SEMESTER-V
BIOMEDICAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE –13 (BIOMED-DSC-13) GENOME ORGANIZATION AND FUNCTION (GOF)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Genome Organization and Function **BIOMED-DSC-13**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The course on Genome Organization and Function (GOF) will review the basic concepts of organization and architecture of human genome.
- This course would equip the students with intriguing concepts of genome packing within the nucleus, the regulatory strategies either at transcriptional or translational level, gene silencing, RNAi and mechanisms of regulatory effects of non-coding RNA.
- The objective is to remain competitive and relevant in international sense by offering high quality academic programs and research activities.

Learning outcomes

- Students will acquire basic concepts of genome, its organization and maintenance, packaging of DNA into chromosome structure, changes in histone and chromosome remodeling proteins.
- Students will learn the concept of regulatory mechanisms governing over-expression and under-expression of genes. They will understand transcriptional and translational control in prokaryotes and in eukaryotes.

- Students will also learn about post-translational control-mRNA decay and Proteolysis. Students will understand regulatory RNA in prokaryotes and in eukaryotes (sRNA, riboswitches, CRISPER- Cas system, RNA interference, miRNA and siRNA, Piwi interacting RNA) and Regulatory RNA in X-inactivation.

SYLLABUS OF BIOMED-DSC- 13

Unit-I: Organization of Human Genome (7 hrs)

General features: Genome size, gene density and diversity. Types of repetitive DNA. Nucleosomes: Basic unit of DNA condensation, packaging of DNA in to chromosome structure, nucleosome assembly. Protein and RNA encoding genes. Gene-families and super families. Processed and non-processed Pseudogenes.

Unit II: Gene Regulation at DNA level (6 hrs)

Prokaryotic gene regulation- Histone like proteins, overlapping genes.

Eukaryotic gene regulation: Genomic control – gene amplification and deletions, DNA rearrangements, chromosome puffs, DNA methylation, CpG islands. Changes in histone and chromosome remodeling proteins-HAT and HDAC, Chromodomain and Bromodomain proteins, nucleosome modifications and nucleosomes positioning.

Unit-III: Transcriptional Regulation in Prokaryotes (6 hrs)

Principles of transcriptional regulation. Activators and Repressors and their mechanism of working. Bacterial gene regulation with reference to Operons- Lactose, Tryptophan and Arabinose operon. Combinatorial control. Role of sigma factors in gene expression.

Unit-IV: Transcriptional Regulation in Eukaryotes (10 hrs)

Difference between gene regulation in Prokaryotes and Eukaryotes. Cis-acting regulatory sequences- Promoters, Enhancers, Insulators, Boundary elements. Regulatory proteins-Activators, Repressors and Co-activators, their structure and mechanism of working, Structural difference among the different DNA binding domains,

Regulation of LCR, Signal integration and Combinatorial control, Signal transduction pathways- MAP kinase and STAT pathways. Techniques for studying DNA-Protein interaction: EMSA, DNA foot printing, ChIP assay.

Unit-V: Regulatory RNAs (6 hrs)

Regulation by RNAs in Prokaryotes: sRNA (6S RNA, RybB, DsrA, RprA, OxyS), Riboswitches, Attenuation in trp operon. Structure, Origin and Functioning of CRISPR-Cas system. Regulation by RNAs in Eukaryotes: RNA interference-need and mechanism. Therapeutic uses of RNAi. RNA Induced silencing complex (RISC) and Argonaute (AGO). miRNA- structure, origin and working. siRNA- structure, origin and working. Piwi-interacting RNA- structure, origin and working. Regulatory RNA and X-inactivation: long non-coding RNA. Mechanism of X-inactivation.

Unit-VI: Translational and Post-Translational Regulation (10 hrs)

Rationale of gene regulation at translation level. Regulation of Prokaryotic translation-protein and RNA bonding to RBS, Ribosomal proteins as translational repressor, Tm RNA. Regulation of Eukaryotic translation-Global regulation and Gene specific regulation. Regulation of Oscar protein by Cup protein in Drosophila, Regulation of Ferritin in Humans, Regulation of Gcn4 in yeast, Eukaryotic mRNA structure and stability. mRNA decay pathway in Eukaryotic cells: De-adenylation dependent pathway and De-adenylation independent pathways- Endoribonucleolytic decay, Nonsense and Nonstop mediated decay, No-Go decay and RNAi dependent pathway of mRNA decay. Proteolysis in Prokaryotes and Eukaryotes, Lysosome and Proteasome mediated protein decay, Ubiquitin-Proteasome pathway.

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of various stock solutions for mentioned experiments.
2. Isolate plasmid/ genomic DNA of the sample provided.
3. Comparative analysis of genomic DNA and plasmid DNA by restriction enzyme digestion and estimation of size of a DNA fragment after electrophoresis using DNA markers.
4. Quantification of unknown DNA using Lambda-Hind III marker.
5. Study transfer of DNA through Southern Blotting.
6. Perform hybridization of DNA using Southern Blot.

8. Separation of proteins using SDS PAGE.
9. Perform Western hybridization.
7. Bioinformatic analysis of Prokaryotic gene.
8. Bioinformatic analysis of Eukaryotic gene.

Essential Readings

- Klug, W. S. Cummings, M. R. Spencer, C. A. and Palladino, M. A. Killian, D. (2019*).* 12th Edition. *Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0134604718
- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2015). 2nd Edition. *Molecular biology: Principles and practice.* London, UK: W H Freeman & Co Publishers, ISBN-13: 978-1464126147
- Watson, J.D. Baker T.A. Bell, S.P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular biology of the gene.* New York, USA: Cold Spring Harbor Laboratory Press.ISBN-13:9780321762436.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons.ISBN-13: 978-0470903599

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cooper, G.M. and Hausman, R.E.(2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
- Green M.R. and Sambrook J. (2012). 4thEdition, (three-volume set). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 978-0470903599.
- Hardin ,J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M.(2008).7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0805393934.
- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.

- Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The Science and technology behind the human genome project.* NewYork, USA: JohnWiley and Sons. ISBN-13:978-0471599081.

DISCIPLINE SPECIFIC CORE COURSE –14 (BIOMED-DSC-14) MEDICAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical / Practice			
Medical Biotechnology **BIOMED-DSC-14**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The objective of this course is to enable the students to comprehend the concepts of recombinant DNA technology and apply the gained knowledge towards cloning and expression of genes and purification of the recombinant proteins.
- In the process, students would get a grasp on the cutting-edge technologies used in the analysis of nucleic acids and expressed proteins. The course aims to give students training in modern molecular techniques and help them make a connection between biological concepts and the technologies developed for various applications in biotechnology.
- The course finally aims to augment students' understanding of the role biotechnology plays/can play in various aspects of human medicine and provide them the platform to appreciate the drivers of emerging innovations in medical biotechnology along with biosafety and ethical concerns.

Learning outcomes

- Students will learn the contemporary techniques being applied in the field of medical biotechnology which include PCR, Gene Cloning, Gel electrophoresis etc.
- Students will gain a comprehensive understanding of DNA manipulation techniques and how to create recombinant DNA molecules by making a suitable choice of vectors and expression hosts.

- An in-depth understanding of gene cloning, expression in prokaryotic and eukaryotic systems and on the production of recombinant proteins shall prepare students to apply the gained knowledge on different organisms.
- Having grasped the fundamentals of recombinant DNA technology, its robust potential and the limitations & challenges, students shall discern the applications of biotechnology in human medicine. Their gained knowledge shall be imbued with a deeper understanding of the safety and limitations of molecular tools used in the diagnostics of infectious diseases, production of biopharmaceuticals and gene therapy.

SYLLABUS OF BIOMED-DSC-14

Unit I: Introduction to Recombinant DNA Technology and its applications in Medical Biotechnology

(13 hrs)

Brief history and scope of molecular biotechnology, concept of manipulation of DNA, cloning vectors and gene cloning. Restriction and modification system: Type I-IV restriction endonucleases, nomenclature and sequence recognition, isochizomers, blunt end and sticky ends, restriction mapping. Joining of DNA molecules: role of DNA ligase enzymes, adaptors, linkers, homopolymer tailing.

Cloning vectors: bacterial plasmids (T-vector, pUC vector), Lambda phage-derived vectors (replacement and insertion vectors), Cosmids, *in vitro* packaging. Gene cloning: Blunt end and directional.

Unit II: Expression of cloned genes in prokaryotes (13hrs)

Prokaryotic expression vector (pET vector). Bacterial transformation (*E.coli*): Preparation of competent cells ($CaCl_2$ method), selection of the transformants (antibiotic-resistance) and screening (blue/white & by colony PCR). Challenges in the expression of foreign proteins in a heterologous host, Factors affecting the expression: Promoters, Codon usage, Plasmid copy number. Fusion proteins and tagged protein cleavage system. Gene Probe preparation, Use of enzymatic and chemiluminescent methods for the detection of proteins.

Unit III: Cloning and expression in a eukaryotic system (09hrs)

Concept of auxotrophic mutants of yeast (eg. *Saccharomyces cerevisiae*) as cloning host. Cloning vectors (yeast Integrative (yIP), Replicative (yRP) and Episomal (yEP) plasmid, YAC), Shuttle vectors. Expression in eukaryotic cells, screening and selection of recombinants. cDNA cloning.

Unit IV: Applications of Medical Biotechnology (10hrs)

(a) Production of recombinant biopharmaceuticals: Insulin and Factor VIII.

(b) Gene Therapy: Strategies and limitations, Somatic and germline gene therapy, Vectors used in gene therapy (viral and non-viral) and their comparison.

(c) Polymerase chain reaction (PCR): Principle and applications. Importance of RT PCR in diagnosis of infectious diseases.

(d) Biosafety and ethical concerns in medical biotechnology.

Practical (30 hrs)

The below listed practicals are based on a guided project: 'PCR-based gene cloning' where students need to work in a group (4-6 students) to perform *in vivo* gene cloning. For this, any prokaryotic gene of interest may be chosen.

1. Plasmid DNA isolation
2. Designing of gene-specific primers
3. PCR amplification of the desired gene
4. Agarose gel analysis of plasmid DNA and PCR product(s).
5. Restriction digestion of plasmid DNA (vector) and PCR product (insert)
6. Ligation of the insert and vector using T4 DNA ligase
7. Preparation of competent cells (*E.coli*) using the calcium chloride method
8. Transformation of competent bacterial cells with ligation mixture along with suitable controls.
9. Screening of transformants by blue/white selection OR by colony PCR.

Essential Readings

- Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2022). 6th Edition. *Molecular biotechnology: Principles and applications of recombinant DNA.*USA: ASM press, ISBN-978-1-683-6736-8
- Brown, T. A. (2016). 7th Edition. *Gene cloning and DNA analysis: An introduction.* NewYork, USA: John Wiley and Sons, ISBN-978-1-119-07256-0.
- Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. *Principles of gene manipulation and genomics.* Oxford, UK: Blackwell Scientific Publishers. ISBN:978-1405135443.

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Green, M.R. and Sambrook, J.(2012). 4th Edition, (three-volume set). Molecular cloning: A laboratory manual. New York, USA: Cold Spring Harbor Laboratory Press ISBN-13:978-1936113422.

DISCIPLINE SPECIFIC CORE COURSE –15 (BIOMED-DSC-15) HUMAN PATHOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical			
Human Pathology **BIOMED-DSC-15**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The course of Human Pathology will build upon the existing knowledge that the students have gained in physiology, cell biology, immunology to help them understand how alteration of normal state takes place and diseases develop. The curriculum is a systematic presentation of the various internal and external stimuli that initiate pathogenesis of diseases.
- Topics like cellular adaptations, inflammation, repair and hemodynamic disorders would assist students for better understanding of the subject.
- Study of neoplasia and a few infectious and non-infectious diseases would help in understanding and integration of all concepts.

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- Basics of disease in human body
- Adaptation of the human body under stress and injury
- Repair and healing of wounds
- Importance of early detection, diagnosis and treatment in any disease
- Prevention is better than cure and one needs to follow the discipline and healthy lifestyle

SYLLABUS OF BIOMED-DSC-15

Unit-I: Introduction, Cellular Adaptations, Cell Injury and Cell responses (7 hrs)

History of pathology with respect to medical science, basic definitions and familiarization with the common terms used in pathology, Causes and mechanisms of cell injury: reversible and irreversible injury, Overview of pathogenesis (salient steps) and Cellular responses: (subcellular, intracellular and intercellular response, Hyperplasia, Metaplasia, Hypertrophy, Atrophy, dysplasia, Necrosis, Apoptosis) with one example each.

Unit-II: Inflammation and its significance in Diseases (7 hrs)

Hallmarks of Inflammation and why inflammation ensues with suitable examples. General features of acute and chronic inflammation: Vascular changes, cellular events, termination of acute inflammatory response, Molecular mediators of inflammation, morphological effects and outcome of acute inflammation. Systemic effects of inflammation

Unit-III: Hemodynamic Pathology (7 hrs)

Edema, hyperaemia, congestion, hemorrhage, haemostasis and thrombosis, Embolism, Infarction, shock and hypertension.

Unit-IV: Tissue Repair and Remodeling (8 hrs)

Control of cell proliferation, maintenance of cellularity and differentiation, mechanism of tissue and organ regeneration. Wound healing by repair (first and second intention), scar formation and fibrosis, role of extracellular matrix. Angiogenesis and pathological aspects of remodeling (eg Atherosclerosis).

Unit-V: Tumor Pathology and Pathogenesis (8 hrs)

Definitions, nomenclature, characteristics of benign and malignant neoplasms, biology of tumor growth, mechanism of tumor invasion, metastasis cancer progression. Overview of genetic changes in transformed cells and cancer stem cells.

Unit-VI: Pathophysiology of Diseases (8 hrs)

Etiopathogenesis of following diseases: Communicable (Tuberculosis), Non-communicable (CAD, Myocardial Infarction and Asthma, Diabetes).

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.- minimum 8 practicals)

1. Urine Analysis: Gross examination of urine for colour, odor etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Histopathology Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slides.
3. Study of four distinct stages of alcoholic liver disease through permanent slide.
4. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia, cirrhosis
5. Hematological assessment: Study and analysis of a blood report: CBC, KFT, LFT, lipid profile, thyroid profile.
6. Measurement of Erythrocyte Sedimentation Rate.
7. To perform Platelet count and its pathological significance
8. To perform reticulocyte count its pathological significance
9. Study of fractures
10. Diagnostic tests: Detection of various Diseases – Montoux test, CRP, VDRL, RA, Pregnancy (any two)

Essential Readings

- Kumar, V., Abbas, A.K., Aster, J.C. and Fausto, N. (2020). 10th Edition. Robbins and Cotran Pathologic basis of disease. Philadelphia, USA: Saunders Publishers. ISBN 13: 9780323531139.
- Cross, S.S. (2019). 7th Edition. Underwood's Pathology: a Clinical Approach: with STUDENT CONSULT Access ISBN-13: 978-0702072123.
- Sood, R. (2009). 6th Edition Volume 1 and 2. Medical laboratory technology methods and interpretations. India: Jaypee Brothers Medical Publishers. ISBN-13:978-8184484496. There is no recent edition but another book which i have not seen

Suggestive Readings

- Goswami, P; Kalla, A.R; Khatri, K. Dubey, A and Goswami, K. (2022) 1st Edition, Comprehensive Pathology Practical and Technical book , Scientific Publishers. ISBN: 9789392590313

Copstead-Kirkhorn, L. C. (2021). 7th Edition. Pathophysiology. Philadelphia, USA: Saunders. ISBN: 9780323761550