

Science

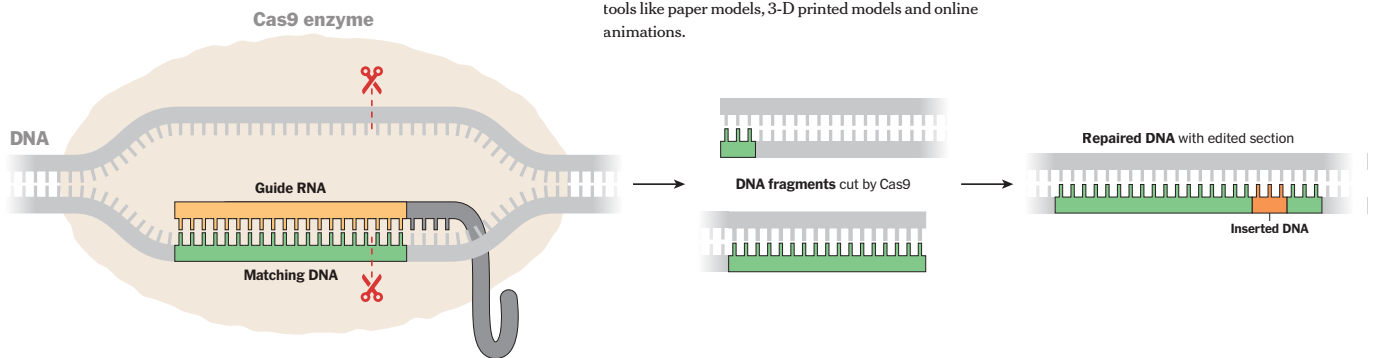
CRISPR in the Classroom

By ELEANOR LUTZ

A decade after CRISPR started to become a major tool in genetic research, a new generation of scientists is growing up with the technology. Even high school students are able to run CRISPR experiments. Some specialized public high schools teach CRISPR as a hands-on lesson in biotechnology. These classes cover everything from molecular biology to pipetting to biomedical ethics and career options.

Visualizing Tiny Molecules

"Visualizing and comprehending what's happening on the molecular level is usually always the challenge," said Katy Gazda, a high school biotechnology teacher who taught CRISPR in her classroom last year. To help students better understand complex molecular movements, teachers use tools like paper models, 3-D printed models and online animations.



1 Target the right gene

Scientists engineer a piece of RNA that is a match for the DNA they want to edit. This is called the **guide RNA**.

Students can practice designing their own guide RNA sequences using the same free bioinformatics search tool that scientists use for research.

2 Bind the target

An enzyme called **Cas9** binds to a piece of DNA and temporarily unwinds a section of the DNA.

Students can model the process with paper cutouts, pushing a paper DNA sequence along a printed guide RNA until they match.

3 Cut the DNA

If the guide RNA matches a section of the DNA, the Cas9 enzyme cuts both strands of the DNA double helix.

An interactive animation from the Howard Hughes Medical Institute shows students how the Cas9 enzyme changes its shape and snips through the DNA.

4 Repair and edit the DNA

Machinery inside the cell rushes to fix the broken DNA. One repair process uses a similar-looking, unbroken piece of DNA as a template to stitch the broken pieces back together.

Scientists can introduce tailor-made DNA into the cell — tricking the repair machinery into using the engineered DNA as the template for stitching together the broken pieces.

Students also learn about real-life examples of DNA editing, such as therapies for genetic illnesses including sickle cell disease and cystic fibrosis.

In some exercises, they can see examples of the actual DNA sequence associated with each illness and evaluate specific gene edits proposed to cure the illness.

Source: H.H.M.I.; instructor materials from the Bio-Rad Explorer education program | Note: Molecular diagrams are simplified

Hands-On Gene Editing With Bacteria

Ms. Gazda believes that hands-on lab lessons help students "open their minds to the idea that they can truly be a scientist." Several companies sell CRISPR curriculum kits to high schools and universities. One kit from Bio-Rad, a life science technology manufacturer, includes a prepackaged experiment using *E. coli* bacteria.

BIO-RAD

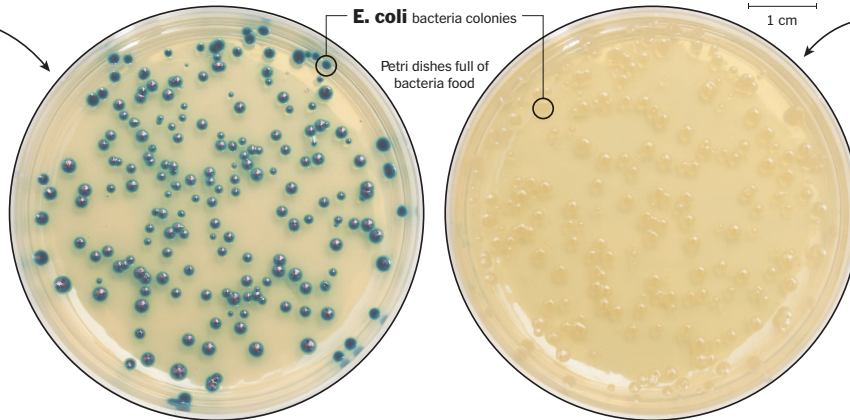
Bacteria Without CRISPR

The *E. coli* bacteria used in the Bio-Rad kit are grown on a food mixture that includes a compound called **X-gal**.

Normally, these bacteria are able to use an enzyme to break down the compound into two parts: a sugar molecule and an indicator molecule.

The indicator molecule turns deep blue, showing students that the bacterial enzyme is working.

This colorful display is an important part of the experiment. It shows students what to expect in an unaltered, or "control" group — a vital part of any scientific experiment.

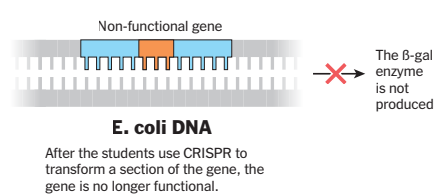
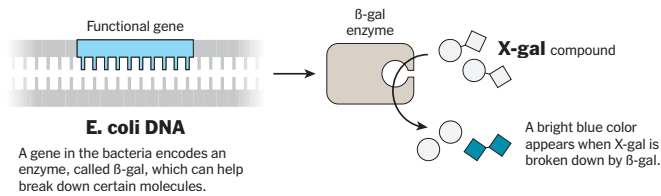


Bacteria Altered With CRISPR

The process of altering *E. coli* DNA with CRISPR involves lab techniques like pipetting liquids and carefully moving bacteria colonies.

Teaching a new lab class like CRISPR can be intimidating, says Gregory Jubulis, a high school science teacher who uses the Bio-Rad kit in his biotechnology class. "It takes you a few years before you're real comfortable with teaching something," he said.

But when classroom CRISPR lab kits first became available, he knew he wanted to teach it. "I just want my kids to be ready for the future of science," he said.



Source: H.H.M.I.; instructor materials from the Bio-Rad Explorer education program | Note: Molecular diagrams are simplified

Not Just About The Molecules

Ms. Gazda uses lab classes as an opportunity to share career options with students. In a CRISPR lab, students may learn about careers in anything from molecular and cellular biology to entrepreneurship and science journalism.

"Ethics always comes up," says Mr. Jubulis, explaining how he relates the lab experiment to real-life CRISPR applications like gene therapy. Many of his students have friends or family with genetic illnesses, so the topic can be deeply personal.

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