**Part 1 - Simulating how Gene Expression works**

1. Google “phet gene machine”. Open the flash program. **Click on the “Lactose Transport” tab on the top of the simulation.**
2. 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.
3. Drag the lac promoter into place. What happens to the RNA polymerase? Are any new molecules created?
4. 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?
5. 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?
6. Turn the lactose injector onto “Auto” mode. What happens to the lactose? Can it enter the cell?
7. Drag the lacY gene into place. What happens to the lacY protein? What is the role of the lacY protein?
8. 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**

1. Drag the lac operator into place. Does anything happen because of it?
2. 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?
3. 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?
4. 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?
5. 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?