**Gene Expression**

**I. Introduction**

Gene expression is the process by which information from a [gene](https://en.wikipedia.org/wiki/Gene) is used in the synthesis of a functional [gene product](https://en.wikipedia.org/wiki/Gene_product). These products are often [proteins](https://en.wikipedia.org/wiki/Protein). The process of gene expression is used by all known life—[eukaryotes](https://en.wikipedia.org/wiki/Eukaryotes) (including [multicellular organisms](https://en.wikipedia.org/wiki/Multicellular_organisms)), [prokaryotes](https://en.wikipedia.org/wiki/Prokaryotes) ([bacteria](https://en.wikipedia.org/wiki/Bacteria) and [archaea](https://en.wikipedia.org/wiki/Archaea)), and utilized by [viruses](https://en.wikipedia.org/wiki/Virus) - to generate the [macromolecular](https://en.wikipedia.org/wiki/Macromolecule) machinery for life.

In [genetics](https://en.wikipedia.org/wiki/Genetics), gene expression is the most fundamental level at which the [genotype](https://en.wikipedia.org/wiki/Genotype), *i.e.* letter designation, gives rise to the [phenotype](https://en.wikipedia.org/wiki/Phenotype), *i.e.* observable trait. The genetic information stored in [DNA](https://en.wikipedia.org/wiki/DNA) represents the genotype, whereas the phenotype results from the "interpretation" of that information. Such phenotypes are often expressed by the synthesis of proteins that control the organism's structure and development, or that act as [enzymes](https://en.wikipedia.org/wiki/Enzyme) catalyzing specific metabolic pathways.

All steps in the gene expression process may be regulated, including the [transcription](https://en.wikipedia.org/wiki/Transcription_(biology)), [RNA splicing](https://en.wikipedia.org/wiki/RNA_splicing), [translation](https://en.wikipedia.org/wiki/Translation_(biology)), and [post-translational modification](https://en.wikipedia.org/wiki/Post-translational_modification) of a protein. [Regulation of gene expression](https://en.wikipedia.org/wiki/Gene_regulation) gives control over the timing, location, and amount of a given gene product present in a cell and can have a profound effect on the cellular structure and function.

In this computer simulation you will explore how gene expression is regulated at the levels of transcription and translation.

**II. Procedure**

1. Start the activity by going to the following website :

<https://phet.colorado.edu/en/simulation/gene-expression-essentials> .

2. **Part I** : Click on the box that says “Expression”. You are presented with a gene that contains

a regulatory region and a transcribed region. Your goal is to produce 5 proteins from each of

three genes. The proteins are indicated by the shapes in the box at the top right. You need to

successfully transcribe each gene, and then translate the message from the gene into a protein

using your knowledge of how these processes work.

a. What two components are required to initiate transcription of the gene? To which

region of the gene do they bind?

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b. What is the product of successful transcription of Gene 1?

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c. What component is necessary to produce a protein from the transcript?

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Suppose Gene 1 produces a protein involved in the development of the eye. In the

simulation, what are two ways that you can prevent production of Gene 1 protein in other

parts of the body?

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a. At what points in the progression from gene to protein do these methods act (i.e., what

processes do they prevent)?

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b. How does initiation of transcription differ in Gene 2 and Gene 3 as compared to Gene 1?

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3. **Part II** : Click on the box that says “mRNA”. You are presented with a gene that contains a

regulatory region and a transcribed region. Your goal is to maximize the rate of transcription

of the gene into mRNA.

a. What three factors maximize the rate of transcription from the gene?

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Click on the check box on the bottom right. Increase the concentration and affinity of negative

transcription factors to high, while decreasing the concentration and affinity of positive

transcription factors to low. What effect does this have on the rate of transcription?

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4. **Part III** : Click on the box that says “Multiple Cells”. You are initially presented with a

single *E. coli* cell that has had the gene for green fluorescent protein (GFP) inserted into its

genome. This protein, when present in the cell, causes the bacterial cell to glow green under

UV light.

a. Move the slider on the bottom from “one to “many” cells. Are all of the cells flashing

the same way? If not, what might explain any variation observed. Give two

possibilities.

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Click on the + signs in each box on the right. Your goal is to make the cells as green as possible

by maximizing production of GFP. What change can you make to each of the following to

maximize expression of the GFP gene?

a. Positive Transcription Factor Concentration :

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b. mRNA Destroyer (exonuclease) Concentration :

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c. Positive Transcription Factor Affinity for the Gene Regulatory Sequence :

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d. RNA Polymerase Affinity for the Gene Regulatory Sequence :

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e. Protein Degradation :

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**III. Analysis & Conclusions**

**1. Why is it important to destroy the mRNA after making sufficient amount of protein?**

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**2. How will the positive and negative transcription factor help maintain the homeostasis of**

**the body system. Explain with an example.**

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**3. Give an example a situation where gene expression without regulation could potentially**

**harm the organism.**

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