

CHAPTER 18

REGULATION OF GENE EXPRESSION

Learning objectives

Bacterial Regulation of Transcription

1. Briefly describe two main strategies that cells use to control metabolism.
2. Explain the adaptive advantage of bacterial genes grouped into an operon.
3. Using the *trp* operon as an example, explain the concept of an operon and the function of the operator, repressor, and corepressor.
4. Explain how repressible and inducible operons differ and how those differences reflect differences in the pathways they control.
5. Describe how the *lac* operon functions and explain the role of the inducer, allolactose.
6. Distinguish between positive and negative control. Give examples of each from the *lac* operon.
7. Explain how cyclic AMP and catabolite activator protein are affected by glucose concentration.

Regulation of Eukaryotic Gene Expression

8. Define differential gene expression. At what level is gene expression generally controlled?
9. Distinguish between heterochromatin and euchromatin.
10. Explain how DNA methylation and histone acetylation affects chromatin structure and the regulation of transcription.
11. Define epigenetic inheritance.
12. Describe the role of the transcription initiation complex.
13. Define control elements and explain how they influence transcription.
14. Distinguish between general and specific transcription factors.
15. Explain the role of promoters, enhancers, activators, and repressors in transcriptional control.
16. Explain how eukaryotic genes can be coordinately expressed. Describe an example of coordinate gene expression in eukaryotes.
17. Describe the process and significance of alternative RNA splicing.
18. Describe the processing of pre-mRNA in eukaryotes.
19. Describe factors that influence the lifespan of mRNA in the cytoplasm. Compare the longevity of mRNA in prokaryotes and eukaryotes.
20. Explain how gene expression may be controlled at the translational and post-translational level.

The Roles of Noncoding RNAs

21. Describe the formation of microRNAs (miRNAs).
22. Distinguish between small interfering RNAs (siRNAs) and miRNAs.
23. What is the evolutionary significance of cellular RNA interference (RNAi) pathways?
24. Describe the role of siRNAs in the formation of yeast centromeric heterochromatin.

Cell Differentiation and Embryonic Development

25. Name three interrelated processes that are responsible for embryonic development.
26. Distinguish between determination and differentiation. Explain why determination precedes differentiation.
27. Describe the molecular basis of determination.
28. Explain the relationship between differentiation and differential gene expression.
29. Describe the two sources of information that instruct a cell to express genes at the appropriate time.
30. Describe the role of *myoD* in skeletal muscle development.

Genetic and Cellular Mechanisms of Pattern Formation

31. Describe how *Drosophila* was used to investigate the basic aspects of pattern formation (axis formation and segmentation).
32. Explain how maternal effect genes affect polarity and development in *Drosophila* embryos.
33. Describe how morphogen gradients may specify the axes of developing *Drosophila* embryos.

Molecular Biology of Cancer

34. Distinguish between proto-oncogenes and oncogenes. Describe three genetic changes that can convert a proto-oncogene to an oncogene.
35. Explain how mutations in tumor-suppressor genes can contribute to cancer.
36. Explain how excessive cell division can result from mutations in the *ras* proto-oncogene.
37. Explain why a mutation knocking out the *p53* tumor suppressor gene can lead to excessive cell growth and cancer. Describe three ways that *p53* prevents a cell from passing on mutations caused by DNA damage.
38. Describe the set of mutations typically associated with the development of cancer.
39. Explain how inherited cancer alleles can lead to a predisposition to certain cancers.
40. Explain how viruses can cause cancer. Name a tumor virus.