



**SARDAR PATEL UNIVERSITY, VALLABH VIDYA NAGAR**  
**Syllabus of M.Sc. Biomedical Science, Semester- IV**  
**(Effective from Academic Year 2020-21)**

**PT04CBMC21: Molecular Diagnostic Techniques**

**Unit-I**

Introduction and History of diagnostics, Diseases- infectious, physiological and metabolic errors, genetic basis of diseases, inherited diseases. Infection – mode of transmission in infections, factors predisposing to microbial pathogenicity, types of infectious diseases: bacterial, viral, fungal, protozoans and other parasites. Philosophy and general approach to clinical specimens, Sample collection- method of collection, transport and processing of samples, Interpretation of results, Normal microbial flora of the human body, Host - Parasite relationships.

**Unit-II**

Molecular Diagnosis: Nucleic acid amplification methods and types of PCR: Reverse Transcriptase-PCR, Real-Time PCR, Inverse PCR, Multiplex PCR, Nested PCR, Alu-PCR, Hot-start, In situ PCR, Long-PCR, PCR-ELISA, Arbitrarily primed PCR, Ligase Chain Reaction. Proteins and Amino acids, Qualitative and quantitative techniques: Protein stability, denaturation; amino acid sequence analysis. RNAi Interference study, CRISPR Cas9 gene biology and its applications.

**Unit-III**

Hybridization techniques and DNA sequencing methods in molecular diagnosis: Southern, Northern, *In-situ* (including FISH), microarrays – types and applications; Protein extraction and analysis (including PAGE and its variations); Western Blot Automated DNA sequencing- Principles, Methods and Instrumentation- Advances in DNA sequencing- Next Generation sequencing Methods, Pyrosequencing, Microarrays- Personalised Medicine- Pharmacogenomics (ADMET)

**Unit-IV**

Infectious diseases Diagnosis: Bacterial-Tuberculosis; Viral-AIDS, Human Papilloma Virus, Herpes, Hepatitis-C; parasitic diseases- Neiseria gonorrhoeae, malaria. Genetic disorders and inborn errors of metabolism: Monogenetic disorder – e.g. Cystic fibrosis etc. Epigenetic disorder – e.g. Cancer etc. Polygenetic disorder – e.g. Diabetes, Triple repeat, Obesity, etc. Inborn error of metabolism: Lipidosis-, Lysosomal storage disorders-, glycogen storage disorders- Gaucher and Pompe; mucopolysaccharidoses- Hunter and Hurler.

**Reference Books:**

- Buckingham L and Flaws ,ML MOLECULAR DIAGNOSTICS: Fundamentals, Methods, & Clinical Applications.
- Nyhan William L, Barshop Bruce A, Ozand Pinar T. Atlas of Metabolic Diseases 2nd edition
- Mousumi Debnath, Godavarthi B.K.S. Prasad, Prakash S. Bisen Molecular Diagnostics: Promises and Possibilities
- Medical Microbiology, Edited by Greenwood, D, Slack, R and Peutherer, J, ELST Publishers.

- Henry's Clinical Diagnosis And Management By Laboratory Methods Mcpherson
- Molecular Diagnostics: Fundamentals, Methods & Clinical applications. Lele Buckingham and Maribeth L. Flaws
- Molecular Diagnostics for the Clinical Laboratorian 2Ed, W.B. Coleman. Humana Press.

## **PT04CBMC22: Medical Imaging Techniques**

### **Unit-I**

Medical imaging techniques: Photography and film image: Principle of photography and radiographic film image, film sensitometry, information content of an image, image quality factors (resolution, contrast, noise). Radiation Detectors: flat panel detector (FPD) assembly, ionization chamber, proportional counter, Geiger-Muller counter, scintillation detectors, semiconductor radiation detector, efficiency and sensitivity of detectors. Image intensifier, automatic brightness control system, image distortion and artifacts. Conventional X-ray Radiography, Fluoroscopy and angiography: Over view of Fluoroscopic imaging system, principle, specific system design. Digital fluoroscopy-c-arm system. Digital subtraction angiography (DSA), digital subtraction programming

### **Unit-II**

Basic Computed Tomography (CT) - Basic principles of CT, generations of CT, CT instrumentation, image formation in CT, CT image reconstruction, Hounsfield unit, CT image quality, CT image display Imaging techniques and protocols for various parts of body, CT contrast enhanced protocols – CT angiography Aortogram, selective angiogram head, neck and peripheral etc.

Radio isotope imaging / Nuclear medicine: Radio nuclides for imaging, radionuclide production: cyclotron production, reactor production, generator production. Rectilinear scanners, Linear scanners, SPECT, PET, Gamma Camera, Comparison of other tomographic techniques.

### **Unit-III**

Ultrasonography: Basic Acoustics, Ultrasound terminologies: acoustic pressure, power, intensity, impedance, speed, frequency, dB notation: relative acoustic pressure and relative acoustic intensity. US machine controls, US focusing. Production of ultrasound: Piezoelectricity, Medical ultrasound transducers: Principle, construction and working, characteristics of US beam. Ultrasound display modes: A, B, M, Real-time ultrasound: Line density and frame rate, Real-time ultrasound transducers: mechanical and electronic arrays, ultrasound artifacts, ultrasound recording devices, and Distance, area & volume measurements. Applications of diagnostic ultra sound Doppler Ultrasound, Doppler artifacts, vascular sonography.

### **Unit -IV**

Magnetic Resonance Imaging: Principles of MRI, Image reconstruction techniques, Advantages and biological effect of MR imaging system. MR Instrumentation: Types of magnets – RF transmitter – RF receiver – Gradient coils – shim coils – RF shielding – computers. Image formation: 2D Fourier transformation method – K-space representation – 3D Fourier imaging – MIP. MR contrast media – MR angiography – TOF & PCA – MR Spectroscopy – functional MRI.

## Reference Books:

- Principles of Medical imaging, K. Kirk Shung, Michael B. Smith, Benjamin M. W. Tsui, Pub: Academic Press.
- Handbook of Biomedical Instrumentation, R.S.Khandpur.
- Introduction to biomedical imaging, Andrew Webb.Pub: IEEE press series: Wiley Interscience
- Fundamentals of medical imaging: Paul suetens. Pub: Cambridge university press.
- The Physics of medical imaging, Steve Webb. Pub: Institute of Physics Publishing, Bristol and Philadelphia.
- Medical Imaging, John G. Webster, Wiley and Sons
- Radiologic science for Technologists, By: Stewart C. Bushong. Pub: Mosby: A Harcourt Health Sciences Company.
- Quality Management: In the Imaging Sciences, By: Jeffery Papp. Pub: Mosby: A Harcourt Health Sciences Company

## PT04CBMC23: Animal Cell Culture and Gene Therapy

### Unit-I

Animal Cell Culture: Historical Background, Importance and progress in Animal Cell Culture Technology and its applications in biomedical sciences,, Laboratory setup and equipments, aseptic technique, different cell culture media and supplements, Importance of Serum and Serum Free Media, preparation and sterilization of cell culture media and supplements

### Unit-II

Cell culture techniques: Disaggregation of tissue and primary culture, Types of primary culture; Chick embryo fibroblast culture; Chick liver and kidney culture; Secondary culture; Trypsinisation; Cell separation ; Continuous cell lines; Passage number; Anchorage and Anchorage independent cells and cultures; Suspension culture; Organotypic and Histotypic cultures: tissue specific stem cells; embryonic hematopoietic and neural stem cells, classification and sources, uses.

### Unit-III

Introduction: Somatic and germ line gene therapy, Gene replacement and gene addition. In vivo, ex vivo and In vitro gene therapy, Transgenic animal models, Vehicles for gene transfer-Viral vectors like retrovirus, Adenovirus, Adeno-associated virus. Lentivirus, Recombinant SV40 virus, Nonviral vectors, DNA vaccines, Liposomes and lipoplexes, Naked DNA, transposon. Gene Transfection methods – (RNAi) – siRNA, shRNA miRNA etc.

### Unit-IV

Cancer gene therapy, Gene therapies for Criglar-Najjar syndrome I, Cystic fibrosis, Duchenne muscular dystrophy, Bleeding disorders, Tyrosinemia, Severe combined immunodeficiency syndrome (SCID), Gene therapy of nonheritable disorders, Cancer gene therapy. Recent advancement in Gene Therapy.

## Reference Books:

- Culture of animal cells: A manual of basic technique- R. Ian Freshney, Wiley Publication.
- Animal cell culture & technology-M. Butler.
- Animal cell culture techniques- M. Clynes, Springer.
- Animal Biotechnology- M. M. Ranga. Agrobios (India).
- Animal Biotechnology-Young, Murray, Moo. Pergamon Press, Oxford.
- Methods in Cell Biology-Vol. 57, Animal cell culture methods- Mather, J.P., Academic Press.
- Animal Cell Biotechnology-Spier, R.E. Academic press.
- Animal biotechnology – P. Ramadass, MJP Publishers
- Biotechnology- U.Styanarayan, Books and Allied (P) Ltd.
- Friedman T. 1999. The Development of Human Gene Therapy. Cold Spring Harbor,NY: Cold Spring Harbor Lab.Press.
- Knipe DM, Howley PM, eds. 2001. Fields Virology. Philadelphia,PA: Lippincott Williams & Wilkins.
- Hackett NR, Crystal RG. 2000.Adenovirus vectors for gene therapy. In Gene Therapy, ed. NS Templeton, DD Lasic, pp.17-39. New York: Marcel Dekker
- Stem cell biology and gene therapy by Peter J Quesenberry, Gary Stain and Berard forget.

## PT04EBMC21: Developmental Biology

### Unit-I

Introduction to animal development: Fertilization: Structure of gametes, Egg sperm recognition, fertilization in sea urchins, Differential gene expression and cell-cell communication in development: Differential gene transcription, RNA processing, Control of gene expression at translation, Cell adhesion and cell signalling

### Unit-II

Early development in invertebrates and vertebrates: Cleavage and pattern of embryonic cleavage; Comparative account of gastrulation; Early development in Sea urchin, C. elegans; Drosophila; Amphibia; Birds; Mammals.

Later embryonic development: Development of ectoderm, Neurulation and Central nervous system, Neural crest cell; Development of mesoderm: Paraxial mesoderm, Intermediate mesoderm, Lateral plate mesoderm. Development of endoderm.

### Unit-III

Body Axes: Establishment of body axes in C.elegans. Birds and Mammals, tetrapod limb development: Tetrapod limb development: Proximo –distal, Anterio-posterior,.

Dorsal-ventral; Cell death pathway

Drosophila axis specification: Dorso- Ventral pattern, Segmentation and Anterior- Posterior body plan, Maternal gradient, Segmentation genes

#### **Unit -IV**

Hormones as mediators of development: Amphibian metamorphosis: Morphological and biochemical changes, Hormonal control. Insect metamorphosis: Imaginal discs discs. Hormonal control, and Molecular mechanism of action of ecdysone. Birth defects, Endocrine disruptors and cancer. Environmental as a normal agent in producing phenotype: Polyphenisms and Plasticity, Temperature and sex, Environmental induct. Medical Implications of Developmental biology – Teratogenesis, genetic errors. Environmental influences on development.

#### **Reference Books:**

- S.F. Gilbert, Developmental Biology, Sinauer Associates Inc. Massachusetts
- Ethan Bier, 'The Coild Spring' Coild Spring Harbor Laboratory Press New York
- Karp G, and Berrill N.J., Development

### **PT04EBMC22: Omics and Computational Biology**

#### **Unit I**

Genomics and methods in genomics: Introduction to the proteome and the genome, codon bias, gene expression, Genome size-C value paradox, DNA sequencing: Maxam- Gilbert, Sanger, Pyrosequencing, automated DNA sequencing. Other features of nucleic acid sequencing. Analysis and Annotation-ORF.

Exon-intron boundaries, DNA Microarray technology: The generation of cDNA expression libraries, their robotic arraying, Complex hybridization on DNA chips.

Transcriptomics: Comparative transcriptomics, Differential gene expression; Genotyping/SNP detection; Detection technology; Computational analysis of microarray data.

#### **Unit II**

Proteomics and methods in proteomics: Relationship between protein structure and function, Identification and analysis of proteins by 2D analysis; Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting; Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LCMS analyses

Protein-protein interactions: Solid phase ELISA, pull-down assay (using GST-tagged protein), far western analysis, surface plasmon resonance technique, Yeast two hybrid system, Phage display; Protein interaction maps.

Protein arrays-definition, applications- diagnostics, expression profiling. Uses of automated technologies to generate protein arrays and chips.

#### **Unit III**

Introduction to computational biology basics and biological databases: Computers in biology, Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage

Pairwise and multiple sequence alignments: Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots.

Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

#### **Unit IV**

Genome analysis: Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks. Human genome project. Structure visualization: Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD. Gene expression study basics: Gene Ontology, metabolic pathways, and gene set enrichment analysis (NGSEA, MGI, GO Annotations)

#### **Reference Books:**

- Discovering Genomics, Proteomics and Bioinformatics, A.M. Campbell, C. S.H. Press, (2003)
- Essential of Genomics and Bioinformatics C.W. Sensen, Wiley (2003).
- Hand book of Comparative Genomics: Principle and Methodology by Cecilia Saccone,
- GrazianoPesole, Wiley-LISS publication (2003).
- Proteomics: From protein sequencing to function by S. R. Pennington & M.J. Dunn, Pvt Ltd (2001)
- Introduction to Proteomics by Daniel C, Liebler, Humana Press.
- Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

### **PT04EBMC23: Biodynamics**

#### **Unit-I**

Introduction to fluid mechanics: Fluid properties, basic laws governing conservation of mass momentum and energy; Laminar flow, Couette flow and Hagen-Poiseuille equation, turbulent flow. Bernoulli's equation and its clinical significance, Make up of blood vessels, Angiology, Compliance and Elastance, Wind Kessel Model, Flow dynamical study of circulatory system, heart and blood vessels, anatomy and physiological considerations; Components and functions of arterial and venous systems; Lymphatic system

#### **Unit-II**

Fluid dynamics of hard and soft tissues: Hard tissues: Bone structure and composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell and Voight models – anisotropy, Electrical properties of bone, fracture mechanism and crack propagation in bones, fracture fixators, repairing of bones, mechanical properties of collagen rich tissues, teeth and its properties. Soft tissues: Structure and functions of cartilages, tendons, ligaments, stress-strain relationship, soft tissue mechanics, mechanical testing of soft tissues standard sample preparation, cross-section measurement, clamping of the specimen, strain measurement, environmental control), time dependent properties of testing.

### **Unit-III**

Biomechanics of joints: Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, forces and stresses in human joints, mechanics of the elbow, mechanics of shoulder, mechanics of spinal column, mechanics of hip, mechanics of knee, mechanics of ankle. Locomotion: Human locomotion, gait analysis and goniometry, Ergonomics, Foot Pressure measurements – Pedobarograph, Force platform, mechanics of foot. Total Hip Prosthesis: requirements, different types of components, Stress analysis and instrumentation, Knee Prosthesis.

### **Unit-IV**

Body fluids and their motions: Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes; Blood flow through arteries and veins; Holt and Conrads experimental investigations. Kinetic energy, flow, pressure-flow relations in vascular beds; Cardiac cycle; Cardiac valve dysfunctions; Blood pressure, regulation and controlling factors; Coronary circulation, heart failure. Left ventricle pressure- volume (P-V) relationship and P-V relationship in different valve diseases

### **Reference Books:**

- Fung, Y.C. Biomechanics: Circulation, Springer Verlag Publications New York.
- Waite L., Biofluid mechanics in cardiovascular system, Mc Grawhill Publications
- Hall S. J., Basic Biomechanics 3rd Edition, WCB/McGraw Hill Publications

### **Practical based on PT04CBMC21 and PT04CBMC22**

- PCR based diagnosis – of Tuberculosis and HPV
- Kit based diagnosis of HIV/ Hepatitis / Tuberculosis
- cDNA Synthesis
- Basic lab layout of Animal cell culture lab
- Sterilization Techniques
- Preparation of Media
- Preparation of Sera
- Primary Cell Culture
- Preparation of established Cell lines
- Cell Counting and Viability
- Staining of Cells
- Preservation of Cells
- Running NCBI-BLAST for protein, DNA and RNA sequences.
- Visit to radiology lab in nearby medical hospital or imaging centre.
- To study X-ray imaging with Diagnostic methods.
- To study Computed Tomography with image characteristics.
- To study Ultrasonography with different Modes.
- To study magnetic properties using electromagnet.
- Dead time determination of a Geiger-Muller Counter.
- Counting statistics of Beta ray absorption coefficient.
- Inverse square law verification by Gamma ray detection using GM counter.

