

RGC 430: Biostatistics and Data Analysis (2 Credits)

This module will introduce Biostatistics and Bioinformatics methods, and software's used for analysis of biological data. The students will also analyze example data sets using different tools and learn to interpret the outputs.

Name of the course
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: Types of Data Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Population Vs Sample, Discrete Vs Continuous, Levels of Measurement, Types of sampling.
Unit III: 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, Level of significance, Chi square, t and F-tests, ANOVA, Correlation and Regression, Skewness, Kurtosis; Quantiles, Outliers; Inferential: Framing hypothesis, Hypotheticodeductive method, Definition & Concept of types of hypothesis, types of errors, Power, Level; Storing Data in public repositories, Statistical Hypothesis; Null and Alternative Hypothesis, Testing of Hypothesis. Data Analysis with Statistical Packages: R, R Bioconductor packages for Biostatistics Quantification and statistical analysis of qPCR data, Western blots, Microscope images. Software's used for analysis of scientific data-SAS, Medcalc, Sigmaplot, etc.
Unit IV: Introduction to biological databases Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB, DDBJ: The knowledge of databases and bioinformatics tools available at these resources. Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; Structure Databases: PDB, NDB, PubChem, ChemBank Protein and nucleic acid properties: Various tools at the ExPASy server, GCG utilities and EMBOSS, Computation of various parameters.
Unit V: Fundamentals of sequence analysis Sequence Analysis: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues; Scoring matrices: basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles. Sequence alignment: Measurement of sequence similarity; Similarity and homology. Pairwise sequence alignment: Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.
Unit VI: Next Generation Sequencing Data Analysis Introduction to Microarrays and RNA-Seq: Data acquisition & Analysis. Data analysis using TopHat and Cufflinks, Functional annotation of Rna-seq data.
Unit VII: Structural Bioinformatics Introduction to Protein analysis & prediction; Basics of Protein Structure Prediction (Homology Modeling, Fold Recognition, Ab-Initio Prediction); Fundamentals of molecular docking, MD simulations using gromacs; Proteomic resources;

Unit 1-III – Theory and exercises

Unit IV-VII – Theory and Practicals (2hr lecture & 2 hr practical)

Suggested reading:

1. J Pevsner (2015) Bioinformatics and Functional Genomics 3rd Edition, Wiley-Blackwell.
2. Arthur Lesk (2019) Introduction to Bioinformatics (5th Edition), OUP.
3. Mann, P. S. (2007). Introductory statistics. John Wiley & Sons.
4. Rice, J. A. (2006). Mathematical statistics and data analysis. Cengage Learning. Campbell, A. M., & Heyer, L. J. (2003). Discovering genomics, proteomics, and bioinformatics (No. QH447 C35 2007). San Francisco: Benjamin Cummings.

RGC 431: Research Methodology- 2Credits

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.

Name of the course
Unit I: Research Methodology- An Introduction, Research Design, Formulating the Research Topic/Question, Defining the Research Topic/Question, Approaches and Methodology for Research, Formulation of Hypothesis, Research Design, Hypothesis as a framework for scientific projects, Experimental design, taking measurements, Data Analysis, sampling, statistical tests with excel, handling data, hypothesis testing, Documentation and presentation of data, Analysis and interpretation of data, Elements / Types of Analysis. Writing of manuscript, Research Paper, Research Project, Thesis, Book chapter, Reviews, Criteria of Good Research. Laboratory behavior, Biosafety and IT usage policy, Regulatory issues in Biotechnology
Unit II: Literature Search, Use of Databases and Experimental Design Databases for literature search, Bibliometrics, Citation, Impact factor,
Unit III: Good Laboratory Practices Responsibilities of a researcher, handling and storage of biological material, laboratory waste disposal. Management of personnel, facilities, buildings and equipment.
Unit IV: 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.

Suggested reading:

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>

RGC 432: Scientific Communication and Research & Publication Ethics-(2 Credits)

The aim of this module is to train and make the students aware of scientific writing and ethical procedures used in scientific research.

Name of the course
Unit I: Scientific Communication: <ul style="list-style-type: none">Maintenance of laboratory notebooks, Grant/Fellowship/Report writing,Manuscript Writing, Preparing for seminar presentations.
Unit II: PHILPHY AND ETHICS <ul style="list-style-type: none">Introduction to philosophy: definition, nature and scope, concept, branchesEthics: definition, moral philosophy, nature of moral judgments and reactions
Unit III: SCIENTIFIC CONDUCT Ethics with respect to science and research <ul style="list-style-type: none">Intellectual honesty and research integrityScientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)Redundant publications: duplicate and overlapping publications, salami slicingSelective reporting and misrepresentation of data
Unit IV: PUBLICATION ETHICS <ul style="list-style-type: none">Publication ethics: definition, introduction and importanceBest practices / standards setting initiatives and guidelines: COPE, WAME, etc.Conflicts of interestPublication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, typesViolation of publication ethics, authorship and contributor shipIdentification of publication misconduct, complaints and appealsPredatory publishers and journals
Unit V: OPEN ACCESS PUBLISHING <ul style="list-style-type: none">Open access publications and initiativesSHERPA/ROMEO online resource to check publisher copyright & self-archiving policiesSoftware tool to identify predatory publications developed by SPPUJournal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.
Unit VI: Institutional committees for ethical research: <ul style="list-style-type: none">Research using animals, Institutional Animal ethics committee (IAEC)Research with Human Subjects, Institutional ethics committee (IEC)Research with Stem Cells, Institutional committee for stem cell research (IC-SCR)Patents and Intellectual property rightsGLP and Guidelines for Biosafety, Institutional Biosafety committee
Unit VII: PUBLICATION MISCONDUCT A. <ol style="list-style-type: none">Subject specific ethical issues, FFP, authorshipConflicts of interest

3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2hrs)

Use of plagiarism software like Turnitin, Urkund and other open-source software tools

Unit VIII: DATABASES AND RESEARCH METRICS

A. Databases (2hrs)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (1 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

Unit IX: Grant writing

Suggested reading:

Fundamental Principles of Writing a Successful Grant Proposal. Chung *et al*, 2008

1. Grant writing 101, Jason et al, 2013
2. The development of open access journal publishing from 1993 to 2009., Laakso et al 2011.
3. Publication ethics., Sabyasatchi et al., 2017
4. An author's guide to publication ethics: a review of emerging standards in biomedical journals. Jason Roberts., 2009.

RGC 601: Biochemical and Biophysical techniques- (4Credits)

The aim of this module is to familiarize the students to the latest techniques used in modern biology. The module will also include application level demonstrations in using the advanced equipment's. The students are also expected to undertake practical training in their respective laboratories.

Name of the course

Unit I: (15h + Demo): Cell biology and Genomics

Cell biology, General Approaches in cell cycle and cell death

Molecular biology, genetic engineering techniques

Cell culture- Culture and maintenance of cell lines, Primary cell culture

Primary Cell culture methods in Cardiovascular research

Transgenics and KOs

Real Time PCR and droplet digital PCR (Lecture + demo - 2 hrs)

Microarray applications (1 hr),

Microarray demo-(1hr)

Sanger sequencing & genotyping (1hr)

Next generation sequencing, various platforms and applications, Illumina, Nanopore, etc

Introduction to Molecular Diagnostics, Diverse Diagnostic platforms and applications

Metagenomics: Introduction to metagenomics, Standard conventional steps in metagenomic analysis (Isolation of metagenomic DNA, Generation of metagenomic libraries, Functional screening of libraries), Benefits of metagenomics in various fields

Unit II: Microscopy and applications (15 h + Demo)

Microscopy: History , Light Microscopy Techniques , Compound Microscopes, Dark Field, Phase contrast and DIC Techniques (2h)

Fluorescence Microscopy: Techniques and Applications (2 h),

Confocal microscopy (2h),

Atomic force microscopy (1 h)

Live cell imaging approaches (1h),

FACS Application and techniques (2)

FRET , FRAP , FLIM (2h).

Electron Microscopes:

Histology and histochemistry: Fixation and sectioning of tissue, embryos and cells. Immunohistochemistry, immunofluorescence, histochemical staining for characterization of cell types.

Unit III: Proteomics (15 h + Demo)

1. Introduction to mass spectrometry: History, principles, types of ionizations, components of mass spectrometer, mass spectrum, mass resolution & accuracy, types of mass spectrometers and uses.

2. Proteomics: History, two dimensional gel electrophoresis, protein identification by peptide mass

fingerprinting and by MS/MS sequencing, databases and search engines in proteomics and applications of proteomics.

3. Post translational modifications and its determination by MS

4. Quantitative proteomics: Principles, ICAT, ITRAQ, SILAC & TMT, Proteolytic 18O labeling and label-free quantification.

5. Absolute quantification by MS: Types of fragmentation, selective reaction monitoring (SRM) and multiple reaction monitoring (MRM).

6. Understanding the mechanism of pathogenesis & biomarker discovery

7. Protein Microarray &

8. Metabolomics

9. Techniques used for purification and characterization of biomolecules: Centrifugation, Ultrafiltration, Chromatography, electrophoresis

Unit IV: (15 h) : Spectroscopy

Overview of spectroscopy, Electromagnetic and quantum theory of radiation, Wave particle duality, Photons, Interaction of light with matter, Transition dipole moment, Jablonsky diagram, Beer-Lamberts law, IR & Raman Spectroscopy and its application in biology

UV-visible absorption spectroscopy, application of UV-visible for estimation of protein. DNA and RNA, enzyme kinetics: protein-ligand interaction

Fluorescence spectroscopy of Biomolecules: quantum yield, static and dynamic quenching of fluorescence, energy transfer, polarization, anisotropy, time resolved fluorescence, application to biomolecule structure and dynamics

Circular dichroism spectroscopy and its application for studying the secondary and tertiary structure of proteins

Surface Plasmon spectroscopy, Electron Microscopy, and Cryo-EM of Biomolecules

References

An Introduction to Microscopy, By Suzanne Bell, Keith Morris, CRC Press

Fournier, M. (1996). The fabric of life: Microscopy in the seventeenth century. Johns Hopkins University Press.

Tortora, G.J et al. 2010. Microbiology- An introduction, Pearson Benjamin Cummings, 10th ed.

Maier, R.M et al . 2006. Environmental microbiology. Elsevier – India

Frans J. de Bruijin. 2011. Molecular Microbial Ecology 2-metagenomics in different habitats,, Wiley-Blackw

RGC 602: Seminar Presentations- 2 Seminars (2 Credits)

This course will consist of 2 Seminars and will carry 2 credits. A panel of faculties will evaluate the presentation of each student.

RGC 701: Infection Biology- 2 Credits

	Topics
Microbiology-Introduction	<ul style="list-style-type: none"> • Microorganisms and Humans: A Dynamic Relationship
	<ul style="list-style-type: none"> • Recognition of the infectious agents by human body
Virology	<ul style="list-style-type: none"> • Classification of viruses • Virus structure and virus replication • Isolation, detection and characterization of viruses • Emerging viruses, viral diagnosis • Identification of vectors associated with viral diseases
	<ul style="list-style-type: none"> • Epidemiology of viral diseases
	<ul style="list-style-type: none"> • Viral immunology • Antivirals, viral vaccines
Bacteriology	<ul style="list-style-type: none"> • Classification of bacteria
	<ul style="list-style-type: none"> • Structure, growth and control of growth • Bacterial genetics
	<ul style="list-style-type: none"> • Virulence factors
	<ul style="list-style-type: none"> • Bacterial Diseases in Humans • Bacterial Biofilms
	<ul style="list-style-type: none"> • Drugs, drug resistance
Human Microbiome	<ul style="list-style-type: none"> • What are microbiome, virome and mycobiome? • Methods of studying microbiome, virome and mycobiome. • Significance of microbiome, • virome and mycobiome in human health and diseases.
Neglected Tropical Diseases - WHO	<ul style="list-style-type: none"> • Overview of diseases in the WHO list. • Brief clinical aspects. • Global Epidemiology • Setting of priorities • Strategies adopted • Research priorities from a population perspective • International cooperation on NTD management.

Suggested Reading:

1. Prescott Microbiology
2. Biology of Microorganisms-Brock
3. Principles of Virology by Vincent R. Racaniello , Glenn F. Rall , Anna Marie Skalka, S. Jane Flint , Lynn W. Enquist
4. Fields Virology by David M. Knipe and Peter Howley | 25 June 2013
5. Medical Microbiology: Murray, Rosenthal and Pfaller
6. The Gut Microbiome in Health and Disease; Editors: **Haller**, Dirk 2018
7. Ending the neglect to attain the Sustainable Development Goals: a road map for neglected tropical diseases 2021–2030. World Health Organization, 2020

RGC 702: Pathophysiology and disease biology – 2 Credits.

Name of the course
<p>Unit I: Introductory pathology and disease markers</p> <p>Definition of Pathology, describe the major divisions of pathology, application in health, disease, and medicine research</p> <p>Biomarkers in disease biology</p>
<p>Unit II: Altered cellular and tissue biology</p> <p>Mechanisms, manifestations and morphology of cellular injury, general mechanisms of cell injury, hypoxic injury, free radicals and reactive oxygen species - oxidative stress, chemical injury, unintentional and intentional injuries and infectious injuries.</p> <p>Chronic cell injury and adaptations and types of cell death</p>
<p>Unit: III Cellular ageing</p> <p>Genetic basis of ageing, senescence, structural and biochemical changes associated with cellular aging, pathological ageing</p>
<p>Unit IV: Inflammation and human defense mechanisms</p> <p>First Line of defense: Innate resistance, Physical, mechanical, and biochemical barriers and protective role of normal flora</p> <p>Second line of Defense: Inflammation Plasma Protein Systems and Inflammation, Cellular Components of Inflammation, Acute and Chronic Inflammation, Local and systemic Manifestations of Acute Inflammation and mechanisms to resolve acute inflammation.</p> <p>Chronic Inflammation, mechanism, major cellular pathways involved, and major diseases arising due to chronic inflammation</p> <p>Systemic lupus erythematosus</p> <p>Inflammation and cancer</p> <p>Inflammatory lung diseases</p> <p>The in vitro, ex vivo and in vivo approaches to study inflammation</p>
<p>Unit V: Inflammation, tissue repair and wound healing</p> <p>Proliferation and new tissue formation, phase, remodeling and maturation, dysfunctional wound healing, tissue repair mechanisms</p>
<p>Unit VI: Immunodeficiency disorders</p> <p>Primary (congenital) immune deficiencies, secondary (acquired) immune deficiencies, evaluation, and care of those with immune deficiency, replacement therapies for immune deficiencies, Acquired Immunodeficiency Syndrome (AIDS)</p>

Unit VII: Genes and genetic diseases

Chromosomes, DNA, RNA, and Proteins: heredity at the molecular level: definitions, from genes to proteins, chromosome aberrations and associated diseases

Genetic diseases: Autosomal dominant inheritance, autosomal recessive inheritance, X-linked inheritance, evaluation of pedigrees

The human genome project and future prospects

Inflammasomes and diseases

References/suggested materials for references

1. Robbins & Cotran Pathologic Basis of Disease, 10th Edition, Elsevier.Inc.
2. "Free Radicals in Biology and Medicine" By Barry Halliwell and John M. C. Gutteridge, Oxford university press.
3. Harrison's Principles of Internal Medicine, McGraw Hill publications.
4. Human Genetics: Concepts and Application - 12th edition by Ricki Lewis, McGraw-Hill Publishing Company

RGCG 703: Applied Neurobiology -2 Credits

Name of the course
Unit I: The Nervous System <ul style="list-style-type: none">a. Introduction to the structure and function of the nervous systemb. Anatomy of Central nervous systemc. Anatomy of peripheral nervous systemd. Comparative Neuroanatomy
Unit II: Cellular and molecular biology of the neuron <ul style="list-style-type: none">a. Neuron- structure and types of neuronsb. Synthesis and trafficking of neuronal proteinsc. Ion channelsd. Membrane potential
Unit III: Signaling in the Nervous system <ul style="list-style-type: none">a. Local signalling: Passive electrical properties of the neuronb. Propagated signalling: The action potentialc. Synapsed. Neurotransmitterse. Modulation of synaptic transmission – Synaptic Plasticityf. Synaptic plasticity as a cellular model of learning and memory
Unit IV: Developmental Neurobiology <p><i>(Focus will be towards understanding neural development in terms of its relevance to facilitating regeneration and recovery of function following disease).</i></p> <ul style="list-style-type: none">a. Basic principles of developmental neurobiologyb. Neural induction, regional specificationc. Neural stem cell biologyd. Differentiation: neurogenesis, gliogenesis,e. Neural migration, axon growth and guidancef. Synaptogenesis and plasticity
Unit V: Neurobiology of Vision <ul style="list-style-type: none">a. Anatomy of retinab. Physiology of visionc. Development of retina and visual centresd. Progenitors in retina: Fate specific differentiatione. Guidance of axons to visual targetsf. Retinal regeneration: Transplantation techniques, activation of endogenous progenitors
Unit VI: Techniques in Neurobiology with demonstration <ul style="list-style-type: none">a. Neuron cultureb. Slice culturingc. <i>In Utero</i> electroporationd. Electrophysiological recordinge. EEG recordingf. Behavioral techniquesg. MRI and CT scanningh. Stereotaxic surgical techniquesi. Vertebrate animal models as discovery tools to investigate the fundamental principles of mammalian brain development.

Unit VII: Neurobiology of disease (*Pathophysiology and genetics*)

- a. Pathophysiological Mechanisms
 - 1. Oxidative stress
 - 2. Excitotoxicity
 - 3. Imbalance between excitation and inhibition
 - 4. Protein misfolding and neurodegeneration
- b. Developmental anomalies
- c. Genetic basis of neurological diseases
 - 1. Aneurism
 - 2. Autism
 - 3. Schizophrenia
 - 4. Epilepsy
 - 5. Glaucoma

Unit VIII: Systems and Cognitive Neuroscience

- a. Systems Neuroscience - Importance of Neural circuits in CNS functions
- b. Cognitive functions and mechanisms
- c. Computational Neuroscience

Suggested Reading:

1. "Principles of Neural Science" by Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, and A. J. Hudspeth (Edition: 5th, Publisher: McGraw-Hill Education, Year: 2012)
2. "Neurobiology: A Functional Approach" by George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, and Leonard E. White (Edition: 1st, Publisher: Sinauer Associates, Year: 2019)
3. "Neuroscience: Exploring the Brain" by Mark F. Bear, Barry W. Connors, and Michael A. Paradiso (Edition: 4th, Publisher: Wolters Kluwer, Year: 2015)
4. "Neurobiology: Molecules, Cells, and Systems" by Gary G. Matthews (Edition: 1st, Publisher: Wiley, Year: 2018)
5. "Neurobiology of Disease" by Sid Gilman, Dennis J. Selkoe, and John T. Coyle (Edition: 1st, Publisher: Academic Press, Year: 2010)
6. "Neurobiology: A Molecular Approach" by Gustavo Deco and Joseph G. Howland (Edition: 1st, Publisher: Oxford University Press, Year: 2019)

RGC 704: Advances in Reproductive Biology – 2 Credits (30 hrs)

This course will address the biological mechanisms underlying reproduction and how the normal biological processes are disrupted to cause reproductive health issues. A range of specific disorders of reproduction (contraception, infertility, maternal health) will be discussed. Attention will be given to the recent advances in understanding of disease at a molecular level and how they translate to become a clinical disorder.

Name of the course	
<p>Unit I: Mammalian Reproduction Overview</p> <ul style="list-style-type: none"> • Male and female reproductive systems – An introduction • Development of male and female reproductive system I (Gonads, genital ducts, glands, external genitalia, descent of testis& ovaries) • Sex determination • Disorders of sex development 	
<p>Unit II: Spermatogenesis and Fertilization</p> <ul style="list-style-type: none"> • Gametogenesis: Conversion of germ cells into male gametes • Germ-line stem cells • Spermatogenesis • Endocrine Control of Spermatogenesis. • Acquisition of fertilizing ability - Capacitation and Acrosome Reaction • Fertilization • Epigenetics of reproduction. <p>Male Infertility – Classification, diagnosis and management</p> <p><u>Will conduct Invited talks</u></p>	
<p>Unit III: Oogenesis and Embryo development female gametes and Oogenesis</p> <ul style="list-style-type: none"> • Ovulation (ovarian cycle, menstrual cycle) • Endocrine Control of Ovulation • Menstrual disorders – Precocious, delayed or absent puberty; • Amenorrhea Fertility disorders – <ul style="list-style-type: none"> ○ POF, PCOS • Embryonic development and Organogenesis– <ul style="list-style-type: none"> ○ Early embryo development , embryo arrest, embryonic stem cells <p>embryo gastrulation and organogenesis;</p>	<p>Gametogenesis: Conversion of germ cells into</p>

Unit IV :(Pregnancy and Female Reproductive Disorders) –

- *Mechanism of Embryo Implantation,*
 - Hormonal control and Embryo activation
 - Uterine reprogramming and decidualization
 - Immune regulation of pregnancy.
 - Early pregnancy loss (RIF, Habitual abortion, recurrent miscarriage or recurrent pregnancy loss (RPL)

- Development of placenta and Fetal membranes
- Placental disorders (Pre-eclampsia and eclampsia, IUGR, placental abruption and abnormal (velamentous) cord insertion.
- Miscarriages, Preterm births, and stillbirth

- Gestational Diabetes Mellitus

- Endometrial Hyperplasia and Endometriosis

- Reproductive Tract Infections in Women

Will conduct Invited talks

Unit V: (Assisted Reproductive Techniques and Fertility Regulation)

- Semen analysis
- Ovulation induction; Oocyte retrieval; In vitro maturation
- In vitro fertilization ICSI, GIFT etc.
- Ethical issues in assisted reproductive technologies.

- Cryopreservation of gametes & embryos; Vitrification
- Embryo biopsy; Embryo hatching, Pre-implantation genetic diagnosis (PGD)

- Methods of fertility regulation in male and female

Will conduct Invited talks

SEMINAR / GROUP DISCUSSION

Suggested Reading Materials:

1. "Principles of Reproductive Biology" by Richard M. Schultz (Edition: 1st, Publisher: Academic Press, Year: 2018)
2. "Essentials of Human Reproductive Biology" by Bruce A. Lessey (Edition: 1st, Publisher: Academic Press, Year: 2018)
3. "Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter (Edition: 6th, Publisher: Garland Science, Year: 2014)
4. "Assisted Reproductive Technologies: Quality and Safety" edited by Botros RMB, Bekir JS (Edition: 1st, Publisher: Springer, Year: 2015)
5. "Principles of Assisted Reproductive Technology" by Pandian Z, Bhattacharya S, Templeton A (Edition: 1st, Publisher: Cambridge University Press, Year: 2011)

RGC 705: Advanced Immunology – 2 Credits

Name of the course
Unit I: The immune system – an overview, evolution and organs and cells; innate immunity (cells of the innate immune system, complement and other components), humoral responses (B-cell origin, types, receptors and VDJ rearrangement), T-cell dependent responses (T-cell origin and subsets, memory T-cell responses), macrophages, dendritic cells and their subsets, overview of cytokines, chemokines and Toll like receptors
Unit II: Vaccines: History, key principle of vaccinology, herd immunity, adjuvants, type of adjuvants, function of adjuvants, classification of vaccines, type of vaccines.
Unit III: New approaches to vaccine design, mRNA vaccines, bacterial vaccines, viral vaccines, T-cell based vaccines, vaccine against parasitic diseases, T cell and B-cell epitope mapping, adverse effects of vaccines
Unit IV: Antibodies: Generation of monoclonal and polyclonal antibodies, recombinant approaches to generate monoclonal antibodies, Application of antibodies, abzymes (Catmab), immunotoxins, Single domain antibodies (Nanobody), bivalent and bi-specific antibodies.
Unit V: Transplantation immunology: History, principles and discovery of immunogenetics, donor antigens, mechanism of graft rejection, graft versus host diseases, physiological interaction that modulates graft rejection, manipulations to prevent graft rejection (strategies to induce central and peripheral tolerance), transplantation of specific organs (kidney, liver, heart, lung, pancreas), hematopoietic cell transplantation, xenogeneic transplantation, immunological issues in clinical transplantation
Unit VI: Tumor Immunology: Tumor recognition by immune cells, tumor antigens and its identification, Immunosuppression in tumor microenvironments, tumor escape mechanism, influence of immune system on tumor development, immunoediting, cancer immunotherapies. NK cell and dendritic cell therapy; CAR T cell therapy.
Unit VII: Biologics and molecular medicine in immunology (cytokines, chemokines, cell-adhesion molecules, co-stimulatory molecules and surface receptor and ligands as therapeutic targets).
Unit VIII: Role of non-coding RNA in immune regulation
Unit IX: Advanced immunological techniques: Flow cytometry, Magnetic sorting, MHC tetramer technology, multiplex assays, antibody purification and protein conjugations, spectra-typing, surface plasmon resonance (SPR).
Unit X: Autoimmunity and tolerance: General principle of autoimmune diseases, mechanism of peripheral and central tolerance, regulatory circuits in autoimmune processes, systemic autoimmune diseases, organ-specific autoimmune diseases (Central nervous system, gastrointestinal, Endocrine, Hepatic, cutaneous and rheumatoid arthritis).
Unit X: Animal model of immunological diseases (Transgenic and knockout animals), generation of bone-marrow chimeras, humanized mice, parabiosis.

Suggested Reading:

1. Cellular and Molecular Immunology 9th Ed. Abbas et al.
2. Fundamental Immunology 7th Ed. William E. Paul
3. Clinical Immunology- Principles and Practice 5th Ed. Rich et al.
4. Immunology 8th Ed. Male et al.
5. Tumour immunology and Immunotherapy Robert C. Ross
6. Plotkin's Vaccines 7th Ed. Plotkin et al.
7. Monoclonal Antibodies 3rd Edition Principles and Practice. James Goding

RGC 706: Advances in Plant Biotechnology – 2 Credits

Name of the course
Plant Growth and Development <ul style="list-style-type: none">• Introduction to plant growth and development- Cell wall, Cell division and cell growth, embryogenesis, determination, differentiation and dedifferentiation in plants• Hormonal regulation of plant development- Introduction to plant hormones, Molecular basis of hormone action & Regulation of developmental processes.• Genes controlling flower development- ABCDE model, floral transition, floral initiation, floral meristem identity, floral organ identity
Plant-pathogen interactions <ul style="list-style-type: none">• Pathogens & Pathosystems – Major pathogens, necrotrophs, biotrophs; Mechanism of infection & colonization process- pre-formed defense, structural and bio chemical.• Molecular basis of host pathogen interaction and plant innate immunity against fungi, oomycetes, bacteria and virus in model systems; pathogen recognition and signal transduction, PTI, ETI.• Induction of defense responses-Pathogenesis Related proteins, Reactive oxygen species, Hypersensitive Response, Systemic Acquired resistance, Virus Induced gene silencing• Effector biology-Understanding the roles and functions of fungal ‘effectors’, molecular mechanisms of effector -host interactions and identification of effector targets for crop improvement• Approaches to enhance plant crop protection-transgenic and non-transgenic (defense priming) approaches, genome editing.
Genetics and genomics in crop improvement for disease resistance <ul style="list-style-type: none">• Construction of molecular maps: linkage maps and association maps; gene tagging; quantitative traits (QTLs); SNP analysis.• Backcross breeding and marker assisted selection (MAS). Positional cloning of defence related genes by knowing map position.• Transcriptomics: determining key genes and pathways in governing resistance and susceptibility reactions against pathogens in crops
Genetic Transformation <ul style="list-style-type: none">• Transformation Techniques in Plants, Transgene silencing and stability.• Metabolic Engineering in Plants, Transgenic Plants as Biofactories: Biopharming in plants for the production of industrial enzymes, edible vaccines• Transgenic technology for the development. Viral, bacterial and fungal resistance plants.

Suggested Reading

Plant Growth and Development. 2002. L M Srivastava. Oxford Academic Press.

Plant Physiology and Development, Sixth Edition 2015. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy. Sinauer Associates, Inc., Publishers.

Dale R. Walters. Plant Defense: Warding off Attack by Pathogens, Herbivores, and Parasitic Plants(2010).PrintISBN:9781405175890|OnlineISBN:9781444328547 DOI:10.1002/9781444328547. Blackwell Publishing.

Jones and Dangl. 2006. The Plant Immune System. Vol.444; doi:10.1038/nature05286

Pastor et al. 2013. Primed plants do not forget. Environmental and Experimental Botany. 94: 46-56.

Saijo et al. 2018. Pattern recognition receptors and signaling in plant–microbe interactions. The Plant Journal. <https://doi.org/10.1111/tpj.13875>

RGC 707: Advances in Molecular Genetics – 2 Credits

Name of the course
Unit I: Principles of Genetics: Principles of genetics and inheritance, developmental and human molecular genetics and associated genetic disorders, epistasis, quantitative genetics, population and evolutionary genetics, Genome mapping- Genetic mapping, Physical mapping, Resolution of mapping, Defects in Genome Maintenance
Unit II: Human Genetics: Recent advances in human molecular genetics, introduction to the human genome, pedigree analysis, gene mapping and linkage analysis, Genome Organisation and application, Chromosomes and their role in inheritance, chromosomal aberrations
Unit III: Gene therapy: Introduction, vectors in gene therapy, advances in gene therapy, safety assurances
Unit III: PCR techniques: Principles of PCR, RT PCR, Primer design, Types of PCR, T-vectors, proof reading enzymes; Isolation of DNA and RNA, reverse transcriptase and cDNA synthesis; cDNA and genomic libraries, sequencing technologies and methods, Phylogenetic analysis Blotting techniques: Southern, Northern, Western :
Unit IV: Molecular forensics: DNA fingerprinting, - genetic identification, Use of technology in anthropological studies
Unit V: Pervasive Transcription and concept of junk DNA Non - coding RNAs (regulatory and functional RNAs, miRNA, lncRNA, piRNA, ceRNA, and other RNA species)
Unit VI: Global expression profiling: Whole genome analysis of mRNA and protein expression, microarray analysis and their applications, Genome sequencing: Strategies for Sequencing whole genome and sequence data analysis, Comparative Genomics
Unit VII: DNA analysis and diagnostics: Methods of DNA analysis, PCR in molecular diagnostics, diagnosing infectious diseases, Identifying genetic disease
Unit VII: Gene editing : Gene silencing technologies, Genome editing by CRISPR-Cas

Suggested Reading

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.
- Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's Genes XII. 12th Edition, Jones & Bartlett Learning

RGC 708: Stem Cell Biology and Regenerative Medicine – 2 Credits (30hrs)

Name of the course
<p>Unit I: Stem Cells Overview of stem cell biology, culture, derivation, Differentiation of embryonic /iPSCs/adult/fetal stem cells, differentiation to different lineages, clinical applications, stem cell niches, organoids; and cancer stem cells.</p>
<p>Unit II: Developmental hematopoiesis, Epigenetic regulation of stem cell fate, Niche biology: regulation of hematopoiesis by the niche-mediated signaling mechanisms.</p>
<p>Unit III: Neural stem cells: Maintenance of neural stem cell niche, Neural stem cell differentiation</p>
<p>Unit IV: Cryopreservation of cells (general), Cord blood banking and long-term storage of stem cells, FACS and its application in stem cell research</p>
<p>Unit V: 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.</p>
<p>Unit VI 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.</p> <p>Therapeutic application of iPSCS</p>
<p>Unit VII: Cell and Developmental Biology: Shaping the embryo Molecular logic of life, Fundamental aspects of Cells, Flow of information in biological systems-</p> <p>Unit VIII: Model organisms</p> <p>C. elegans:</p> <p>Drosophila:</p> <p>Zebrafish: How cells form tissues and organs: Zebrafish- gastrulation, morphogens, morphogen gradients, axis formation, Fate maps, lineage tracing, transplantation experiments, developmental anomalies Tissue/ Organ Development, Damage and Regeneration.</p> <p>KO Mouse models</p>

Unit IX: Techniques in Stem Cell Biology:

1. Neural/Cancer stem cell isolation and culture techniques
2. Neurosphere/Tumorsphere assay
3. Mouse ES Cell generation and culture
4. Human ES/iPSC culture
5. Organoid generation and maintenance
6. Zebrafish: maintenance, breeding, *in situ* hybridization, microinjections- morpholino/ mRNA
7. Generating transgenic and knockout zebrafish

Invited talks related to current developments in the field of stem cell Biology

Suggested Reading

Molecular Biology of the Cell by Bruce Alberts

Principles of Development by Lewis Wolper

RGC 709: Cardiovascular system disorders and Diabetes – 2 Credits

Name of the course
Unit I: Physiology cardiovascular system, Anatomy of heart Molecular basis of cardiac growth and development Cardiac hypertrophy (physiological and pathological hypertrophy Angiogenesis, development of vasculature, molecular mechanism of normal and pathological angiogenesis
Unit II: Introduction to cardiovascular diseases genetics of cardiovascular diseases Cardiomyopathies and Congenital heart defects Atherosclerosis Peripheral arterial and venous diseases, Pulmonary hypertension and pulmonary embolism Heart failure (heart failure with preserve and reduced ejection fractions)
Unit III: Diabetes Mellitus: History, Symptoms, Classification, Epidemiology and Diagnosis, Type-I diabetes, Monogenic forms and Gestational diabetes
Unit IV: Type-2 diabetes: Genetic considerations, Mechanism and Pathophysiology, Insulin resistance & Impaired insulin secretion, Increased hepatic glucose and lipid production Complications of diabetes mellitus and current research

Reference books:

[Harrison's Internal Medicine](#)

RGC 710: Advances in Chemical Biology- 2 Credits

Name of the course
Unit I: Basics of chemistry Acids, alkali, Normality, Molarity and preparation of solutions. Buffers; preparation, pH and determination. Centrifugation Techniques-Ultracentrifugation and principles
Unit II: Engineering membrane proteins for chemical biology, Synthetic pores, Pore-forming toxins, Nanopore technology, Fundamental properties of ion channels, Single-molecule chemistry and catalysis, DNA origami and applications, Liposomes and applications of liposomes in chemical biology, Liposome assays.
Unit III: Basics and principle of IR spectroscopy and sample characterization and illustration, Differential Scanning Calorimetry (DSC), Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM, ESEM) and its applications in material chemistry and biomedical applications Demonstration of IR, DLS, DSC and TEM
Unit IV: Nanotechnology and its applications in biomedical field, characterization of particles, different targeting mechanism in internalization, Role of peptides in drug targeting, Different techniques used for preparation
Unit V: Applications of biomaterial in biomedical science and tissue engineering, different techniques used in biocompatible material synthesis and characterization, cell differentiation, role of spectroscopic techniques in material characterization
Unit VI: Physics and Chemistry behind important biological systems function, Dynamics in different parts of a cell movement and function, biomedical applications of biophysics Bioimaging techniques
Unit VII: Natural peptides- peptide hormones, host defense peptides- their mode of action, role in therapy. Synthetic peptides- antagonist peptides- their role in biology, applications in therapy Biotin tagging- applications; Fluorescent tagging-applications; Radiolabeling-applications

Suggested Readings:

1. 3D Bioprinting and nanotechnology in tissue engineering and regenerative medicine

Author : Zhang, Lijie Grace; Fisher, John P

Publisher : Elsevier - Academic Press

2. Nanomaterials and nanosystems for biomedical applications

Author : Mozafari, Reza

Publisher : Springer

3. Scanning microscopy for nanotechnology: Techniques and applications

Author : Zhou, Weilie; Wang, Zhong Lin, ed.

Publisher : Springer Publishing Co., New York

4. Transmission Electron Microscopy and diffractometry of materials

Author : Fultz, Brent; Howe, James

Publisher : Springer-Verlag, Berlin

5. Biomaterials, artificial organs and tissue engineering

Author : Hench, Larry L; Jones, Julian R., Ed.

Publisher : CRC Press, Wood Head Publishing Ltd, Cambridge, England.

6. Principles of tissue engineering; Edition 4

Author : Lanza, Robert; Langer, Robert

Publisher : Elsevier - Academic Press

RGC 711: Advances in Cancer Biology – 2 Credits (30H)

This course will provide detailed understanding of cancer biology.

Name of the course
Unit I: Fundamentals of cancer Introduction to cancer as a disease and essentials of cancer management, classification of cancers and tumors, Cancer epidemiology,
Unit II: Etiology of cancer Etiology of cancer, Tobacco and cancer development, Cancer Prevention Viruses and cancer (RNA and DNA viruses) Cancer susceptibility syndromes, 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, autophagy, senescence, telomeres Gene Regulation and Epigenetics in Cancer
Unit IV: Invasion and Metastasis Genomic Instability, 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 VI: Translational Cancer Research

use of cell kinetics to optimize cancer treatment,

Principles of Clinical drug trials for new cancer treatment,

Natural Products as a platform for anti cancer drug development

monoclonal antibodies as anti cancer agents, new modalities in cancer treatment, personalised therapy, Biomarkers for Cancer Diagnosis,

Unit VII: Experimental Techniques in Cancer Research

Cancer cell culture techniques, Cell Proliferation assays,

Cancer cell immortalization, Immuno assays & Radiolabelling Techniques Gene silencing/ over expression

Animal models for cancer

SUGGESTED READING MATERIALS

1. The Biology of Cancer- R.Weinberg (Full PDF can be downloaded - [\(PDF\) The Biology of Cancer- R.Weinberg | Vet Help - Academia.edu](#))
2. Title : Molecular cell biology; Author : Lodish, Harvey; Berk, Arnold; Year : 2016; Publisher : Macmillan Education
3. Title: Advances in cancer researuch, Vol.93; Author: vande Woude, George F; Klein, George, Ed. Year : 2005; Publisher : Elsevier Academic Press, New York
4. Title : An introduction to the use of anticancer drugs; Author : Rafi, Imran Year : 2006; Publisher : Elsevier Publishing Co., New York
5. Title : Anticancer drug toxicity: Prevention, management, and clinical pharmacokinetics; Author : Hans- Peter Lipp; Year : 1999; Publisher : Marcel Decker, Inc
6. Title : Anticancer: A new way of life; Author : Servan - Schreiber, David; Year : 2011; Publisher : Penguin
7. Title : Breast cancer research protocols; Author : Brooks Susan A; Harris Adrian; Year : 2006; Publisher : Humana Press, New Jersey
8. Title : Cancer bioinformactics: From therapy design to treatment Author : Nagt, Sylvia, Ed. Year : 2006; Publisher : John Wiley & Sons Inc., England
9. Title : Cancer Biology; Author : King, Roger J B; Robins, Mike,W; Year :2006; Publisher : Pearson Education Asia
10. Title : Cancer cell culture: Methods and protocols; Author : Langdon, Simon P; Year : 2004; Publisher : Humana Press, New Jersey
11. Title : Cancer cell signalling: Methods and protocols Author : Terrian, David M; Year : 2003; Publisher : Humana Press
12. Title : Cancer microenvironment and therapeutic implications: Tumor pathophysiology mechanisms and therapeutic strategies
13. Author : Baronzio, Gianfranco; Fiorentini, Giammaria; Year : 2009 Publisher : Pringer
14. Title : Clinical oncology; Author : Abeloff, Martin D., Armitage, James O

- Year : 2004; Publisher : Elsevier
15. Title : DNA repair genetic instability, and cancer; Author : Wei, Qingyi; Li Lei;
Year : 2007; Publisher : World Scientific
16. Title : Estrogens, estrogen receptor and breast cancer; Author : Parl, Fritz, F; Year :
2000; Publisher : IOS Press, Amsterdam
17. Title : Hand book of metastatic breast cancer; Author : Johnson, Stephen RD; Swanton,
Charles; Year : 2006; Publisher : Informa healthcare, UK
18. Title : Metastasis of breast cancer; Author : Mansel, Robert E; Fodstad, Oystein;
Year : 2007; Publisher : Springer

RGC 712: Certification courses -10 Lectures

The certification courses will take care of certification requirements for using radioactive materials and laboratory animal handling.

Name of the course
<ul style="list-style-type: none">• Certification course for using Radioactive materials
<ul style="list-style-type: none">• Certification course in Animal handling

RGC 713: Group Theory and Molecular Spectroscopy: 3 Credits

Introduction to Group Theory: Definition, Theorems of Group Theory, Examples of Groups, Subgroups, Classes

Molecular symmetries and the symmetry groups: Symmetry elements and operations, Symmetry planes and reflection, Inversion center, Proper axes and proper rotation, Improper axes and improper rotation, the product of symmetry operations, Equivalent symmetry elements and equivalent atoms, relations among symmetry elements and symmetry operations. Symmetry elements and optical isomerism, the symmetry point groups, symmetries with multiple higher-order axes, class of symmetry operations, a systematic procedure for classification of molecules, and examples.

Representation of groups: Brief introduction to Matrices and Vectors, representation of groups, The great orthogonality theorem, and its consequences, Character tables, Representation of cyclic groups.

Infrared and Raman spectroscopy: Electromagnetic radiation and its absorption by molecules, Frequency, wavenumber, and wavelength, Molecular vibration, Factors influencing molecular vibrations, Instrumentation: Infrared spectroscopy, Sampling techniques, Applications of Infrared spectroscopy – fingerprint and functional groups.

Light Scattering Phenomena, the basic theory of incoherent light scattering, Classical theory of Raman and Rayleigh scattering, Quantum mechanical theory of Raman scattering, Instrumentation: Raman spectroscopy, sampling techniques, Applications of Raman scattering.

Nuclear Magnetic Resonance: Proton NMR spectroscopy - NMR phenomena, Theory of NMR, Chemical shift and its measurements, Factors influencing chemical shift, use of correlation tables in proton NMR and influence of restricted rotation, solvents used and integrals in proton NMR, Spin-spin coupling and spin-spin splitting, factors influencing coupling constant, Non-first-order spectra, Simplification of complex proton NMR spectra

Carbon-13 NMR Spectroscopy - Natural Abundance carbon-13 NMR Spectra, Resolution, Multiplicity, proton Decoupling-noise decoupling-broad band decoupling, Deuterium coupling, NOE signal enhancement, Quantitative measurement of line intensities, Off-resonance proton decoupling, Structural Applications of ¹³C NMR.

Pre-requisites: Some basic mathematics and physics knowledge would be preferred.

Reference Materials:

1. Chemical applications of group theory – F. Albert Cotton, third edition, Wiley Interscience publication (1990) ISBN 0-471-51094-7.
2. Organic Spectroscopy – William Kemp third edition, Palgrave Publishers Ltd (2002) ISBN 978-1-4039-0684-7 ISBN 978-1-349-15203-2 (cBook), DOI 10.1007/978-1-349-15203-2.
3. The Raman Effect – D.A. Long, John Wiley and Sons Limited (2002) ISBN 0-471-49028-8