CRISPR in the Classroom

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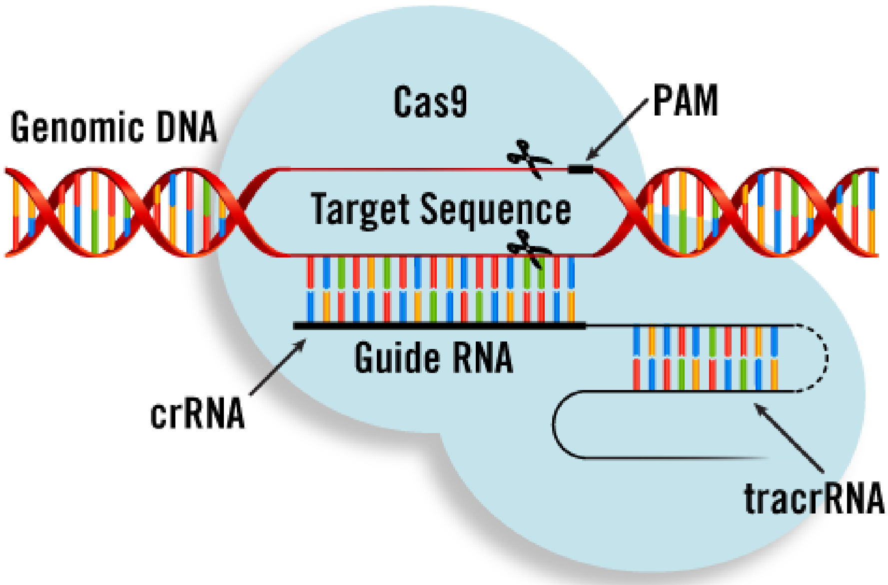

Cas9 binds and accurately cuts genomic DNA via a guide RNA, enabling for useful genome engineering

For a state bearing the company/institute offices of BASF, Sun Pharmaceuticals, MSKCC, Becton Dickinson, and Celgene to name a few, a comprehensive life sciences program is essential. With steady country-wide biology job growth, New Jersey emerges as one of the top states to be in as a biology major. In-state graduates are now in high demand close to home. Biotech is in style, and this upward trend shows no signs of leveling off.

A Revolutionary Technology

At forefront of this biological charge is the Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated protein 9 system (CRISPR/Cas9 or CRISPR for short), a revolutionary new technology for genome editing that provides unheard-of ease, efficiency, and low cost. Its now universal use in laboratories worldwide has led to subsequent breakthroughs in inherited disease, HIV, malaria, retinitis, and cancer. Most NJ biotechs have adopted the technology for in-house experimentation.

Scientists are able to design their own expression vectors (a.k.a. DNA-comprised CRISPR delivery methods, typically plasmids) via computerized tools. Upon vector delivery, cells transcribe the vector's encoded portions into genetic products: the protein Cas9, a desired template DNA strand for insertion, and the guide RNA (gRNA) containing a custom sequence complementary to the desired location or locus to edit in the genome. Cas9 then complexes with the gRNA, using it as a template to locate the complementary locus. Once found, Cas9 binds to the DNA and performs a double stranded break. This induces a DNA repair pathway called homology directed repair, which inserts the template DNA strand into the genome. Effectively, CRISPR can introduce new traits in foreign organisms. If the aim is to confer gene knockout to study function, cutting the genome without supplying a template initiates the error-prone repair pathway non-homologous end joining, introducing mutations that 'corrupt' the gene of interest.

With CRISPR, institutions can develop treatments and discover novel protein functions at an accelerated rate, making the drug industry and biology in general all the more lucrative and exciting. Now, we see the emergence of biotechnology companies and organizations like Addgene and Thermo Fisher Scientific making CRISPR affordable and widespread. Biotechs have even played with new business models, transforming themselves into plasmid-pumping factories.

Why CRISPR Education Matters

I applied for a general biology internship this summer and was a bit surprised to hear the question: “Do you know what CRISPR/Cas9 is?” in the interview. I told the professor what I knew. He added, “Great. We use it in the lab all the time.” Just knowing about the technology gave me preference over other candidates which ultimately helped me get the position. Due to its sudden ubiquity, CRISPR is now a permanent implement in research and industry labs internationally, which begs that we familiarize our biology students with it as early as possible.

But the recent developments in biology have made high school and college curricula somewhat outdated. Today, CRISPR is completely absent from syllabi. This is despite the fact that many bioscience students post-graduation will be expected to have worked with or at least understand CRISPR technology. For students intending to study nonclinical biology, CRISPR will inevitably be part of their future experience. Therefore, curricular inclusion is a must.

Teaching Methods

Teaching CRISPR may appear daunting at first, but in actuality, it's a great, simple addition to the classroom. A Wired feature demonstrated how easy it is to explain CRISPR and how difficulty can be scaled if necessary. CRISPR learning would fit perfectly in a class' biotechnology unit. And if pressed for time, a learning activity can be limited to a single slide in a presentation. AP Biology teachers in particular are locked into a set curriculum by the College Board. However, there’s plenty time to introduce fun and new concepts to your students after the May exams. Even with a little exposure the key concepts come through. Alternatively, CRISPR can be taught alongside a genetic recombination (an obsolete but still tested on method of gene editing) lesson. This lesson typically includes an experiment familiar to many bio teachers: bacteria are engineered to glow in the dark and/or become antibiotic resistant. This can be replaced/supplemented with a CRISPR activity achieving a similar goal, also at a modest price.

The Odin, a successfully kickstarted biotech purveyor, recently began offering classroom CRISPR kits containing everything (wares, bacteria, gels, manuals, plasmids, etc.) needed for five experiments at $75.00. (I did the experiment myself and found the instructions fairly easy to grasp; I thought it was a great experience.) The experiment is similar to a genetic recombination lab (save a couple steps) as it engineers the bacteria to be antibiotic resistant. At 5–8 students per experiment, a school can fund large biology classes relatively cheaply. I am leading an initiative at my high school to acquire CRISPR classroom kits. The science department believes integrating CRISPR would be a fantastic opportunity. We plan to request a grant from the local education foundation in the fall.

For the more adventurous schools, CRISPR offers a myriad of opportunities for future scientists. Custom CRISPR/Cas9 plasmid vectors (also similar to those used in genetic recombination) now range from $200–500 an order. After AP exams, a few, small student groups can be invited to develop their own independent science projects. With some basic knowledge of vector design (and instructor guidance), a student lab group can select which genes they would like to disrupt/insert via online easy-to-use plasmid pickers (e.g. Deskgen). At the end of the year, the students can give presentations on their experiments and findings to the community and their peers.

Impact

Students planning to explore new edits to microorganisms would probably be conducting their own original research, being that CRISPR is so new. These experiments may be the first of their kind—all taking place within the high school laboratory classroom. Budget-willing, CRISPR technology is a great way to demonstrate students' scientific prowess, curiosity, and successful application of the scientific method.

Getting students to critically think about CRISPR technology and its impact may help them better prepare for the New Jersey Biology Competency Test as well. And if integrated into curriculum, CRISPR education may help satisfy the following NGSS standards: HS-LS3 Heredity: Inheritance Variation of Traits, HS-LS1-1 From Molecules to Organisms: Structures and Processes, HS-LS4-6 Biological Evolution: Unity and Diversity, and HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics.

Although CRISPR/Cas9 technology may not be realistic for some schools, its integration into curricula is still crucial for the biological literacy of NJ's future scientists. Our STEM students *must* be introduced to CRISPR and the CRISPR revolution, not only to push them to the cutting edge of science, but to better prepare them for the real world.

Further reading:

CRISPR-Cas in the laboratory classroom (article)

A Primer on CRISPR, and Adaptations for the Classroom (presentation)

How A Gene Editing Tool Went From Labs To A Middle-School Classroom (article)

Good opportunity for biology students (letter to the editor)

Genetic Engineering Will Change Everything Forever – CRISPR (video overview)