MINNESOTA IGEM TEAM 2013

ECORI SQUAD: SYNTHETIC BIOLOGY 2-DAY CURRICULUM

Science for everyone! | ECORI Squad

Preface

The ECORI (**E**ducating **C**ommunities **O**n **R**esearch **I**nnovation) Squad from the University of Minnesota 2013 iGEM team developed a **curriculum on synthetic biology** that **can be tailored to any age group**. After much research, discussion, and revision, we've developed the first edition of our curriculum to include hands-on activities to help students at any age understand tools in biotechnology such as recombinant DNA, microorganisms, and synthetic biology toolkits.

The ECORI squad launched its **pilot program** Salk Middle School in Elk River, Minnesota, where the team taught synthetic biology to **over 150 7th grade students** in five different sessions. This curriculum was developed for class sizes around 30, and implemented within two 50-minute time spans. All the materials and procedures are designed in accordance to safety measures, so students can learn and enjoy doing science in the safest environment.

The pilot program was a **success** at Salk Middle School, and the team has **been invited back** in the spring. We will also be pairing up to work with Salk's "Girls in STEM" group to help promote women in STEM fields. Excitement is brimming around The ECORI Squad, and we are quickly lining up more schools who wish to run the two-day course! We are actively **seeking more collaboration** opportunities, not only to improve this curriculum but also to spread our **love and excitement for synthetic biology**!

As always, the University of Minnesota 2013 iGEM team and the ECORI Squad **promote open-access science**! Therefore, we **hold NO copyright and encourage use of this material**, as it has proven successful in our first pilot school. That being said, we would love a shout-out and to hear any comments or feedback when you use this curriculum in your communities or schools.

Sample 2-Day Lesson Timeline

Day 1

1. Introduction to Synthetic Biology (10 min)
2. Strawberry DNA Extraction Exercise (15min)
3. Draw "Bacterial Art" (15 min)
4. Show glow-in-the-dark bacteria: *Vibrio harveyi* (5 min)

Day 2

1. Recap & Introduction of restriction enzymes (10 min)
2. Activity: Restriction enzyme using yarn (15min)
3. View bacteria art (15 min)
4. Q & A/Ethics (10 min)

Safety Information

An important part of studying biology is to observe living organisms through experiments. It is important to realize that your safety is the foremost priority when performing experiments. Most of the laboratory activities are quite safe; nevertheless, the equipment and materials can be dangerous if handled improperly. In this section, you will learn how to work safely and prevent accidents.

General Practices:

- No running during demonstrations
- No eating or drinking is permitted
- Wear gloves at all time when handling biological materials including microorganisms
- Immediately report any accident - no matter how small - to your instructor.

Physical Hazard:

Gloves: Some individuals develop allergic symptoms when in contact with certain types of gloves. Latex-free gloves should be provided.

Chemical Hazards:

Rubbing alcohol/ isopropyl alcohol: Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Check for and remove any contact lenses. In case of eye contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.
In case of skin contact, wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms appear.
http://www.sciencelab.com/msds.php?msdsId=9924412

Biohazard:

Biohazards refer to the biological agents such as organisms, viruses or biological materials pose potentially risk to human health. The other category could be defined to include blood samples, DNA, RNA, proteins, enzymes, prions or anything that is produced by biological systems. Biohazard waste generators are responsible for ensuring waste is treated correctly and labeled properly. This series of laboratory exercises complies with standard microbiological practices. Organisms used in this curriculum should be autoclaved before disposal.

Escherichia coli (BL21) and *Vibrio harveyi* are the primary biohazards used in this exercise. These two species of bacteria are derived from laboratory-safe strains and are considered Biosafety Level 1 (BSL1), which is the designation for microbes that are not known to consistently cause disease in healthy adults and present minimal potential hazard to students and the environment. Work associated with BSL1 microbes can be performed on an open table or bench without posing risk to human health. However, we will treat everything contaminated with living bacteria as biohazard and collect in biohazard bags.
http://www.cdc.gov/training/QuickLearns/biosafety/

Exercise 1: Extracting DNA from Strawberries

Objectives:

Demonstrate how the blueprint of life, **deoxyribonucleic acid (DNA)**, can be extracted from strawberries using everyday household materials. This procedure, if followed precisely, will produce a large amount of macroscopic, visible DNA strands which carry the information directing all actions of a cell and the physical attributes of an organism. You will create a detergent mixture that will disrupt the strawberry cells and enable extraction of DNA from the solution. The DNA will then be precipitated out by adding rubbing alcohol.

You Will Need

- Strawberries
- 2 Plastic cups
- 1 Resealable plastic bag
- 2 tablespoons of detergent (dish soap)
- 1 tablespoon of salt
- 1/2 cup of water
- 1/3 cup of cold rubbing alcohol
- 1 Coffee Filter
- 1 Funnel

Procedure

1. Chill the rubbing alcohol.
2. Place a strawberry into the plastic bag, seal it and gently squeeze and crush the strawberry completely.
3. In a plastic cup, mix 2 tablespoons of detergent, and a tablespoon of salt with ½ a cup of water.
4. Add 2 tablespoons of your mixture to the bag with the strawberry and gently crush it.
5. Place the coffee filter in a funnel on the other plastic cup.
6. Pour the liquid strawberry into the filter.
7. Lift the filter and gently squeeze the remaining liquid into the cup.
8. Pour 1/3 a cup of cold rubbing alcohol. Cloudy white DNA strings should appear at the top of the solution within a few seconds.

Exercise 2: Restriction Enzyme Game

Objectives:

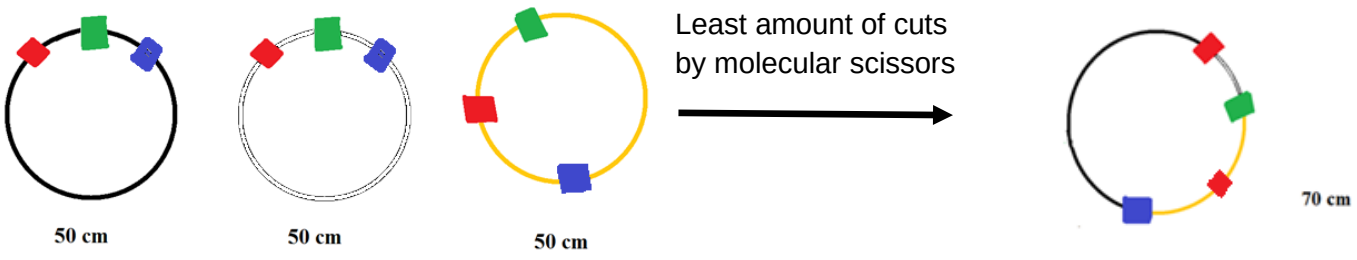
Restriction enzymes are the protein machines that cut DNA at specific sites and are often referred to as "molecular scissors." Restriction enzymes are one of the most important tools in biotechnology as the DNA fragments they generate can be rearranged, moved to different organisms, and code for new DNA devices. In this activity, you will learn how "molecular scissors" work. You will be given three different colored yarn ropes that symbolize plasmids (circularized DNA), each with one unique function. By cutting the DNA fragments with "molecular scissors," you will be able to combine two new functions (yellow and gray) into your main plasmid (black) (see below). After the activity, have the students brainstorm and discuss the two novel functions they want to incorporate into their microorganism.

You Will Need:

- Three circularized yarns of different color (black, white, yellow)
- One target plasmid
- A pair of scissors

The three plasmids

Goal plasmid



Please refer to **Appendix** to see preparation for circularized yarns with restriction enzyme.

Goal and Rules

Our goal is to use least amount of cuts to generate DNA fragments from different plasmids so we can create the plasmid we want. Here are the rules of the game:

1. Only the ends with the same color can be joined together
2. Re-joined the ends with the clear tape of the same color

Discussion Questions

What components or functions do you want to design in your biobricked plasmid?

Where should we draw the line concerning manipulating human genetics?

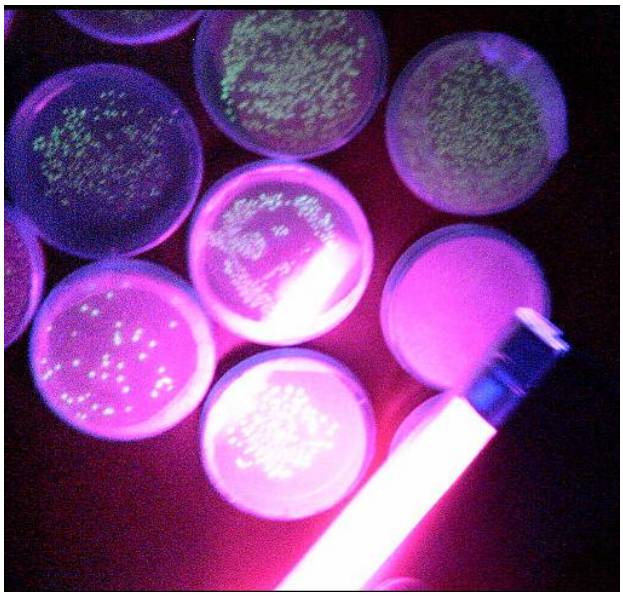
How would modified organisms be responsibly controlled?

What would be the impact of introducing genetically altered organisms into a preexisting ecosystem?

Exercise 3: Bacterial Art Plates

Objectives:

In this activity, you will be creating "bacterial art" plates with bioluminescent and fluorescent strains that would only be visible in the dark or under black light, respectively.



Green Fluorescent Protein (GFP) is a protein produced by a jellyfish *Aequorea victoria*; which produces glowing points of light around the margin of its umbrella. By transferring and incorporating this gene into a bacterial strain, we are able to make bacteria fluoresce in the presence of a handheld black light.

Escherichia coli is a very common bacteria that lives in gastrointestine tracts and part of the common gut flora (Yes, there are actually millions of bacteria in your gut!). These small ordinary bacteria play a significant role in biotechnology. The features that draw scientists attention to *E. coli* are its simple and completely sequenced genome, rapid rate of growth, and easiness to cultivate and handle. Compared to humans which have 21,000 genes, *E. coli* has only 4,400 genes.

Vibrio harveyi is a species of marine bacteria that can be found in free-living planktonic state. Its close relative, *Vibrio fischeri* colonizes the specialized light organ and emits bioluminescence to eliminate shadows caused by moonlight and thus protect the luminescent animal from predators. Through a process called bioluminescence, *V. harveyi* and *V. fischeri* are capable of emitting light via a chemical reaction that originates within the organism. Similarly bioluminescent organisms include fireflies, anglerfish, glowworms, and jellyfish.

Materials:

- Gloves
- Incubator
- Luria-Bertani (LB) agar plates
- Goggles
- Disposable wooden applicator sticks
- Lab coat
- Hand-held blacklight

Procedure:

- Using wooden applicator sticks, gently streak bacteria on agar media to create your desired image. It might be helpful to draw it on a piece of paper which would be placed beneath the plate and traced.
- The plates will be incubated at 37C overnight so the bacteria will grow to become visible to naked eyes.
- View bioluminescent bacteria in a dark area and fluorescent bacteria by shining black light.

The lab strains of bacteria and media recipe are available upon request. Please contact Aunica Kane if you have any questions regarding this particular activity: ***skog0122@umn.edu***

Appendix

This page will help you to prepare the materials needed for Exercise 2: Restriction enzyme game.

Figure 1. The materials and three circularized yarns for Exercise 2. The green, red and blue blocks represent the restriction sites, where the molecular scissors recognize and cut in the middle. The restriction sites can be created using color tapesWe suggested to use 50 cm or 10 inches of yarns to make circularized DNA.

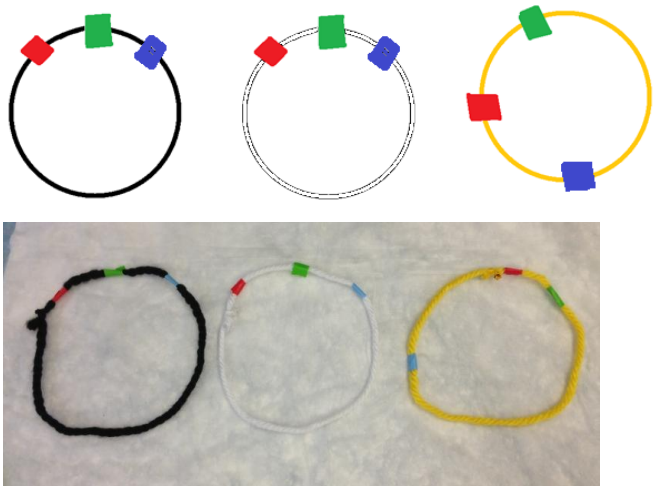


Figure 2. The goal plasmid.