Syllabus template

Semester: 5	
Course : Major	
Paper Title: Advanced Molecular Biology and Microbial Genetics	
Paper code: C3MB230511T	**Credits: 4**
Hours/week : 4	
Category: Core/MDC/SEC/VAC : CORE (Major)	
Theory / Practical / Composite : Theory	
No of Modules : None	

Course Overview: This course provides an in-depth understanding of the molecular mechanisms that regulate gene expression, maintain genome stability, and drive genetic variation in both prokaryotic and eukaryotic systems. It integrates classical genetic experiments with modern molecular insights to build a strong conceptual foundation in molecular genetics and microbial genetics.

Course Outcome:

(CO1): Remember

1. Define transcriptional regulation in prokaryotes and eukaryotes.
2. Recall the operon model proposed by François Jacob and Jacques Monod.
3. List types of mutations, mutagens, DNA damage, DNA repair mechanisms, and transposable elements.
4. Identify mechanisms of horizontal gene transfer (transformation, conjugation, transduction)

(CO2): **Understand**

- Explain mechanisms of gene regulation at transcriptional and translational levels.
- Describe RNA processing events and RNA interference.
- Summarize plasmid replication and maintenance systems.
- Discuss the significance of classical experiments such as the Luria–Delbrück experiment and mutagen detection using the Ames test.

(CO3): **Apply**

- Apply principles of gene regulation to interpret gene expression patterns.
- Demonstrate how different mutations influence phenotype.
- Apply knowledge of DNA repair pathways to specific types of DNA damage.
- Use concepts of horizontal gene transfer and transposition in microbial genetics applications.

(CO4): **Analyze**

- Differentiate between prokaryotic and eukaryotic gene regulation mechanisms.

- Compare types of mutations and DNA repair systems.
- Analyze mechanisms of generalized vs. specialized transduction and replicative vs. non-replicative transposition.
- Examine regulatory networks controlling gene expression.

(CO5): **Evaluate**

- Evaluate the biological significance of regulatory mechanisms in cellular adaptation.
- Assess experimental data from mutation and gene transfer studies.
- Critically evaluate the role of DNA repair systems in genome stability.
- Judge the impact of transposable elements on genome evolution.

(CO6): **Create**

- Design experiments to study gene regulation and mutation detection.
- Propose genetic engineering strategies using plasmids and transposons.
- Develop conceptual models explaining regulatory pathways in cells.

Prerequisites: ***Basic knowledge about any prior course***

SYLLABUS

UNIT/Module	CONTENT	HOURS or NUMBER OF CLASSES	CO Mapping	COGNITIVE LEVEL
I.	**Transcriptional Regulation in Prokaryotes:** Principles of transcriptional regulation, Operon model of Gene regulation, Activators and repressors, Two component regulatory systems, Alternative sigma actors, Specific versus Global control of gene Expression	**6**	**CO1,CO2,CO3,CO4**	**K1,K2,K3,K4**
II.	**Transcriptional Regulation in Eukaryotes:** Specific transcription factors, Mediator complex, enhancers, Insulators, Negative regulation of Transcription in eukaryotes by modification of histones and DNA. Brief idea about Eukaryotic	**12**	**CO1,CO2,CO4,CO5**	**KI,K2,K4,K5**

	Post-transcriptional mRNA Processings (Capping, Polyadenylation, Spliceosome-mediated Splicing, RNA editing), miRNA, Proteasomal degradation of Proteins.			
III.	**Regulation at the level of RNA:** Regulatory proteins causing Translation activation and repression, Regulation of Translation by Antisense RNA, Regulation by alteration of Ribosomes, RNA interference (RNAi), Riboswitches-RNA acting directly as a control mechanism	**5**	**CO1,CO2,CO4,CO5**	**K1,K2,K4,K5**
IV.	**Horizontal gene transfer: Plasmids:** Replication and copy number, control mechanism, mechanism to prevent curing of plasmid, partitioning systems of plasmids. **Transformation:** Discovery and molecular mechanism of natural transformation and artificial transformation. **Conjugation:** Hfr and F' strains, Interrupted Mating **Transduction:** Generalized and Specialized Recombination repair, SOS repair.	**10**	**CO1,CO2,CO3, CO4,CO5,CO6**	**K1,K2,K3, K4,K5,K6**
V.	**Mutations, DNA damage and repair** Mutations and mutagenesis: Definition, types and molecular basis of Mutations; Luria Delbruck experiment and Replica plating technique, Different types of mutants (absolute, conditional, lethal, leaky, Functional mutants - loss and gain of function mutants); Physical (heat, UV	**8**	**CO1,CO2,CO3, CO4,CO5,CO6**	**K1,K2,K3, K4,K5,K6**

	and X radiation) and chemical mutagens (base analogue, alkylating and deaminating agent) Uses of mutations, Reversion (true revertants) and suppression (Intra- and inter-genic suppression); detection of mutagen- Ames test; Mutator genes. DNA damage-Depurination, deamination, crosslinking. DNA repair-Photorepair, alkyltransferase, Base Excision and Nucleotide excision repair, Mismatch repair, Recombination repair, SOS repair.			
VI.	**Unit 6: Transposable elements** Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Eukaryotic transposable elements– Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds) Uses of transposons and transposition	**4**	**CO1,CO3, CO5,CO6**	**K1,K3,K5,K6**
Text Books				
1. Molecular Genetics of Bacteria Larry Snyder				
2. Molecular Biology by Clark				
3. Molecular Biology of the Gene Watson				
Suggested readings				
1. Powerpoint slides and teaching videos given in the class				
Web Resources				
1. Swayam course on Molecular Biology by Dr Mahashweta Mitra Ghosh				
Evaluation Theory CIA: 30 Semester Exam:70				
Paper Structure for Theory Semester Exam: Full marks 70 Short questions: 10 (each 2 marks) from 12 (10x2=20) Long questions: 5 (each 10 marks) from 7 (5x10=50)				

Course outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive levels
CO1	**Remember :** 1. Define transcriptional regulation in prokaryotes and eukaryotes. 2. Recall the operon model proposed by François Jacob and Jacques Monod. 3. List types of mutations, mutagens, DNA damage, DNA repair mechanisms, and transposable elements. 4. Identify mechanisms of horizontal gene transfer (transformation, conjugation, transduction)	K1
CO2	**Understand** 1. Explain mechanisms of gene regulation at transcriptional and translational levels. 2. Describe RNA processing events and RNA interference. 3. Summarize plasmid replication and maintenance systems. 4. Discuss the significance of classical experiments such as the Luria–Delbrück experiment and mutagen detection using the Ames test	K2
CO3	**Apply** 1. Apply principles of gene regulation to interpret gene expression patterns. 2. Demonstrate how different mutations influence phenotype. 3. Apply knowledge of DNA repair pathways to specific types of DNA damage. 4. Use concepts of horizontal gene transfer and transposition in microbial genetics applications	K3
CO4	**Analyze** 1 Differentiate between prokaryotic and eukaryotic gene regulation	K4

	mechanisms. 2 Compare types of mutations and DNA repair systems. 3 Analyze mechanisms of generalized vs. specialized transduction and replicative vs. non-replicative transposition. 4 Examine regulatory networks controlling gene expression.	
CO5	**Evaluate** 1. Evaluate the biological significance of regulatory mechanisms in cellular adaptation. 2. Assess experimental data from mutation and gene transfer studies. 3. Critically evaluate the role of DNA repair systems in genome stability. 4. Judge the impact of transposable elements on genome evolution.	K5
CO6	**Create** 1. Design experiments to study gene regulation and mutation detection. 2. Propose genetic engineering strategies using plasmids and transposons. 3. Develop conceptual models explaining regulatory pathways in cells.	K6