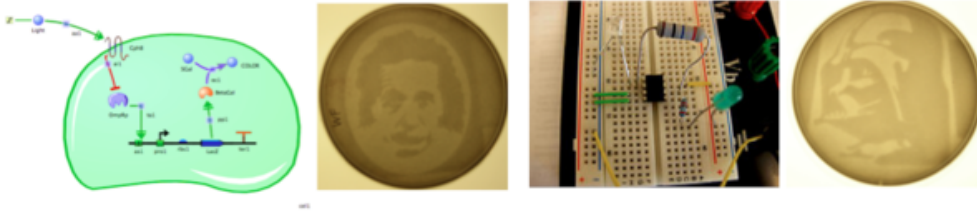


BioBuilding: Synthetic Biology for Teachers: Picture This

Lab 3: Picture this



Teacher Considerations

The Picture This lab consists of three activities that focus on circuit design. Students examine a two component sensing system that has been engineered to produce bacterial photographs. Picture This activities include a downloadable program to model the genetic system and change experimental parameters, an exercise to model the same system using electronic parts on a bread board, and an opportunity to send a stencil that will be turned into a bacterial photograph. While there is little emphasis on lab techniques, these activities provide the students with the opportunity to engage in modeling, an important engineering and scientific tool. They can then engage in discussions about the purpose and value of modeling and the strength of the analogy each model provides. It is recommended that the students read the introduction to the [design assignment](#) for more information about the two component signaling system modeled in this lab.

Part I: TinkerCell Activity

The ultimate goal for this activity is to simulate the operation of the bacterial photography system using the CAD tool. The tool we've chosen (Tinkercell) is one of many, but it is useful in this teaching context because it has an easy-to-use graphical interface, can be an informative "drawing" tool in other contexts when you'll be teaching gene expression, and does not require computer programming skills. During this activity, the students will create a CAD model of the bacterial photography system and then manipulate various parameters, such as promoter strength, concentration of substrate and enzyme activity to examine their effects on the system. In doing this, the students will learn how the parts of a 2 component sensing system (and other genetic and enzyme systems) interrelate. We recommend that the students spend one class period conducting the TinkerCell activity. A second class period can be devoted to altering parameters and examining effects. If students have access to the internet at home or in their dorm, they can download TinkerCell and conduct further studies outside of class.

A correctly built TinkerCell model file can be downloaded [here](#).

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Part II: Electronics Modeling

During this activity the students will create an electronic analogy for the bacterial photography system.

The bacterial photography system is constructed from two devices:

1. A **Sensor**: an input detection device which, in response to darkness, produces a signal.
2. An **Actuator**: an output generating device which takes an input signal from the first device and produces a detectable output.

The devices are connected through the two-component signaling pathway. We can construct an analogous system from electrical components:

1. A **photodiode**: a sensor device that allows current to pass through it in response to incoming light
2. An **LED**: an actuator that responds to a current input by emitting colored light. We also include a resistor in this box so we don't burn out the LED.

The devices are connected through an operational amplifier and a resistor to build a circuit that will operate identically to the bacterial photography system. The photodiode will sense light and generate an electrical signal that will be detected by the LED, which produces a color output in response (on in the dark, off when the flashlight is shining on the photodiode). If you'd like to explore the issue of "gain" in the signaling system, then the resistor associated with the OpAmp can be swapped out for smaller ones (or open circuit or wire), and the system can be observed to behave less digitally (because the system gain is proportional to the resistance). Depending on your goals, it may be sufficient to simply build the circuit with a large resistor in place and omit the gain exercise. We recommend that the students spend one class period on the electronic model. Building the model takes only a short time and the students can then experiment with the system.

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Part III: U-do-it Bacterial Photograph

Since the bacterial photography system requires expensive indicator media and a specialized light source in an incubator, we do not have an easy way for you to try this part of the work in your classroom. We're working on it! But in the meantime, if you'd like to send a transparency for us to develop for you in our lab, please contact us through the BioBuilder site and we'll work out a way to collaborate! Students might like to see their school logo or favorite actor in a bacterial photograph. As you think about an image to develop, remember that the goal is to have each cell growing distinctly in the light or dark, so simple black-and-white images are preferable (anything with gray-scale will not show up adequately). Light can bounce around edges and may blur the resulting image if the black and white are highly intermingled, so a large blocky design will work better than an intricate one. In general, it's better to have a dark background and a light image rather than the other way around. Once you've chosen an image to develop, generate a computer file with this image and print it to a transparency. To darken the dark parts of your photo, you might want to print it on two transparencies, and we'll use them both to mask the Petri dish. We can then send you a digital photo of your result.

Survey

To help us improve the labs, you can

1. send the students [here](#), where they can upload their data.
2. "join a discussion" from the [BioBuilder homepage](#)
3. email us: "info AT biobuilder DOT org"

Thanks!

Feedback

We're always looking to hear back from you if you've thought about this unit, tried it, or stumbled across it and want to know more. Please email us through [BioBuilder](#), info AT biobuilder DOT org.