**Gene Regulation Learning Objectives**

1. **Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.**

a. Observable cell differentiation results from the expression of genes for tissue specific proteins.

b. Induction of transcription factors during development results in sequential gene expression.

1. Homeotic genes are involved in developmental patterns and sequences.
2. Embryonic development requires the correct timing of events and gene expression.
3. Temperature and the availability of water determine seed germination in most plants.
4. Genetic mutations can result in abnormal development.
5. Genetic transplantation experiments support the link between gene expression and normal development.
6. Genetic regulation by microRNAs plays an important role in the development of organisms and the control of cellular functions.

c. Programmed cell death (apoptosis) plays a role in the normal development and differentiation. For example:

• Morphogenesis of fingers and toes

• Immune function

***X Names of the specific stages of embryonic development are beyond the scope of the course and the AP Exam.***

1. **Gene regulation results in differential gene expression, leading to cell specialization.**

a. Both DNA regulatory sequences, regulatory genes, and small regulatory RNAs are involved in gene expression.

1. Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription. For example:

• Promoters

• Terminators

• Enhancers

1. A regulatory gene is a sequence of DNA encoding a regulatory protein or RNA.

b. Both positive and negative control mechanisms regulate gene expression in bacteria and viruses.

1. The expression of specific genes can be turned on by the presence of an inducer.
2. The expression of specific genes can be inhibited by the presence of a repressor.
3. Inducers and repressors are small molecules that interact with regulatory proteins and/or regulatory sequences.
4. Regulatory proteins inhibit gene expression by binding to DNA and blocking transcription (negative control).
5. Regulatory proteins stimulate gene expression by binding to DNA and stimulating transcription (positive control) or binding to repressors to inactivate repressor function.
6. Certain genes are continuously expressed; that is, they are always turned “on,” e.g., the ribosomal genes.

c. In eukaryotes, gene expression is complex and control involves regulatory genes, regulatory elements and transcription factors that act in concert.

1. Transcription factors bind to specific DNA sequences and/or other regulatory proteins.
2. Some of these transcription factors are activators (increase expression), while others are repressors (decrease expression).
3. The combination of transcription factors binding to the regulatory regions at any one time determines how much, if any, of the gene product will be produced.

d. Gene regulation accounts for some of the phenotypic differences between organisms with similar genes.

1. **A variety of intercellular and intracellular signal transmissions mediate gene expression.**

a. Signal transmission within and between cells mediates gene expression. For example:

• Cytokines regulate gene expression to allow for cell replication and division.

• Mating pheromones in yeast trigger mating gene expression.

• Levels of cAMP regulate metabolic gene expression in bacteria.

• Expression of the SRY gene triggers the male sexual development pathway in animals.

• Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen.

• Gibberellin hormone and seed germination.

1. **Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.**

a. Differentiation in development is due to external and internal cues that trigger gene regulation by proteins that bind to DNA.

b. Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type.

c. Environmental stimuli can affect gene expression in a mature cell.