Modeling Prokaryotic Operons

Adapted from AP® Biology Daily Lesson Plans by Kristen Dotti

Gene regulation can be a difficult topic to understand because the control mechanisms are too small to visualize. It may be easier for your students to compare different modes of gene suppression and gene induction if they build models of these processes.

Materials:

- 2 Styrofoam® Water "Noodles"
- Construction Paper
- 1 Wire Coat Hanger
- Wire Cutters
- 2 Tennis Balls
- Stick-On Velcro® Tabs

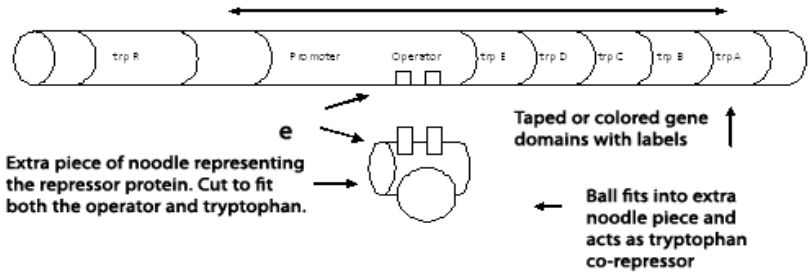
Pre-Lab Questions:

1. State the function of the operator.
2. Name the specific organism we use to study the *lac* and *trp* operons.
3. What does it mean when an operon is said to be "repressible"?
4. Are operons examples of positive feedback or negative feedback?

Procedures:

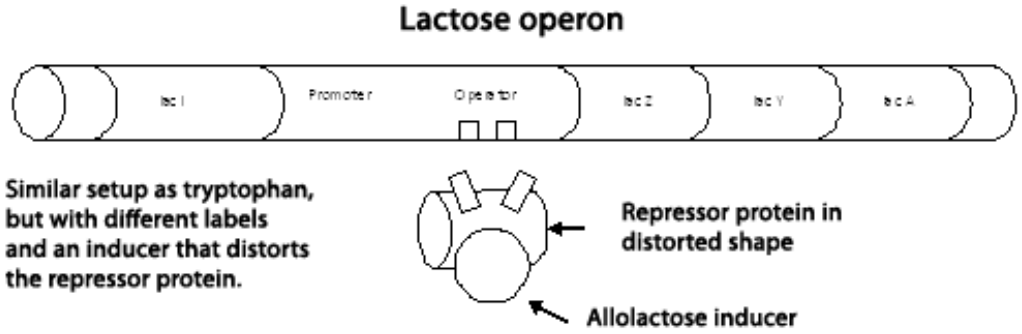
1. Make a model of a repressible operon and an inducible operon using the above supplies and the following sample diagrams of a prokaryotic tryptophan operon and a prokaryotic lactose operon.
2. For the repressible operon, use the prokaryotic tryptophan operon as an example:

Tryptophan operon



a. Using a serrated knife, cut an 8-inch segment from the first noodle (the following steps all apply to this noodle). This segment will be used as the repressor protein.
b. Each end of the noodle/operon should feature an unlabeled section to show the continuation of the DNA strand.
c. Wrap spirals of colored construction paper where each of the 5 gene domain regions would be found (trp E, trp D, trp C, trp B , and trp A), using a different color for each gene domain.
d. Wrap spirals of colored construction paper where to identify the regulatory gene (trp R) region as far upstream of the promoter region as possible.
e. Using a Sharpie®, draw the shape of the active form of the repressor protein onto the lower portion of the noodle/operon, in the operator region. (See e in the diagram on the previous page.) Make the shape simple, like the one in the diagram, since you will need to carve it out using a serrated knife. Also, carve a matching shape into the regulatory repressor protein piece that you cut off in step a above.
f. On the bottom side of the repressor protein, carve a U and wedge the racquet/tennis ball into the U.
g. Cut a piece of wire from a coat hanger and shove the wire into the repressor protein and bend the repressor protein into a shape so that it will not fit the co-repressor (tryptophan) is not in place.
h. Write the word "tryptophan" on one of the tennis balls (use tape to label the ball). Write "repressor protein" on the carved foam piece (use tape to label the piece). Now label the various parts of the noodle/operon using tape: "trp R," "promoter/operator," "trp E," "trp D," "trp C," "trp B," and "trp A."
i. Place stick-on Velcro® tabs on the parts of the operator and the repressor protein that fit together, so that they can stick together without being held in place. You may do the same for the repressor and the co-repressor/tryptophan ball.

3. For the inducible operon, use the prokaryotic lactose operon as an example:



   a. Using a serrated knife, cut an 8-inch segment from the second noodle (the following steps all apply to this noodle). This will be used as the repressor protein.
   b. Again, each end of the noodle/operon should feature an unlabeled section, to show the continuation of the DNA strand.
   c. Wrap spirals of colored construction paper where each of the 3 gene domain regions would be found (lac Z, lac Y, and lac A), using a different color for each gene domain.
   d. Wrap spirals of colored construction paper to identify the regulatory gene (lac I) region, which is immediately upstream of the promoter region.
   e. Using a Sharpie®, draw the shape of the active form of the repressor protein onto the lower portion of the noodle in the operator region. Make the shape simple, like the one in the diagram, since you will need to carve it out using a serrated knife. Also, carve a matching shape into the regulatory repressor protein piece that you cut off in step a above.
   f. On the bottom side of the repressor protein, carve a wide, semicircle shape that is a little too wide to accommodate the tennis ball. You want the repressor protein to have 2 shapes, one that fits the operator shape perfectly when the inducer is NOT present and one that distorts the repressor so that the carved top shape appears to pop out of the operator when the inducer fits into the bottom (you can shove a piece of coat hanger wire into the repressor to make it hold 2 different shapes).
   g. Write “allolactose” on one of the tennis balls (use tape to label the ball). Write “repressor protein” on the carved foam piece. Write “lac I,” “promoter/operator,” “lac Z,” “lac Y,” and “lac A” at the appropriate places along the noodle.
   h. You may place stick-on Velcro® tabs on both the operator and repressor protein parts so that they can stick together without being held in place. You may do the same for the repressor and the co-repressor/allolactose ball.
4. Sketch both models in your lab notebook (sketches should be neat, colored and labeled).

Post-Lab Questions:

1. In the *lac* operon, is the repressor active or inactive when lactose is present?
2. In the *trp* operon, is the repressor active or inactive when tryptophan is present?
3. What is the product of the *trp* operon? The *lac* operon?
4. What is more common for each type of operon−the gene nonrepressed state or repressed state?

Analysis/Reflection:

A difference between prokaryotes and eukaryotes is seen in the organization of their genetic material.

(a) **Discuss** the organization of the genetic material in prokaryotes and eukaryotes.

(b) **Contrast** the following activities in prokaryotes and eukaryotes:

- Replication of DNA
- Transcription or translation
- Gene regulation
- Cell division