CRISPRkit: Democratizing Biotechnology through Scalable Education

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Abstract

Equitable and accessible education in life sciences, bioengineering, and synthetic biology is crucial for training the next generation of scientists, fostering transparency in public decision-making, and ensuring biotechnology can benefit a wide-ranging population. As a groundbreaking technology for genome engineering, CRISPR has transformed research and therapeutics. However, hands-on exposure to this technology in educational settings remains limited due to the extensive resources required for CRISPR experiments. Here, we develop CRISPRkit, an affordable kit designed for gene editing and regulation in high school education. CRISPRkit eliminates the need for specialized equipment, prioritizes biosafety, and utilizes cost-effective reagents. By integrating CRISPRi gene regulation, colorful chromoproteins, cell-free transcription-translation systems, smartphone-based quantification, and an in-house automated algorithm (CRISPectra), our kit offers an inexpensive (~$2) and user-friendly approach to performing and analyzing CRISPR experiments, without the need for a traditional laboratory setup. Experiments conducted by high school students in classroom settings highlight the kit's utility for reliable CRISPRkit experiments. Furthermore, CRISPRkit provides a modular and expandable platform for genome engineering, and we demonstrate its applications for controlling fluorescent proteins and metabolic pathways such as melanin production. We envision CRISPRkit will facilitate biotechnology education for communities of diverse socioeconomic and geographic backgrounds.

Our Mission: To Democratize Science

Background

Impactful research is solving many world problems in health, environmental and materials

Problem

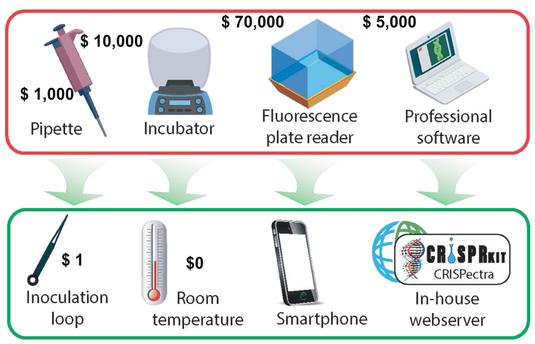
Lab science is inaccessible to students due to limitations in accessibility

Solution

Develop strategies that decrease economical, logistical, cultural, technological and pedagogical challenges

CRISPRKIT

Our Approach

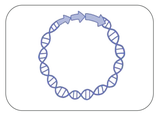


Innovation with accessibility

- Providing low-cost, but effective alternatives
- Biosafety-driven design
- Open access software
- Smartphone compatibility

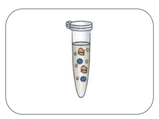
5 Core Components of CRISPRkit[1]

1. DNA / Plasmid encoding gene (colorimetric)

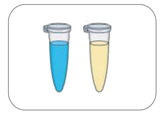


2. DNA encoding guide RNA

3. dCas9 to block transcription



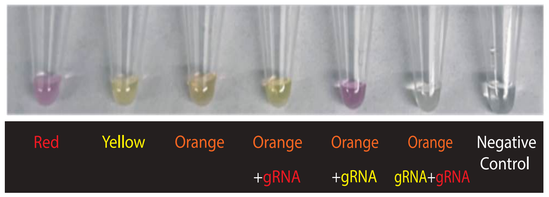
4. Reagents for biochemical reactions
5. Cell-free system for biosafe protein expression



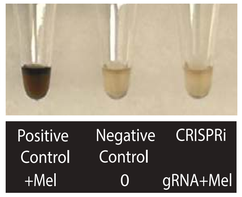
1. Collins, M.; Lau, M. B.; Ma, W.; Shen, A.; Wang, B.; Cai, S.; La Russa, M.; Jewett, M. C.; Qi, L. S. A frugal CRISPR kit for equitable and accessible education in gene editing and synthetic biology. Nature Communications 2024, 15 (1), 6563. DOI: 10.1038/s41467-024-50767-2.

CRISPRkit is not a One-Off Experiment

Multicolor CRISPRkit



Melanin Synthesis CRISPRkit



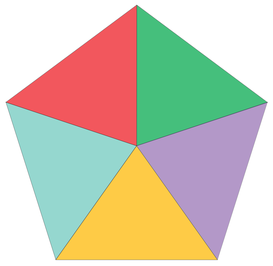
- Current Kit Offering: (1) Single-color; (2) Multi-color; (3) Melanin
- Next-Generation Kits: Glow-in-the-dark, Fluorescent Protein, Scented
- State-of-the-art CRISPR: Base-Editing, RNA degradation
- Customization for real-world discovery

Democratizing Biotech in 5-Dimensions

Financial
- Cost
- Equipment / Reagents

Logistical
- Shipping& Regulations
- Regulations and Tarrifs
- Storage (cold, long-term)

Technological
- Chat-bot Support
- Apps (analytical, social)



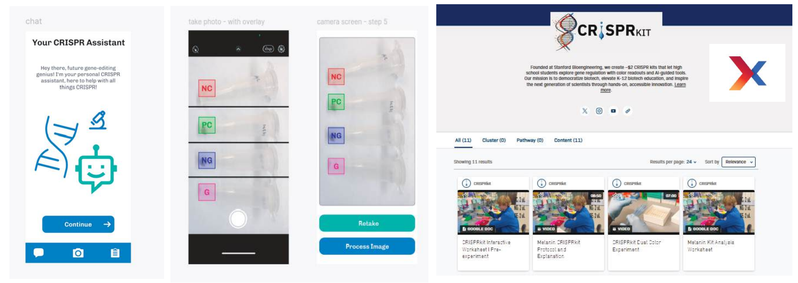
Cultural
- Real-World Impact
- Cultural Sensitivities
- Language & Diversity

Pedagogical
- Instructor Training
- Curricular Relevance
- Rigor & Ease of Integration

Our Accessibility-Driven Solutions

- Logistical: Lyophilization and Corporate Partnerships
- Technological: AI-assistant for in-classroom troubleshooting
- Economical: Low-cost equipment alternatives (i.e pipettes)
- Cultural: Diverse lesson plans and translated materials
- Pedagogical: Alignmment with AP curriculum + Teacher Organization Partnerships

Integration of Technology & Artificial Intelligence



- Retreival-Augmented Generation (RAG) based AI for personalized CRISPRkit chatbot
- CRISPectra: iPhone/Android-based colormetric analysis tool
- LabXChange: Simulations & Customizable Videos

Outreach: Reaching 10,000 Students by 2026

Khan Academy & Khan Lab Schools

School of Engineering 100 Year Anniversary

- Pilots: 1,000 students in 2025
- Reach: Local (California) and Domestic: International in 2026
- Collaborations: CityLabs (Boston University), Khan Academy & Khan Lab Schools
- Corporate Collaborations: Amgen Biotechnology Experience (ABE), LabXchange

Meet the Team

Acknowledgements

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