Knowledge-based Learning Outcomes

Upon completion of *Gene Regulation Explored*, students should be able to:

1. Compare and contrast the definitions of operon and gene.
2. Explain the key steps in gene expression in a prokaryotic operon (transcription, translation), including the roles of actors and products in each step.
3. Distinguish between conditional and constitutive gene expression, including how cells benefit from conditional expression by avoiding the expense of making unnecessary products.
4. Explain that a benefit of transcriptional control is that the cell avoids making mRNA that won't be used.
5. Explain why *E. coli* metabolize lactose last if carbon sources such as glucose are available.
6. Explain that in repression, a repressor binds to an operator to block the attachment of RNA polymerase to the promoter, effectively turning off transcription.
7. Describe how the products of the *lacZ*, *lacY*, and *lacI* genes help a cell metabolize lactose.
8. Differentiate between weak and strong promoters.
9. Explain that during activation, an activator binds to the activator site, which effectively changes a weak promoter to a strong promoter, thereby increasing transcription.
10. Explain how ligands (such as lactose and cAMP) can affect the binding of repressor to operator, or of activator to activator site.
11. Explain why, in the *lac* operon, repression will "win" over activation when both are in play.
12. For the *lac* operon, given the relative availability of both lactose and cAMP, identify which proteins will be bound to which regulatory sequences, and predict the level of *lacZY* expression (e.g., when lactose is absent and cAMP low: repressor is bound, activator is not bound, and *lacZY* expression is very low).
13. Describe mutations as changes to the DNA sequences that can alter regulatory sequences and regulatory protein function.
14. Explain why most genes are regulated.

Skills-based Learning Outcomes

Upon completion of *Gene Regulation Explored*, students should be able to:

1. Guide a prokaryotic cell through the process of expressing the genes in an operon.
2. Given the function of a gene product in a cell, predict whether the gene should be expressed conditionally or constitutively, and if conditionally, under what general conditions expression should occur.
3. Predict whether an operon will be transcribed when a repressor and/or activator is bound or not bound to the DNA.
4. Diagram and label the key molecules and DNA regions involved in negative and positive control of a generic gene.

5. Outline (with words and/or drawings) how transcription of the *lac* operon is regulated, and under what conditions, including labeling or describing each component of the genetic system.
6. Predict the effects of various perturbations or mutations on the *lac* operon, such as loss of promoter/operator/activator site or repressor/activator, explaining how gene expression will be altered and identifying possible consequences to the cell.
7. Given a change to the expression of the *lac* operon (such as: genes are always expressed), identify possible perturbations that could produce the behavior.
8. Co-opt the *lac* operon to perform virtual genetic engineering, designing a system that allows expression of an additional gene or genes under specific conditions (e.g., expressing HGH or GFP/RFP when lactose is present).
9. Given a regulatory protein's observed effect on a cell, deduce whether the protein is involved in activation or repression.
10. Given information about a desired gene expression behavior (such as: express gene X when factor Y is present), deduce whether a cell should use activation, repression, or both, in order to conserve its resources.