Name **MASTER**

The Lac Operon Modeling Lab

The **Lac Operon** simulation will provide you 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 proteins (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 you 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. Using ctrl and the link below, you can open up the Java script for the lab. You can also go to the "Homework Board" under the ECE Biology tab on the class website and click on the embedded script.

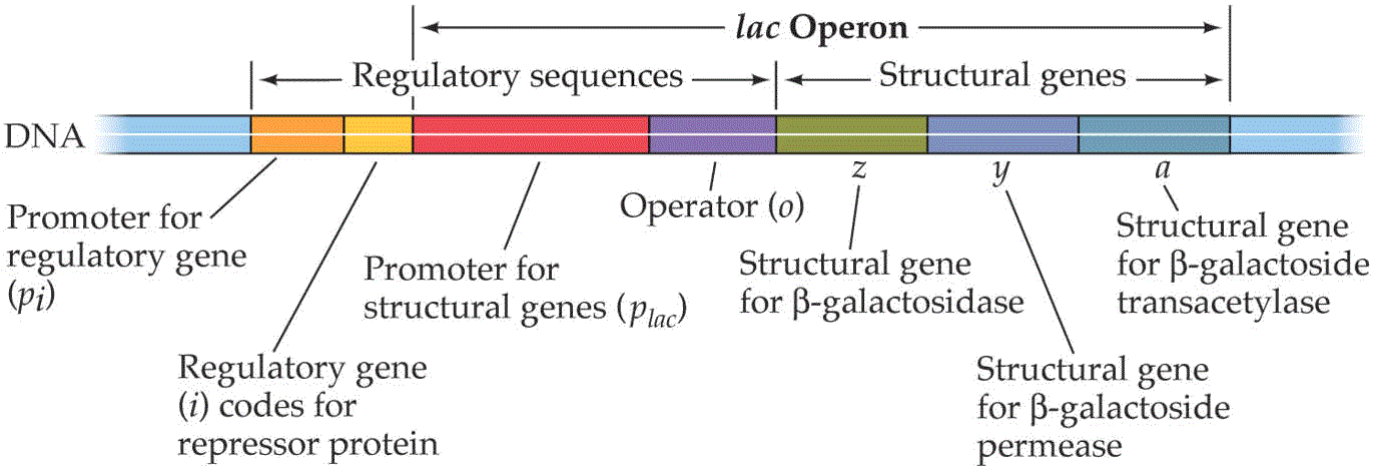
Gene Machine: The Lac Operon

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 your ideas.

lac Operon Simulation



Part I. Function of Each Part

(please note the names of each part may be different between the picture above and the simulation)

a. Promoter for regulatory gene/*lacI* gene

b. Regulatory gene/*lacI* gene

c. Repressor protein/LacI

d. Promoter for structural genes

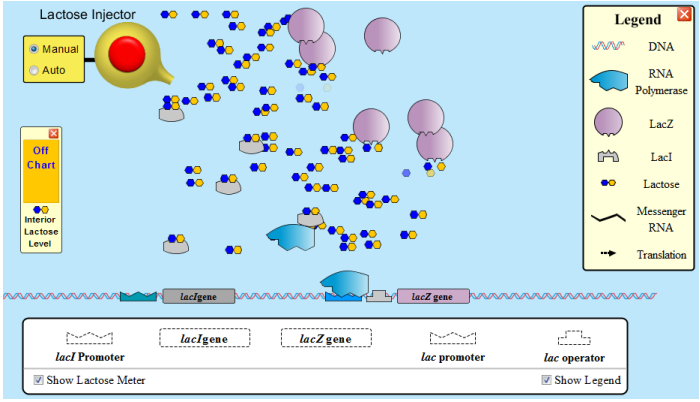
e. Operator for structural genes

f. lacZ gene

g. LacZ protein

h. lacY gene

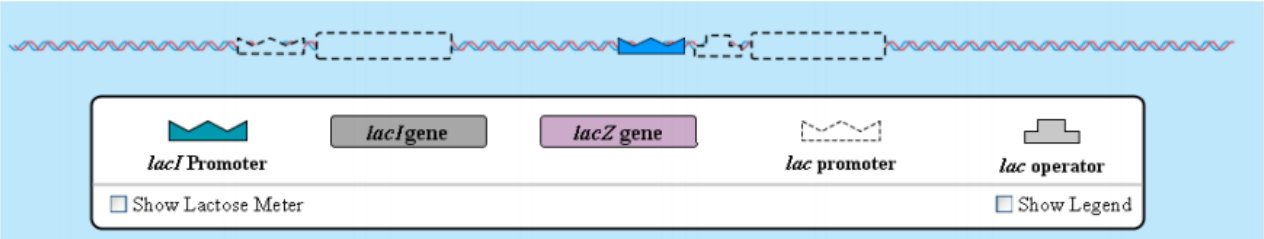
i. LacY protein



Lac Operon ECE Biology PhET Simulation

The goal of this simulation is to help you understand how prokaryotes (note that this is for prokaryotes and NOT eukaryotes) control gene expression. Specifically, this activity will simulate an inducible operon called the lac operon used to control the expression of genes that control lactose levels in bacteria. Again, this is for bacteria only and has nothing to do with lactose catabolism or lactose intolerance in humans.

Directions: Now that you've experimented with the simulation, tie it all together by following the steps below and answer the questions you see at each step. If you need the PowerPoint to help, regulate yourself!!



1. On the screen you should see two floating blue molecules, these are RNA polymerase. There is also an incomplete DNA gene beneath them. You can turn on the legend in the lower right and that will help you identify the molecules. Click the "show legend" box in the lower right.

2. Drag the lac promoter into place. What happens to the RNA polymerase? Are any new molecules created?

3. Drag the lacZ gene into place. What happens? What molecule is represented by the black line? What is the name of the process that converts the lacZ DNA gene to the black line?

4. Eventually, arrows appear from the black line and purple circles appear from it. What type of molecules do the purple spheres represent? What is the name of the process that converts the black line to the purple spheres?

5. Turn the lactose injector onto “Auto” mode. What happens to the lactose? Can it enter the cell?

6. Drag the lacY gene into place. What happens to the lacY protein? What is the role of the lacY protein?

7. Now that lacY is letting lactose into the cell, we can see the function of lacZ. What happens to the lactose once it is inside of the cell? What is the function of lacZ?

Part 2 - Simulating how Gene Expression can be turned off and on

8. Drag the lac operator into place. Does anything happen because of it?

9. Switch the lactose injector to “Manual” mode and wait for all lactose to disappear. Drag the lacI promoter into place. Can the RNA polymerase bind both promoters? Is the RNA polymerase able to make the lacI gene now?

10. Drag the lacI gene into place. Does this allow for the creation of new proteins? To what does the lacI protein bind to? What effect does the lacI gene have on transcription of the LacZ and LacY genes?

11. Remove the lac operator. Wait for LacY to return to the membrane. Turn the lactose injector onto “Auto” mode and wait for lactose to enter the cell. Drag the lac operator back into place. What happens now to the LacI protein? Does the presence of lactose in the cell alter its ability to repress translation?

12. If the lacZ protein breaks down lactose, is it worthwhile to make it when there is no lactose around? How does the bacteria use this system to efficiently control the production of the lacZ protein?