

Lesson for [Gene Machine: The Lac Operon](http://phet.colorado.edu)- Brief Inquiry activity

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From the Design doc: The Lac Operon simulation will provide students with a realistic interactive model of the bacterial lac operon. The lac operon is a set of genes which are responsible for the production of enzymes important for regulating the import and utilization metabolism of lactose by some bacterial cells, for example E.coli. The simulation is designed to mimic the cellular systems that control this operon and ultimately control the production of the enzymes and lactose metabolism. The simulation will also allow students to explore the effects of mutations within the operon and other related genes. The lac operon is used extensively across post-secondary biology curricula as a starting point for instruction in gene regulation (the control systems used by the lac operon are considered to relatively non-complex). As such, the concepts that are learned by studying the lac operon are used as key concepts in understanding more complex gene regulation systems.

Gene Machine: The Lac Operon Sim Description: Build a gene network! The lac operon is a set of genes which are responsible for the metabolism of lactose in some bacterial cells. Explore the effects of mutations within the lac operon by adding or removing genes from the DNA.

Learning Goals: Students will be able to:

- Predict the effects on lactose metabolism when the various genes and DNA control elements are mutated (added or removed).
- Predict the effects on lactose metabolism when the concentration of lactose is changed.
- Explain the roles of LacI, LacZ, and LacY in lactose regulation.
- Use evidence to defend their ideas.

Teacher notes: I am not a biologist or a biology teacher. I wanted to provide a structure for an inquiry activity that leverages the learning goals and description provided for the sim and the interactive engagement of the PhET sims in general. This is a lesson that invites students to investigate the sim and the models shown to make sense, explain their ideas about the model, and describe their reasoning. The simulation was designed for undergraduate biology students (which have met a prerequisite of high school biology), so there is a preconception that students understand some basics of reproduction, but do not understand the underlying molecular models. I found useful information at http://en.wikipedia.org/wiki/Lac_operon (accessed 8/11/12). Interviews showed that undergraduate students could build an understanding using the sim. You may want to have students start with more simple systems by doing activities about [Membrane Channels](#) or [Neurons](#) to develop ideas about molecular models for biological systems. Using the sim could be assigned for homework.

Lesson:

1. Facilitate a class discussion before using the sim. *Here are some ideas that I might use:*

Say: What do you understand about cells regulate chemicals like lactose? *Students should be encouraged to describe their ideas in an informal fashion using their own words not scientifically. For example, they could discuss in small groups and share out or if the class is small allow students to share large group. I would ask them to illustrate their ideas as well. You might prompt them some more with "How do substances interact with a gene on a DNA to change how the cell behaves?"*

2. Introduce the sim activity: Say something like "We want to learn more about the underlying models by using the lac operon which is a set of genes responsible for the production of enzymes important for regulating the import and utilization metabolism of lactose by some bacterial cells." And "Lac operon is a classic reaction because the sugar causes the cell to change."

3. Students use the sim: Then, have the students play with the sim and tell them to write their ideas about the learning goals (you could make copies of the goals or have them projected) and encourage them to use illustrations. Students might prepare a presentation instead of turning the assignment in. Have them use the sim during their presentation to help explain their ideas.

Post-Lesson: Have a class discussion and encourage the students to use the sim. Maybe have students come up to the projected computer.