent stem cells (iPSCs), recent advances in use of iPSCs, different kind of stem cell banking.

Unit IV: Developmental Disorders
Overview of developmental disorders, childhood anxiety disorders, attention-deficit hyperactivity disorder (ADHD), conduct disorder, autism, and intellectual disability (intellectual developmental disorder), prevalence and pathogenesis, treatment.

RGC 405	**LABORATORY COURSE 7: METHODS IN CELL & MOLECULAR BIOLOGY APPLIED TO CANCER AND CARDIOVASCULAR DISEASE BIOLOGY** ***Practical 1***: Immunocytochemistry and immunohistochemistry for the detection of tumor specific markers in different types of cancers ***Practical 2:*** Genotyping of HPV viruses ***Practical 3:*** Apoptosis assay ***Practical 4:*** Flow cytometry based analysis of cancer cell cycle. ***Practical 5:*** Cancer cell invasion assay by matrigel invasion and scratch assay ***Practical 6***: In vivo Tumorigenic assay in NOD-SCID mice ***Practical 7:*** Metastatic assay- Tail vein Injection of cells in NOD-SCID mice followed by IHC of metastatic lesions. ***Practical 8:*** Telomere repeat assay ***Practical 9***: Staining of animal heart tissues including masson trichome and Oil Red O staining.	**3**
RGC 406	**LABORATORY COURSE 8: METHODS IN CELL & MOLECULAR BIOLOGY APPLIED TO INFECTIOUS DISEASE BIOLOGY** ***Practical 1:*** Culture and Isolation of animal viruses ***Practical 2***: Haemagglutination and Hemaglutination inhibition assays ***Practical 3:*** ELISA method for virus Ag/Ab detection ***Practical 4:*** Detection of viral proteins by Western Blot ***Practical 5:*** PCR based detection of viral nucleic acid ***Practical 6:*** Viral genome sequencing by Sanger's method ***Practical 7:*** Basic computational approaches in viral phylogenetics- Sequence alignment by Clustal W, construction of Neighbour Joining trees ***Practical 8:*** Bacteriological examination of water ***Practical 9:*** Isolation of Metagenome from microbial populations in environmental samples and gut microbiome ***Practical 10:*** Detection of protozoa in contaminated water samples.	**4**
RGC 407	**LABORATORY COURSE 9: METHODS IN STEM CELL BIOLOGY** ***Practical 1***: Observation and understanding the cell morphology of mouse/human embryonic stem cell in culture condition ***Practical 2:*** Culture and passaging of Embryonic stem cells ***Practical 3:*** Differentiation of embryonic stem cell to embryoid bodies and analysis of gene expression pattern in cells ***Practical 4:*** Differentiation of embryonic stem cells to different lineages followed by the sorting of these cells by FACS ***Practical 5***: Isolation of adult stem cells from patient samples. ***Practical 6:*** Observation and understanding the generation of induced pluripotent stem cells from fibroblasts.	**4**
	Total Credits	**22**

PRESCRIBED READING

RGC 401	**Human Anatomy and Physiology** 1. Tortora, G. J., & Derrickson, B. H. (2008). *Principles of anatomy and physiology*. John Wiley & Sons. 2. Kurpad, A., Vaz, M., & Raj, T. D. (2013). *Guyton & Hall: Textbook of Medical Physiology-A South Asian Edition*. Elsevier India
RGC 402	**Human Disease and Health Care Policy** 1. DeVita, V. T., Lawrence, T. S., & Rosenberg, S. A. (2012). *Cancer: principles & practice of oncology: primer of the molecular biology of cancer*. Lippincott Williams & Wilkins. Wolters Kluwer. 2. Libby, P., Bonow, R. O., Mann, D. L., & Zipes, D. P. (2007). *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine, 2-Volume Set*. Elsevier Health Sciences. 3. Sorenson, M., Quinn, L., Klein, D. (2018). *Pathophysiology: A Case-based Approach.* 4. Harris, R.E., (2007). Epidemiology of chronic diseases. Jones & Bartlett learning. 5. Banerjee B. (2018). DK Taneja's Health Policies & Programmes in India. Ed. 16. Jaypee Brothers Medical Publisher 6. https://www.nhp.gov.in/health-policies_pg 7. http://shodhganga.inflibnet.ac.in/bitstream/10603/38985/9/09_chapter-i.pdf
RGC 403	**Introduction to Drug Discovery and Development** 1. Blass, B. (2015). *Basic principles of drug discovery and development*. Elsevier. 2. Brunt LL, Hilal-Dandan R, Knollmann BC. (2017). *Goodman and Gilman's The Pharmacological Basis of Therapeutics. 13th edn.* Publisher: McGraw Hill Education 3. Tozer, T.N., Rowland, M. (2006). *Introduction to Pharmacokinetics and Pharmacodynamics. 4th edn* . Lippincott Williams & Wilkins.
RGC 404	**Human Disease Biology** **Cancer** 1. DeVita, V. T., Lawrence, T. S., & Rosenberg, S. A. (2012). *Cancer: principles & practice of oncology: primer of the molecular biology of cancer*. Lippincott Williams & Wilkins. Wolters Kluwer. 2. Weinberg, R. (2013). *The biology of cancer*. Garland science, Taylor & Francis Group. **Diabetes & Cardiovascular Diseases** 1. Libby, P., Bonow, R. O., Mann, D. L., &Zipes, D. P. (2007). *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine, 2-Volume Set*. Elsevier Health Sciences. 2. Poretsky, L. (Ed.). (2010). *Principles of diabetes mellitus* (pp. 347-351). New York: Springer. 3. Skyler, J. (Ed.). (2012). *Atlas of diabetes*. Springer Science & Business Media. 4. Alsahli, M., &Gerich, J. E. (2012). *Pathogenesis of type 2 diabetes. In Atlas of Diabetes* (pp. 149-166). Springer, Boston, MA. **Infectious Diseases** 1. Evans, A. S. (2013). *Viral infections of humans: epidemiology and control*. Springer Science & Business Media. 2. Flint, S. J., Enquist, L. W., Krug, R. M., Racaniello, V. R., & Skalka, A. M. (2000). *Principles of virology: molecular biology, pathogenesis and control*. ASM press. 3. Murray, P. R. (2017). *Basic Medical Microbiology*. Elsevier Health Sciences. 4. Russell, D. G., & Gordon, S. (Eds.). (2009). *Phagocyte-pathogen interactions*. ASM press. **Stem Cell and Developmental Disorders** 1. Knoepfler, P. (2013). *Stem cells: an insider's guide*. World Scientific. 2. Meyers, R. A. (Ed.). (2013). *Stem cells: from biology to therapy*. John Wiley & Sons. 3. Lanza, R., Langer, R., & Vacanti, J. P. (Eds.). (2011). *Principles of tissue engineering*. Academic press.

STREAM 2: MOLECULAR PLANT SCIENCES

SEMESTER III

ONE CREDIT = 12 TEACHING HOURS

CODE	COURSE	CREDIT (S)
RGC 408	**PLANT PHYSIOLOGY AND PATHOLOGY** *his course deals with the basic physiology and pathological aspects of plants, which will enable the students to understand plant metabolism and the changes associated with pathological infection.* **Unit I: Structure and Anatomy** Root, stem, leaf, seeds; Intercellular and long-distance transport systems: translocation of water, solute and photosynthates **Unit II: Essential Nutrients** Elements essential for plant growth, Nutrient functions, Deficiency syndromes; Movement of nutrients to roots from soil; Mineral nutrient acquisition, transport and utilization. **Unit III: Primary metabolism** Photosynthesis; ATP synthesis, Cyclic photophosphorylation, Calvin cycle: Intermediates, enzymes and stoichiometry, Rubisco structure and Kinetics of Rubisco, C assimilation and metabolism, Respiration, Photorespiration; Comparison of C3 and C4 plant photosynthesis, Crassulacean acid metabolism (CAM). **Unit IV: N and S assimilation pathways** Overview of N and S assimilation pathways; Biological N fixation; Amino acid synthesis; Polyamines and non-protein amino acids, Metabolic flux, sharing of intermediates between primary and secondary metabolism. **Unit V: Secondary metabolism** Overview of the biosynthesis and physiological functions of the major classes of plant secondary metabolites: terpenes, cyanogenic glucosides and glucosinolates, alkaloids and phenolics; Ecological and evolutionary perspectives on the significance of secondary metabolites. **Unit VI: Plant Diseases and causative organisms** Bacteria, Fungi, Nematode and Viral diseases: symptoms and life cycles of selected pathogens; Plant Disease Diagnosis and Management, Fungicides, Mycotoxins; An overview of plant defense against pathogens and herbivores; Roles for secondary metabolites in plant defense against pathogens.	**3**

RGC 409	**PLANT GROWTH AND DEVELOPMENT** *This topic deals with the molecular mechanisms of hormone action in the precise regulation of plant growth and development.* **Unit I: Introduction to plant growth and development** Cell wall: biosynthesis, architecture and function; Cell division: features of the plant cell cycle, cyclins and cyclin dependent kinases, regulation of cell cycle; Cell growth: tip growth, diffuse growth; Seed germination and mobilization of food reserves; Light perception and transduction. **Unit II: Hormonal regulation of plant development**: Introduction to plant hormones, their structure and metabolism and their effect on root and shoot development, Hormonal regulation of developmental processes, Molecular basis of hormone action; signal perception and transduction. **Unit III: Meristems** Root and shoot apical meristems; Embryogenesis: pattern formation in Arabidopsis, mutant phenotypes in maize and rice; Growth and differentiation of roots, Growth and differentiation of leaves; Shoot architecture and stature. **Unit IV: Reproductive systems in plants** Floral development: Homeotic genes, ABCDE model, floral initiation, floral meristem identity, floral organ identity, vernalization; Types of flowering, Incompatibility, Apomixis, Seed and fruit development: MADS Box genes; Seed dormancy. **Unit V: Senescence, ripening and programmed cell death** Senescence in plants and plant organs, gene expression in senescence, leaf senescence; Cell death during growth and morphogenesis, cell death in the development of reproductive structures and seeds; Fruit ripening; Environmental influences on programmed senescence and death.	**3**
RGC 410	**CROP EVOLUTION, ECOLOGY AND IMPROVEMENT** *This topic deals with evolution and ecology of crops and its associated methods of improvement.* **Unit I: Crop Evolution** Origins of Agriculture, Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship, crop-weed, crop -herbivore, plant microbe relationships, agro-biodiversity related wild species and the history of cultivated plants including palaeo-ethnobotany. Centers of origin and biodiversity hot spots; Crop domestication: domestication syndrome, monophyletic and polyphyletic domestication with examples. Twenty-first Century Plant Domestication. Gene bank management: Gene conversion, Gene duplication and divergent evolution, collecting, maintenance, evaluation, storage and documentation Genetic diversity within crops, Tools for drawing phylogenetic inferences and its importance.	**2**

	Unit II: Ecology Introduction to Ecology; Climate, The Aquatic & Terrestrial Environment; Ecological Genetics, Plant Adaptations to the Environment (biotic and abiotic) forces, Species Interactions, Interspecific Competition, Predation, Parasitism and Mutualism; Community Structure, Factors Influencing the Structure of Communities; Community Dynamics: Succession, Landscape Ecology, Ecosystem energetics, Decomposition; Biogeochemical Cycles Large-Scale Patterns of Biological Diversity **Unit III: Crop improvement methods** Breeding, Hybridization, backcross breeding, recombinant inbred lines, Molecular breeding- marker assisted selection (MAS), foreground and background selection, QTLs- cisQTLs, eQTLs, trait introgression, Genome wide association studies. Cytoplasmic male sterility and principles of hybrid seed production, TGMS and PGMS, applications of male sterility in hybrid seed production. Transgenic male sterility, clonal propagation, grafting and their uses, Plant tissue culture, Hormones and their uses, Double haploids development mechanisms and its application in crop improvement. Whole genome sequencing and transcriptomics uses in crop improvement. **Unit IV: Biotechnological advances in crop improvement** Genetic engineering methods to improve stress tolerance. Binary vectors, overexpression, gene silencing, gene editing, plant transformation, transgenic plants few examples (Bt-cotton, Bt-brinjal). Socio-economic benefits of transgenic plants, Biosafety -ethical issues associated with GM crops.	
RGC 411	**SIGNAL TRANSDUCTION AND PLANT STRESS BIOLOGY** *This course unravels fundamentals of plant defense/adaptive mechanisms that help the plant in survival during biotic and abiotic stresses.* **Unit I: Signal transduction in plants** Perception of stress, structure and function of cystosolic and membrane bound receptors, intra and intercellular signaling networks; modulation of major phytohormone signaling networks and crosstalks. **Unit II: Plant stress biology** Plant adaptation to abiotic stress: salinity, drought, temperature stresses, Plant defenses to biotic stress: innate immunity, PTI and ETI, hormones in plant immune signaling networks. **Unit III: Plant growth regulation by light** Photoreceptors, structure and function of phytochromes and cryptochromes, Photomorphogenesis, Phototropism, plant responses to photoperiod.	**2**

RGC 412	**MEDICINAL BOTANY** *This course deals with how plant products can be exploited for the well being of mankind in addition to food.* **Unit I: History of using plants as medicines** Plants as medicines in early human evolution, Hippocrates and his classification of medicinal herbs, contributions of Aristotle and Theophrastus. History of some known drugs and their plant sources; plants in different cultures and societies; Identify and isolation of bioactive compounds in plants; Common diseases and their ethnobotanical cures. **Unit II: Plants as a source of food** Domestication, civilization and history of food; The spice trade and world discovery, ethnic vegetables and herbs. **Unit III: Global warming and feeding the planet** The conservation of plant biodiversity, environmental sustainability and indigenous knowledge. Foods for the future, Patenting and ethics in ethnobotanical research.	**2**
RGC 413	**PLANT GENETIC ENGINEERING** *This course gives an opportunity to students to find out ways of exploiting the plants using biotechnological interventions for value addition or for novel plant products for human use.* **Unit I: Plant tissue culture** Scope, Importance and limitations of plant tissue culture; Tissue culture media - composition and preparation **Unit II: Micro propagation of plants** Initiation and maintenance of callus and suspension cultures; in vitro genetic conservation; in vitro clonal multiplication; Plant growth regulators for organogenesis, somaclonal variation and cell line selection, production of haploids and homozygous cell lines. Selection and maintenance of cell lines, cryopreservation, germplasm collection and conservation. **Unit III: Gene editing tools in plant system** Different plant transformation methods like Agrobacterium mediated and direct gene transfer; Plasmid construction – introduction to binary vector system, Gateway system, introduction to RNA interference, CRISPR Cas9, overexpression, Virus Induced Gene Silencing (VIGS). **Unit IV: Applications of plant genetic engineering** Plant cell culture for the production of useful chemicals and secondary metabolites (Hairy root culture, Biotransformation, Elicitation); Molecular farming, Production of Industrial enzymes, biodegradable plastics, therapeutic proteins, edible vaccines and antibiotics using transgenic technology, Delay of softening and ripening of fleshy fruits. Post-harvest protection.	**3**

RGC 414	**LABORATORY COURSE 7: METHODS IN GENETIC MANIPULATION OF PLANTS** ***Practical 1:*** Media preparation, Basic techniques of plant tissue culture and somatic embryogenesis. ***Practical 2***: Restriction analysis of recombinant vector, Agrobacterium-mediated transformation: preparation of explants, co-cultivation of explants with *Agrobacterium tumefaciens.* ***Practical 3:*** Selection of transformed tissues and regeneration of transformed tissues. ***Practical 4***: Isolation of genomic DNA from transgenic plants, PCR, Southern hybridization analysis. ***Practical 5:*** RNA isolation, cDNA synthesis, Real Time PCR, Isolation of proteins- PAGE, Western blot analysis, ELISA, GUS staining. ***Practical 6***: Over expression by floral dip transformation, Gene silencing. ***Practical 7:*** Histochemical methods and microscopy- Sectioning and staining of different parts of the plant including root, stems, leaves and visualization by bright field microscopy.	**4**
RGC 415	**LABORATORY COURSE 8: METHODS IN MOLECULAR BREEDING** ***Practical 1:*** Crossing, clonal propagation, grafting of scion-root stalk. ***Practical 2:*** Plant transformation- explant preparation (sterilization), media preparation. ***Practical 3:*** Agro- bacterium mediated transformation, selection on antibiotics. ***Practical 4:*** Genomic DNA isolation from plant tissues. Primer Designing. ***Practical 5:*** Polymerase chain reaction to trace gene confirmation, segregation of marker/mutation. ***Practical 6:*** Utilization of software (computer packages) pertaining to linkage mapping, QTL analysis, and biodiversity analysis. GWAS etc.	**3**
	Total Credits	**22**

PRESCRIBED READING

RGC 408	**Plant Physiology and Pathology** 1. Chakraborty, U., & Chakraborty, B. (Eds.). (2005). *Stress biology*. Alpha Science Int'l Ltd. 2. Taiz, L., & Zeiger, E. (2006). *Plant Physiology, Respiration and Lipid Metabolism.* 3. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John Wiley & Sons. 4. Agrios, G. (2009). *Plant pathology*. Amsterdam: Elsevier Acad. Press.
RGC 409	**Plant Growth and Development** 1. Jones, R., Ougham H., Thomas, H., Waaland, S. (2013). *The Molecular Life of Plants.* Wiley-Blackwell. 2. Davies, P. J. (Ed.). (2013). *Plant hormones: physiology, biochemistry and molecular biology.* Springer Science & Business Media.
RGC 410	**Crop Evolution, Ecology and Improvement** 1. Christou, P. & Lee, H. K. (2005). *Handbook of Plant Biotechnology*; Vol 1 and 2.

	John Wiley Publ. 2. Henry, R. J. (2005). *Plant Genotyping: The DNA fingerprinting of plants*. CABI, New Delhi. 3. Schulze, E.D., Erwin, B., Klaus, M.K. (2005). *Plant Ecology.* Vol I. Springer-Verlag Berlin Heidelberg (edn. 1). 4. Connor, D., Loomis, R., Cassman, K. & Loomis, R. (2011). *Crop ecology*. Cambridge: Cambridge University Press. 5. Hancock, J. (2014). *Plant Evolution and the Origin of Crop Species*. Wallingford: CABI Publishing.
RGC 411	**Signal Transduction and Plant Stress Biology** 1. Chakraborty, U., & Chakraborty, B. (Eds.). (2005). *Stress biology*. Alpha Science Int'l Ltd. 2. Taiz, L., & Zeiger, E. (2006). *Plant Physiology, Respiration and Lipid Metabolism*. Sinauer Associates Inc. 3. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John Wiley & Sons. 4. Rao, K. M., Raghavendra, A. S., & Reddy, K. J. (Eds.). (2006). *Physiology and molecular biology of stress tolerance in plants*. Springer Science & Business Media. 5. Sopory, S. K., Oelmüller, R., & Maheshwari, S. C. (2001). *Signal transduction in plants: current advances.* Springer. 6. Hirt, H. (2010). *Plant stress biology*. Weinheim: Wiley-VCH. 7. Jenks, M.A., & Hasegawa, P.M. (Eds.). (2014). *Plant Abiotic Stress.* Wiley-Blackwell. 8. Sessa, G. (Ed.). (2013). *Molecular Plant Immunity*. Wiley-Blackwell. 9. Wada, M., Simazaki, K., & Lino, M. (2010). *Light Sensing in Plants*. Springer.
RGC 412	**Medicinal Botany** 1. Martin, G. J. (2010). *Ethnobotany: a methods manual*. Springer. 2. Lewis, W. H., & Elvin-Lewis, M. P. (2003). *Medical botany: plants affecting human health*. John Wiley & Sons.
RGC 413	**Plant Genetic Engineering** 1. Kung, S. D., & Wu, R. (2012). *Transgenic plants: engineering and utilization*. Academic Press. 2. Stewart Jr, C. N. (2016). *Plant biotechnology and genetics: principles, techniques, and applications*. John Wiley & Sons. 3. Smith, R. H. (2012). *Plant tissue culture: techniques and experiments*. Academic Press. 4. Chrispeels, M. J., & Sadava, D. E. (2003). *Plants, genes, and crop biotechnology*. Jones & Bartlett Learning.

STREAM 3: MOLECULAR DIAGNOSTICS & DNA PROFILING

SEMESTER III

ONE CREDIT = 12 TEACHING HOURS

CODE	COURSE	CREDIT (S)
RGC 416	**MOLECULAR DIAGNOSTICS** *This course overviews the basic principles of molecular diagnostics and applications of the emerging technologies. Students learn about the clinical applications of molecular diagnostic in patients with infectious disease.* **Unit I: Introduction to Diagnostics** Introduction and History of diagnostics of diseases, mode of infection, types of infectious diseases, philosophy and general approach to clinical specimens. **Unit II: Traditional disease diagnosis methods** Diagnosis of infectious diseases caused by bacteria, fungi, viruses, protozoa and Helminthes. **Unit III: Molecular Techniques for diagnosis** Disease identification and Genetic tests of disorders; Population screening genetic disorders; Treatment and management of genetic disorders. **Unit IV: Biochemical tests** Detection and quantification of biochemical parameters. **Unit V: Applications of PCR-based microbial typing** PCR based microbial typing; Culture independent analysis of bacteria; Molecular diagnosis of fungal pathogens; RAPD for animal and plants. **Unit VI: Immunoassays** Types [RIA, ELISA, Chemiluminescent IA, FIA] and specific applications; Immunohistochemistry – principle and techniques. Different Levels of Biosafety, Containment	**2**

RGC 417	**CYTOGENETIC AND GENETIC DISORDERS** *In this course, inheritance patterns in human genetic diseases along with the role of traditional, conventional and futuristic diagnostic techniques in screening for genetic diseases will be covered in these units.* **Unit I: Medical Genetics** Human genome Project, Genome Organization, Genome Annotations and databases, Identifying human disease genes. Genetic markers for diseases (microsatellites, SNPs), Pharmacogenomics, Ecogenomics, Metabolomics, Teratogenetics. Mapping and identification of disease genes (linkage analysis, LOD score, association study) SNPs in diagnostics, Genome wide association studies, Whole genome sequencing, exome sequencing. **Unit II: Human Cytogenetics** Cell division, Techniques of chromosome analysis; Karyotyping; Meiotic chromosomes; Chromosomal abnormalities in cancer. Non-disjunction and associated disorders, Aneuploidy, Chromosome structural abnormalities, X inactivation, Mosaicism, Chimeras. **Unit III: Genetic disorders** Cystic Fibrosis and Sex – linked inherited disorders; Dominant and recessive mutations, Mutagenesis, Autosomal disorders, Genomic imprinting, Neonatal and Prenatal disease diagnostics. Gender identification; Analysis of mitochondrial DNA for maternal inheritance. Molecular diagnosis for early, Stem cells and cord blood banking, Treatment advances for genetic disorders, Ethical issues, Genetic counseling.	**2**
RGC 418	**FORENSIC BIOLOGY AND MOLECULAR FORENSICS** *The objective of this course is to introduce the student to Forensic Biology, its history, its methods and the application to both human and non-human DNA typing techniques and instrumentation.* **Unit I: Biological evidence** Nature and importance, hair and fibres, types, identification, collection, preservation; significance of biological evidence. **Unit II: Microbial Forensics & Entomology** Organisms of Forensic significance, types, isolation and identification of different microbial strains using conventional and molecular methods; Introduction to forensic Entomology, insects/invertebrates of forensic importance, collection of entomological evidence, their life cycle, the role of aquatic insects in forensics. **Unit III: Forensic Botany** Importance of biological evidences such as pollen grains, leaves, fruits, seeds, wood, etc; types, significance and collection of evidence, identification and comparison. methods of Forensic Botany: Importance of biological evidences such as pollen grains, leaves, fruits, seeds, wood,	**4**

	etc; types, significance and collection of evidence, identification and comparison. Diatoms– types, morphology, methods of isolation from tissue and organs, identification and forensic significance. **Unit IV: Forensic Serology** Identification, study of various body fluids such as semen, perspiration, blood, saliva, urine, and fecal matter, classification and their relationship to a crime scene.; blood group systems, history, biochemistry and genetics of ABO, Rh, MN and other blood group systems; rare blood groups, methods of blood grouping, DNA typing for identification, ELISA, PCR, Sequencing **Unit V: Wildlife Forensics** Animal poaching, wildlife trading, protection of endangered animals; wildlife protection act; morphological and molecular identification of wildlife materials like hair, skin, fur, bones, nail, teeth, etc; Indian scenario **Unit VI: DNA Forensics** Allele frequency determination, match probability- database; Forensic Significance of DNA profiling, applications in disputed paternity cases, child swapping, missing person's identity; legal standards for admissibility of DNA profiling; DNA profiling in India and abroad; SNPs, cf DNA and limitations of DNA profiling, mitochondrial DNA, STR analysis	
RGC 419	**DNA BAR-CODING** *This course focuses on the introduction to DNA Barcoding that will provide students with a basic understanding of DNA-based approaches for species identification and discovery. Students will have the opportunity to explore the historical framework for species identification. The fields of taxonomy, ecology, and evolution will be explored.* **Unit I: Evolution.** Basics, Darwin's evidence and mechanism of evolution, geological succession, natural selection, adaptation, evolutionary genetics, Hardy-Weinberg; recombination; gene duplication, genetic drift, migration, selection, mutation, gene flow, speciation, DNA barcoding and its relevance from an evolutionary perspective. **Unit II: Molecular taxonomy.** Molecular taxonomy; phylogenetic trees; Delimitation and identification of taxa; Molecular data, Integrated Taxonomy Cryptic, and Nominal Species, Type Specimens. **Unit III: Biodiversity.** Introduction to the concept of biodiversity: definition, qualitative and quantitative assessment. Biodiversity in the world's megatrends: threats identification. Management, conservation, preservation as approaches to biodiversity. Biodiversity indicators, sustainable management, DNA barcoding in ecology and conservation biology.	**2**

	Unit IV: DNA Barcoding. Introduction, history, conventional morphological identification against molecular identification using DNA barcode, Metabarcoding, DNA sequencing, DNA barcode regions in plants, animals and microbes, sequence variations, data analysis, phylogenetic tree, character-based tree, haplotype, network; use in conservation and forensics, BLAST, BOLD, I Barcode, Applied DNA barcoding, Next generation sequencing.	
RGC 420	**LABORATORY COURSE 7: METHODS IN NUCLEIC ACID AND PROTEIN BASED DIAGNOSTICS** ***Practical 1***: Hormone assay for thyroid (TSH, T3, T4) and Sexual disorders (testosterone, dihydrotestosterone, estradiol, FSH, LH by RIA) ***Practical 2***: Isolation of Genomic DNA ***Practical 3***: Nucleic acid labeling and Southern Hybridization ***Practical 4:*** Automated DNA sequencing (Demo) ***Practical 5***: RNA isolation, Pulsed Field Gel Electrophoresis, PAGE ***Practical 6***: PCR based diagnosis of human and plant bacterial pathogen ***Practical 7***: Culture independentanalysis of microbes ***Practical 8***: Molecular diagnosis of parasitic disease ***Practical 9:*** Amplification of Short Tandem Repeats, Multiplex STRPCR, SSCP analysis. ***Practical 10***: Bioinformatics tools for genome, proteome analysis.	**4**
RGC 421	**LABORATORY COURSE 8: METHODS IN GENETICS AND CYTOLOGY** ***Practical 1:*** Metaphase chromosome preparations ***Practical 2:*** Karyotype by Q-banding and G-banding ***Practical 3:*** Fluorescence in-situ Hybridization (FISH) ***Practical 4:*** Micronucleus assay ***Practical 5:*** Sister Chromatid Exchange (SCE) ***Practical 6:*** Study of Chromosomal Aberrations ***Practical 7:*** Meiotic Chromosome preparations ***Practical 8***: Immunological methods- Agglutination (ABO/Bacterial), Precipitation, Immunodiffusion, Immunoelectrophoresis. ***Practical 9:*** Checking of BRCA gene polymorphism for susceptibility to breast cancer ***Practical 10***: Human identification and paternity determination (simulated) by VNTR Probes ***Practical 11:*** Mutation detection methods.	**4**
RGC 422	**LABORATORY COURSE 9: METHODS IN FORENSICS** ***Practical 1:*** Microscopic examination of pollen grains ***Practical 2:*** Microscopic examination and morphological and molecular identification of diatoms ***Practical 3:*** ABO blood grouping ***Practical 4:*** DNA Extraction from biological samples	**4**

	Practical 5: PCR Amplification of DNA samples, Agarose gel electrophoresis of PCR products. ***Practical 6:*** Capillary Electrophoresis using genetic analyzer ***Practical 7***: Mitochondrial DNA sequencing ***Practical 8:*** Autosomal STR DNA Typing ***Practical 9:*** Y and X-chromosomal STR DNA typing ***Practical 10:*** Parentage testing ***Practical 11:*** STR data analysis using Gene Mapper IDX software ***Practical 12:*** Protein-based forensics using single amino acid polymorphisms, genetically variant peptide, ELISA.	
	Total Credits	**22**

PRESCRIBED READING

RGC 416	**Molecular Diagnostics** 1. Wegner, R. D. (Ed.). (2013). *Diagnostic cytogenetics*. Springer Science & Business Media. 2. Carl A. Burtis, Edward R. Ashwood and David E. Bruns (eds) (2007): Tietz *Textbook of Clinical Chemistry and Molecular Diagnosis* (5th edition). Elsevier 3. McPherson, R. A., & Pincus, M. R. (2017). *Henry's Clinical Diagnosis and Management by Laboratory Methods E-Book*. Elsevier Health Sciences. 4. Coleman, W. B., & Tsongalis, G. J. (Eds.). (2006). *Molecular diagnostics: for the clinical laboratorian*. Springer Science & Business Media. 5. Leonard, D. G., Bagg, A., Caliendo, A. M., Deerlin, V. M., & Kaul, K. L. (Eds.). (2007). *Molecular pathology in clinical practice* (pp. 411-424). Springer.
RGC 417	**Cytogenetic and Genetic Disorders** 1. Wegner, R. D. (Ed.). (2013). *Diagnostic cytogenetics*. Springer Science & Business Media. 2. Burtis, C. A., Ashwood, E. R. & Bruns, D. E. (eds) (2007): Tietz *Textbook of Clinical Chemistry and Molecular Diagnosis* (5th edition). Elsevier 3. Gersen, S. & Beagle, M. (2015). *The principles of Clinical Cytogenetics.* Springer. 4. Brooker, R. (2012). *Genetics Analysis and Principles.* McGraw Hill 5. Speicher, M., Antonarakis, S.E., Motulsky, G. (2010). *Voegl and Motulsky's Human Genetics Problems and approaches* (4th ed). Springer.
RGC 418	**Forensic Biology and Molecular Forensics** 1. Li, R. (2015). *Forensic biology*. CRC Press. 2. Budowle, B., Murch, R., & Chakraborty, R. (2005). Microbial forensics: the next forensic challenge. *International journal of legal medicine*, *119*(6), 317-330. 3. Coyle, H. M. (2004). *Forensic botany: principles and applications to criminal casework*. CRC Press. 4. Shewale, J. G., & Liu, R. H. (Eds.). (2013). *Forensic DNA Analysis: Current Practices and Emerging Technologies*. CRC Press. 5. Butler, J. M. (2005). *Forensic DNA typing: biology, technology, and genetics of STR markers*. Elsevier. 6. Epplen, J., & Lubjuhnn, T. (Eds.). (2012). *DNA profiling and DNA fingerprinting*. Springer Science & Business Media. 7. McClintock, J. T. (2008). *Forensic DNA analysis: a laboratory manual*. CRC Press. 8. Huffman, J. E., & Wallace, J. R. (2012). *Wildlife forensics: methods and applications* (Vol. 6). John Wiley & Sons. 9. John Butler (2014). *Advanced Topics in Forensic DNA typing: Interpretation*. Elsevier.

RGC 419	**DNA Bar-coding** 1. Baum, D. A., & Smith, S. D. (2013). *Tree thinking: an introduction to phylogenetic biology*. Greenwood Village, CO: Roberts. 2. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2002). *Plant systematics*. Sunderland, Massachusetts, USA: Sinauer. 3. Moritz, C., & Cicero, C. (2004). *DNA barcoding: promise and pitfalls*. *PLoS biology*, *2*(10), e354. 4. Lopez, I. & Erickson, D. L (2012). DNA Barcodes: Methods and Protocols. Humana Press. 5. Wheeler, Q.D. (2008). *The New Taxonomy*. CRC Press.

SEMESTER IV

RGC 423	**DISSERTATION** *As a primer to building a career in biotechnology research, the student will choose a small lab project in consultation with the supervisor, learn and master the relevant research techniques, conduct experiments and collect data that will be collated in the form of a dissertation.*	**22**