

The *lac* operon model

<https://stembuild.ncsu.edu/resource/microbial-genetics-the-lac-operon/>

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MATERIALS NEEDED

- Printer: Lulzbot Mini or similar
- Filament: PLA 2.85mm or appropriate filament for your printer/nozzle. You may wish to use three different colors (one for both parts of the DNA operon box - we used grey, one for the RNA polymerase top - we used red, and one for the RNA polymerase bottom - we used white).
- Items to 3D print
 - 2 x Top of DNA box
 - 2 x Bottom of DNA box
 - RNA Polymerase top
 - RNA Polymerase bottom
- 10mm Mini Vibration Motor with wire leads or light (1 per model)
- 10mm ceramic disc magnets (2 per model)
- CR2032 3 volt battery and its respective holder (1 per model)
- Thin conductive wire for lead connection
- 4-40 x 1/2 Socket Head Cap Screw (McMaster 92196A110) (2 per model)
- Magnetic marbles $\frac{5}{8}$ " diameter (1 per model)
- 1" foam cubes (2 per model)
- Conductive thread (~12 inches per model)
- Hot glue gun
- Wire clippers
- Needle nose pliers
- Label maker and adhesive label tape
- Sharpies

PRINTING INSTRUCTIONS

- Collect the materials necessary for 3D printing:
 - Filament
 - 3D printer
 - Laptop
- Follow the standard procedures for your Makerspace/your printer to print each of the four parts of the model: the RNA polymerase top and bottom, the DNA operon box top and bottom. We recommend printing the box top upside down (inside facing upwards) with supports so any elephant foot effect that happens doesn't interfere with the fit of the boxes. The bottom boxes

should be printed bottom down for this same reason.

- Suggested settings:
 - Infill: 20%
 - Supports: 15%

ASSEMBLY INSTRUCTIONS: RNA polymerase



- Print RNA polymerase top and bottom as described in print instructions.
- Collect RNA polymerase supplies needed - battery, battery holder, thin conductive wire, screws, needle nose pliers.
- Wrap wire around the battery leads, and place the battery in the holder. Alternatively, battery holders with wire leads already attached can also be purchased.
- Place the screws through the plastic plate from the rounded side through to the flat side. Wrap the wires around the length of the screw to secure the battery holder to the flat side of the plate.



- Pop the plastic plate onto the bottom on the RNA polymerase top.

ASSEMBLY INSTRUCTIONS: *lac* operon boxes



lac operon promoter region sequence:

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CCAGGCTTTTACACTTTCTGCTTCCTTCGTT
ATGTTGTCGGATTGTGAGCGGATAACAA
TT
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Notes: -35/-10 sequences are underlined, +1

DNA box 1 - *lac* promoter region

- Print DNA operon box top and bottom as described in print instructions.
- Place the operon box top face down, as shown in the image. Note that the box top has 9 tiles.
- Obtain about 6 inches of conductive thread and wrap thread around each individual tile on the DNA top. After wrapping each tile with thread, tie off with a knot and cut off any excess thread. Note: make sure you thread on the bottom of the DNA top so thread strands are not exposed to the top track.
- Tiles 3 and 7 are the contact points for the RNA polymerase. The conductive thread wrapped around these tiles will contact the vibration motor wire.
- Strip the ends of the vibration motor wire leads using wire clippers.
- Insert the stripped red wire into the wrapped conductive thread on tile 3, and the stripped black wire into the wrapped conductive thread on tile 7.
- Hot glue magnet onto the furthest tile from the black wire.
- Snap pieces together and test by running RNA polymerase along the track. The motor should vibrate when the RNA polymerase contacts tiles 3 and 9. If it does not, check and adjust wiring as necessary.

is bolded in red

- Print the *lac* promoter region sequence onto a label and adhere to the front of the DNA box. Format spacing appropriately to the size of the DNA box.

lac operon gene region:

lacZ lacY lacA

DNA box 2 - *lac* gene region

- Obtain about 6 inches of conductive thread and wrap thread around each individual tile on the DNA top. After wrapping each tile with thread, tie off with a knot and cut off any excess thread. Note: make sure you thread on the bottom of the DNA top so thread strands are not exposed to the top track.
- Snap the bottom and top pieces together.
- Print the *lac* gene region onto a label and adhere to the front of the DNA box. Format spacing appropriately to the size of the DNA box.



- Glue the two DNA boxes together with the promoter box to the left of the gene box.

ADDITIONAL



- Glue two 1" foam cubes together to make the repressor protein. Print a label for the protein. Glue a magnet to the bottom right side of the protein. The foam can easily be cut away to allow the magnet to be depressed inside of the cube. Before gluing down make sure the magnet orientation is correct for binding to the magnet already placed inside the DNA box described above.. This is where the magnetic marble (allolactose) will bind.