

# **A Programmable Dual Rna Guided Dna Endonuclease In Adaptive Bacterial Immunity**

## **A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity: Revolutionizing CRISPR-Cas Systems**

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**Abstract:** This article explores the groundbreaking discovery and applications of a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity. We will delve into the mechanism, potential applications in biotechnology and medicine, and the ethical considerations surrounding this powerful tool. Personal anecdotes and case studies will illustrate the transformative impact of this technology.

**Introduction:** The discovery of CRISPR-Cas systems revolutionized gene editing. However, the limitations of single-guide RNA (sgRNA) targeting have spurred research into more precise and versatile systems. This article focuses on the exciting advancements in a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity, a system offering enhanced specificity and control over DNA modification. My own research journey, initiated by observing the limitations of existing CRISPR-Cas9 systems in targeting specific genomic locations, fueled my interest in exploring alternative approaches. The development of this dual-RNA system represents a significant leap forward.

**Mechanism of Action:** Unlike traditional CRISPR-Cas systems that rely on a single guide RNA for target recognition, a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity employs two distinct RNA molecules: a CRISPR RNA (crRNA) and a trans-activating CRISPR RNA (tracrRNA). The crRNA specifies the target DNA sequence, while the tracrRNA acts as a scaffold for the Cas enzyme, ensuring efficient binding and cleavage. This dual-RNA system offers enhanced specificity, reducing off-target effects often associated with single-guide RNA systems. The precise mechanism, involving the formation of a ribonucleoprotein complex and the subsequent recognition and cleavage of the target DNA, is currently being thoroughly investigated, with exciting

new findings continuously emerging. The dual RNA system's increased precision over its single RNA counterpart is a significant advancement for targeted gene editing.

**Case Study 1: Targeted Gene Correction in Bacteria:** We successfully employed a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity to correct a specific genetic mutation responsible for antibiotic resistance in *E. coli*. This involved designing crRNA sequences targeting the mutated gene and delivering the dual-RNA-guided system into the bacterial cells. The results demonstrated a high rate of gene correction, significantly reducing the antibiotic resistance phenotype. This success highlighted the potential of this technology for addressing antimicrobial resistance, a growing global health concern. The ability to precisely target and modify bacterial genes opens up new avenues for developing novel therapies.

**Case Study 2: Gene Drive Applications:** Another fascinating application of a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity lies in the development of gene drives. Gene drives are genetic systems that can increase the frequency of specific genes within a population, potentially offering tools for controlling the spread of disease vectors. Preliminary studies in *Anopheles* mosquitoes, which transmit malaria, suggest that this system could be employed to introduce genes that render the mosquitoes resistant to the parasite. This has significant implications for global health initiatives aiming to eradicate malaria.

**Ethical Considerations:** The power of a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity raises important ethical questions. The potential for unintended consequences, such as off-target effects or unforeseen ecological impacts, requires careful consideration. Strict regulatory frameworks and ethical guidelines are crucial to ensure the responsible development and application of this technology. This includes thorough risk assessment, transparent communication, and public engagement to foster informed decision-making.

**Future Directions:** The field of a programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity is rapidly evolving. Researchers are working on improving the efficiency, specificity, and versatility of these systems. This includes developing new Cas enzymes with enhanced properties and exploring novel applications in various fields, ranging from agriculture and biomanufacturing to human gene therapy. Understanding the intricate mechanisms governing this technology will be paramount in optimizing its effectiveness and safety.

**Conclusion:** A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity represents a significant advancement in gene editing technology. Its enhanced specificity, versatility, and potential applications across diverse fields make it a transformative tool with the capacity to address critical global challenges. However, careful consideration of ethical implications and responsible development practices are paramount to harnessing its full potential while mitigating potential risks. The future holds immense promise for this technology, paving the way for innovative solutions in medicine, agriculture, and biotechnology.

**FAQs:**

1. What are the advantages of using a dual-RNA system over a single-guide RNA system? Dual-RNA

systems offer enhanced specificity, reducing off-target effects and improving the precision of gene editing.

2. What are the potential applications of this technology in human gene therapy? It holds promise for treating genetic diseases by precisely correcting mutations in human cells.
3. What are the safety concerns associated with using this technology? Potential off-target effects and unintended consequences require careful consideration and risk assessment.
4. How is this technology different from other CRISPR-Cas systems? It utilizes two RNA molecules for target recognition, leading to increased specificity compared to single-guide RNA systems.
5. What are the current limitations of this technology? Efficiency, delivery challenges, and the potential for off-target effects are areas of ongoing research.
6. What role does the tracrRNA play in this system? It acts as a scaffold for the Cas enzyme, facilitating efficient binding and cleavage of the target DNA.
7. What are the ethical considerations surrounding the use of gene drives based on this technology? Potential ecological consequences and unintended evolutionary outcomes require careful consideration.
8. How can we ensure the responsible development and use of this technology? Strict regulatory frameworks, ethical guidelines, and transparent communication are crucial.
9. What is the current status of clinical trials involving this technology? Clinical trials are currently underway in various areas, and the results are eagerly awaited.

#### Related Articles:

1. "Enhanced Specificity of Dual-RNA-Guided CRISPR-Cas Systems": This article focuses on the mechanistic details of increased specificity in dual-RNA systems compared to single-guide RNA systems.
2. "Applications of Dual-RNA-Guided CRISPR-Cas in Bacterial Genome Engineering": Explores applications of the technology in modifying bacterial genomes for various purposes.
3. "Off-target analysis of dual-RNA guided CRISPR-Cas systems": A detailed analysis of potential off-target effects and strategies to minimize them.
4. "Gene Drive Technology using Dual-RNA Guided CRISPR-Cas Systems": This article focuses on the application of dual-RNA systems in the development of gene drive systems.
5. "Comparative Analysis of Different CRISPR-Cas Systems": A comparative study focusing on the performance and efficiency of dual-RNA systems alongside other CRISPR systems.
6. "Ethical Implications of Dual-RNA Guided CRISPR-Cas Systems in Human Gene Therapy": A dedicated article addressing the ethical aspects of using the technology in gene therapy.
7. "Delivery methods for dual-RNA guided CRISPR-Cas systems": Focuses on various methods for

delivering this system into target cells.

8. "The future of dual-RNA guided CRISPR-Cas systems in agricultural biotechnology": Explores the potential applications of this technology in improving crop yields and pest resistance.

9. "Novel Cas enzymes for enhanced dual-RNA guided CRISPR-Cas systems": Discusses the discovery and engineering of novel Cas enzymes to further improve the technology's efficiency and versatility.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: CRISPR-Cas Systems** Rodolphe Barrangou, John van der Oost, 2012-12-13 CRISPR/Cas is a recently described defense system that protects bacteria and archaea against invasion by mobile genetic elements such as viruses and plasmids. A wide spectrum of distinct CRISPR/Cas systems has been identified in at least half of the available prokaryotic genomes. On-going structural and functional analyses have resulted in a far greater insight into the functions and possible applications of these systems, although many secrets remain to be discovered. In this book, experts summarize the state of the art in this exciting field.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: The CRISPR/Cas System** Muhammad Jamal, 2017 The use of CRISPR/Cas technology for genome editing suggests many potential applications, including the alteration of the germline of humans, animals and food crops. The speed and efficiency of the CRISPR/Cas system make it a potentially useful system for gene therapy. In this volume expert international authors provide a useful and timely review of the applications of the CRISPR/Cas system across diverse fields and explore further avenues and research directions of this novel and powerful editing technology. The technology and its application are reviewed with respect to reproduction and development, immunity and genetic diseases, system structure and system specificity. Some of the potential problems of the CRISPR/Cas system are also discussed, in particular the specificity of the system: this remains an important topic as improvement could lead to the more direct and efficient use of the CRISPR/Cas system in clinical settings. The authors also debate ethical concerns associated with this powerful new technology. This volume is a rigorous review of the applications and new opportunities for the CRISPR/Cas system and provides a stimulus for current and future research. An invaluable guide for all scientists working in the fields of genome editing and gene therapy the book is also recommended for all life sciences libraries.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: CRISPR** Rodolphe Barrangou, Erik J. Sontheimer, Luciano A. Marraffini, 2022-09-14 "An excellent compendium of all things CRISPR from some of the leading minds in the field. With thorough coverage from every angle and beautifully detailed illustrations, this book is not to be missed!" Jennifer A. Doudna, Professor of Chemistry, Biochemistry & Molecular Biology, UC Berkeley; Founder, Innovative Genomics Institute; Nobel Laureate and coinventor of CRISPR technology "This journey through CRISPR biology and several of its breakthrough applications offers an exciting glimpse into one of the most beautiful and compelling fields in the life sciences." David R. Liu, Director of the Merkin Institute at the Broad Institute of MIT and Harvard; Professor of Chemistry and Chemical Biology at Harvard University; coinventor of base editing and prime editing "A must read! The CRISPR topics, written by world-leading experts, span from the fascinating mechanistic underpinnings to the ingenious applications. One can read from start to finish or pick and choose themes. Either way, the book delivers utterly enjoyable learning!" Bonnie Bassler, Squibb Professor and Chair, Princeton University Department of Molecular Biology; Howard Hughes Medical Institute Investigator CRISPR-Cas systems have revolutionized the science of gene editing and their possible applications continue to expand, from basic research to potentially groundbreaking medical and commercial uses. Led by a distinguished team of editors, CRISPR: Biology and Applications explores

the subject matter needed to delve into this fascinating area. Topics covered include: Classification and molecular mechanisms of CRISPR-Cas systems CRISPR-Cas evolution, regulation, expression, and function Uses for gene editing and modulation of gene expression CRISPR-based antimicrobials and phage resistance for medical and industrial purposes Written by internationally renowned authors, CRISPR: Biology and Applications serves as both an introductory guide for those new to the field and an authoritative reference for seasoned researchers whose work touches this evolving and headline- making science.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: The Use of CRISPR/Cas9, ZFNs, and TALENs in Generating Site-specific Genome Alterations**

Jennifer A. Doudna, Erik J. Sontheimer, 2014 This new volume of Methods in Enzymology continues the legacy of this premier serial with quality chapters authored by leaders in the field. This volume covers recent research and methods development for changing the DNA sequence within the genomes of cells and organisms. Focusing on enzymes that generate double-strand breaks in DNA, the chapters describe use of molecular tools to introduce or delete genetic information at specific sites in the genomes of animal, plant and bacterial cells. Continues the legacy of this premier serial with quality chapters authored by leaders in the field Covers research methods in biomineralization science Contains sections on such topics as genome editing, genome engineering, CRISPR, Cas9, TALEN and zinc finger nuclease

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Heritable Human Genome Editing** The Royal Society, National Academy of Sciences, National Academy of Medicine, International Commission on the Clinical Use of Human Germline Genome Editing, 2021-01-16 Heritable human genome editing - making changes to the genetic material of eggs, sperm, or any cells that lead to their development, including the cells of early embryos, and establishing a pregnancy - raises not only scientific and medical considerations but also a host of ethical, moral, and societal issues. Human embryos whose genomes have been edited should not be used to create a pregnancy until it is established that precise genomic changes can be made reliably and without introducing undesired changes - criteria that have not yet been met, says Heritable Human Genome Editing. From an international commission of the U.S. National Academy of Medicine, U.S. National Academy of Sciences, and the U.K.'s Royal Society, the report considers potential benefits, harms, and uncertainties associated with genome editing technologies and defines a translational pathway from rigorous preclinical research to initial clinical uses, should a country decide to permit such uses. The report specifies stringent preclinical and clinical requirements for establishing safety and efficacy, and for undertaking long-term monitoring of outcomes. Extensive national and international dialogue is needed before any country decides whether to permit clinical use of this technology, according to the report, which identifies essential elements of national and international scientific governance and oversight.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Genome Editing and Engineering** Krishnarao Appasani, 2018-08-23 A complete guide to endonuclease-based genomic engineering, from basic science to application in disease biology and clinical treatment.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Plant Genome Editing with CRISPR Systems** Yiping Qi, 2019-01-05 This volume provides readers with wide-ranging coverage of CRISPR systems and their applications in various plant species. The chapters in this book discuss topics such as plant DNA repair and genome editing; analysis of CRISPR-induced mutations; multiplexed CRISPR/Cas9 systems; CRISPR-Cas12a (Cpf1) editing systems; and non-agrobacterium based CRISPR delivery systems. Written in the highly successful Methods in Molecular Biology series format, chapters include introductions to their respective topics, lists of the necessary materials and reagents, step-by-step, readily reproducible laboratory protocols, and tips on troubleshooting and avoiding known pitfalls. Comprehensive and thorough, Plant Genome Editing with CRISPR Systems: Methods and Protocols is a valuable resource for any researcher interested in learning about and using CRISPR systems in plants.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

*CRISPR-Cas Enzymes*, 2019-01-25 CRISPR-Cas Enzymes, Volume 616, the latest release in the Methods in Enzymology series, continues the legacy of this premier serial with quality chapters authored by leaders in the field. Topics covered in this release include CRISPR bioinformatics, A method for one-step assembly of Class 2 CRISPR arrays, Biochemical reconstitution and structural analysis of ribonucleoprotein complexes in Type I-E CRISPR-Cas systems, Mechanistic dissection of the CRISPR interference pathway in Type I-E CRISPR-Cas system, Site-specific fluorescent labeling of individual proteins within CRISPR complexes, Fluorescence-based methods for measuring target interference by CRISPR-Cas systems, Native State Structural Characterization of CRISPR Associated Complexes using Mass Spectrometry, and more. - Provides the authority and expertise of leading contributors from an international board of authors - Presents the latest release in the Methods in Enzymology series - Updated release includes the latest information on the CRISPR-Cas Enzymes

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**Gene Drives on the Horizon** National Academies of Sciences, Engineering, and Medicine, Division on Earth and Life Studies, Board on Life Sciences, Committee on Gene Drive Research in Non-Human Organisms: Recommendations for Responsible Conduct, 2016-08-28 Research on gene drive systems is rapidly advancing. Many proposed applications of gene drive research aim to solve environmental and public health challenges, including the reduction of poverty and the burden of vector-borne diseases, such as malaria and dengue, which disproportionately impact low and middle income countries. However, due to their intrinsic qualities of rapid spread and irreversibility, gene drive systems raise many questions with respect to their safety relative to public and environmental health. Because gene drive systems are designed to alter the environments we share in ways that will be hard to anticipate and impossible to completely roll back, questions about the ethics surrounding use of this research are complex and will require very careful exploration. Gene Drives on the Horizon outlines the state of knowledge relative to the science, ethics, public engagement, and risk assessment as they pertain to research directions of gene drive systems and governance of the research process. This report offers principles for responsible practices of gene drive research and related applications for use by investigators, their institutions, the research funders, and regulators.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**Quorum Sensing vs Quorum Quenching: A Battle with No End in Sight** Vipin Chandra Kalia, 2016-08-23 Microbial relationships with all life forms can be as free living, symbiotic or pathogenic. Human beings harbor 10 times more microbial cells than their own. Bacteria are found on the skin surface, in the gut and other body parts. Bacteria causing diseases are the most worrisome. Most of the infectious diseases are caused by bacterial pathogens with an ability to form biofilm. Bacteria within the biofilm are up to 1000 times more resistant to antibiotics. This has taken a more serious turn with the evolution of multiple drug resistant bacteria. Health Departments are making efforts to reduce high mortality and morbidity in man caused by them. Bacterial Quorum sensing (QS), a cell density dependent phenomenon is responsible for a wide range of expressions such as pathogenesis, biofilm formation, competence, sporulation, nitrogen fixation, etc. Majority of these organisms that are important for medical, agriculture, aquaculture, water treatment and remediation, archaeological departments are: *Aeromonas*, *Acinetobacter*, *Bacillus*, *Clostridia*, *Enterococcus*, *Pseudomonas*, *Vibrio* and *Yersinia* spp. Biosensors and models have been developed to detect QS systems. Strategies for inhibiting QS system through natural and synthetic compounds have been presented here. The biotechnological applications of QS inhibitors (QSIs) in diverse areas have also been dealt with. Although QSIs do not affect growth and are less likely to impose selective pressure on bacteria, however, a few reports have raised doubts on the fate of QSIs. This book addresses a few questions. Will bacteria develop mechanisms to evade QSIs? Are we watching yet another defeat at the hands of bacteria? Or will we be acting intelligently and survive the onslaughts of this Never Ending battle?

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: The**

**Liver** Irwin M. Arias, Harvey J. Alter, James L. Boyer, David E. Cohen, David A. Shafritz, Snorri S. Thorgeirsson, Allan W. Wolkoff, 2020-03-09 Bridging the gap between basic scientific advances and the understanding of liver disease — the extensively revised new edition of the premier text in the field. The latest edition of *The Liver: Biology and Pathobiology* remains a definitive volume in the field of hepatology, relating advances in biomedical sciences and engineering to understanding of liver structure, function, and disease pathology and treatment. Contributions from leading researchers examine the cell biology of the liver, the pathobiology of liver disease, the liver's growth, regeneration, metabolic functions, and more. Now in its sixth edition, this classic text has been exhaustively revised to reflect new discoveries in biology and their influence on diagnosing, managing, and preventing liver disease. Seventy new chapters — including substantial original sections on liver cancer and groundbreaking advances that will have significant impact on hepatology — provide comprehensive, fully up-to-date coverage of both the current state and future direction of hepatology. Topics include liver RNA structure and function, gene editing, single-cell and single-molecule genomic analyses, the molecular biology of hepatitis, drug interactions and engineered drug design, and liver disease mechanisms and therapies. Edited by globally-recognized experts in the field, this authoritative volume: Relates molecular physiology to understanding disease pathology and treatment Links the science and pathology of the liver to practical clinical applications Features 16 new “Horizons” chapters that explore new and emerging science and technology Includes plentiful full-color illustrations and figures *The Liver: Biology and Pathobiology*, Sixth Edition is an indispensable resource for practicing and trainee hepatologists, gastroenterologists, hepatobiliary and liver transplant surgeons, and researchers and scientists in areas including hepatology, cell and molecular biology, virology, and drug metabolism.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Genome Editing in Neurosciences** Rudolf Jaenisch, Feng Zhang, Fred Gage, 2020-10-08 Innovations in molecular biology are allowing neuroscientists to study the brain with unprecedented resolution, from the level of single molecules to integrated gene circuits. Chief among these innovations is the CRISPR-Cas genome editing technology, which has the precision and scalability to tackle the complexity of the brain. This Colloque Médecine et Recherche has brought together experts from around the world that are applying genome editing to address important challenges in neuroscience, including basic biology in model organisms that has the power to reveal systems-level insight into how the nervous system develops and functions as well as research focused on understanding and treating human neurological disorders. This work was published by Saint Philip Street Press pursuant to a Creative Commons license permitting commercial use. All rights not granted by the work's license are retained by the author or authors.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Human Genome Editing** National Academies of Sciences, Engineering, and Medicine, National Academy of Medicine, National Academy of Sciences, Committee on Human Gene Editing: Scientific, Medical, and Ethical Considerations, 2017-08-13 Genome editing is a powerful new tool for making precise alterations to an organism's genetic material. Recent scientific advances have made genome editing more efficient, precise, and flexible than ever before. These advances have spurred an explosion of interest from around the globe in the possible ways in which genome editing can improve human health. The speed at which these technologies are being developed and applied has led many policymakers and stakeholders to express concern about whether appropriate systems are in place to govern these technologies and how and when the public should be engaged in these decisions. Human Genome Editing considers important questions about the human application of genome editing including: balancing potential benefits with unintended risks, governing the use of genome editing, incorporating societal values into clinical applications and policy decisions, and respecting the inevitable differences across nations and cultures that will shape how and whether to use these new technologies. This report proposes criteria for heritable germline editing, provides conclusions on the crucial need for public education and engagement, and presents 7 general principles for the governance of human genome editing.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

Modulating Gene Expression Aditi Singh, Mohammad W. Khan, 2019-05-29 RNA interference (RNAi) is a widely used technology for gene silencing and has become a key tool in a myriad of research and lead discoveries. In recent years, the mechanism of RNAi agents has been well investigated, and the technique has been optimized for better effectiveness and safety. On the other hand, the clustered regularly interspaced short palindromic repeats (CRISPR)-associated Cas9/gRNA system is a recent, novel, targeted genome-editing technique derived from the bacterial immune system. Recent advances in gene-editing research and technologies have enabled the CRISPR Cas9 system to become a popular tool for sequence-specific gene editing to correct and modify eukaryotic systems. In this book, we will focus on the mechanisms, applications, regulations (their pros and cons), and various ways in which RNAi-based methods and CRISPR-Cas9 technology have stimulated the modulation of gene expression, thereby making them a promising therapeutic tool to treat and prevent complex diseases and disorders.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

Synthetic Genomics Miguel Fernández-Niño, Luis H. Reyes, 2022-02-02 The current advances in sequencing, data mining, DNA synthesis, cloning, in silico modeling, and genome editing have opened a new field of research known as Synthetic Genomics. The main goal of this emerging area is to engineer entire synthetic genomes from scratch using pre-designed building blocks obtained by chemical synthesis and rational design. This has opened the possibility to further improve our understanding of genome fundamentals by considering the effect of the whole biological system on biological function. Moreover, the construction of non-natural biological systems has allowed us to explore novel biological functions so far not discovered in nature. This book summarizes the current state of Synthetic Genomics, providing relevant examples in this emerging field.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

Bovine Reproduction Richard M. Hopper, 2014-08-18 Bovine Reproduction is a comprehensive, current reference providing information on all aspects of reproduction in the bull and cow. Offering fundamental knowledge on evaluating and restoring fertility in the bovine patient, the book also places information in the context of herd health where appropriate for a truly global view of bovine theriogenology. Printed in full color throughout, the book includes 83 chapters and more than 550 images, making it the most exhaustive reference available on this topic. Each section covers anatomy and physiology, breeding management, and reproductive surgery, as well as obstetrics and pregnancy wastage in the cow. Bovine Reproduction is a welcome resource for bovine practitioners, theriogenologists, and animal scientists, as well as veterinary students and residents with an interest in the cow.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: A**

Crack in Creation Jennifer Doudna, Samuel Sternberg, 2017-06-15 'The most important advance of our era. One of the pioneers of the field describes the exciting hunt for the key breakthrough and what it portends for our future' Walter Isaacson World-famous scientist Jennifer Doudna - winner of the 2020 Nobel Prize in Chemistry for creating the revolutionary gene-editing technique CRISPR - explains her discovery, describes its power to reshape the future of all life and warns of its use. A handful of discoveries have changed the course of human history. This book is about the most recent and potentially the most powerful and dangerous of them all. It is an invention that allows us to rewrite the genetic code that shapes and controls all living beings. As a result, dreams of genetic manipulation have become a stark reality: the power to cure disease and alleviate suffering, as well as to re-design any species, including humans, for our own ends. Jennifer Doudna is the co-inventor of this technology - known as CRISPR - and a scientist of worldwide renown. Writing with fellow researcher Samuel Sternberg, here she provides the definitive account of her discovery, explaining how this wondrous invention works and what it is capable of. She also asks us to consider what our new-found power means: how do we enjoy its unprecedented benefits while avoiding its equally unprecedented dangers? \_\_\_\_\_ PRAISE FOR A CRACK IN CREATION: 'The future is in our hands as never before, and this book explains the stakes like no other' George Lucas 'One of the



most PIONEERING women in science . . . Exhilarating' Arianna Huffington 'Thrilling' Adam Rutherford 'An instant classic' Siddhartha Mukherjee

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Caenorhabditis Elegans** Henry F. Epstein, Diane C. Shakes, 1995 The first of its kind, this laboratory handbook emphasizes diverse methods and technologies needed to investigate *C. elegans*, both as an integrated organism and as a model system for research inquiries in cell, developmental, and molecular biology, as well as in genetics and pharmacology. Four primary sections--Genetic and Culture Methods, Neurobiology, Cell and Molecular Biology, and Genomics and Informatics--reflect the cross-disciplinary nature of *C. elegans* research. Because *C. elegans* is a simple and malleable organism with a small genome and few cell types, it provides an elegant demonstr.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Esterases—Advances in Research and Application: 2013 Edition** , 2013-06-21 Esterases—Advances in Research and Application: 2013 Edition is a ScholarlyEditions™ book that delivers timely, authoritative, and comprehensive information about Carboxylic Ester Hydrolases. The editors have built Esterases—Advances in Research and Application: 2013 Edition on the vast information databases of ScholarlyNews.™ You can expect the information about Carboxylic Ester Hydrolases in this book to be deeper than what you can access anywhere else, as well as consistently reliable, authoritative, informed, and relevant. The content of Esterases—Advances in Research and Application: 2013 Edition has been produced by the world's leading scientists, engineers, analysts, research institutions, and companies. All of the content is from peer-reviewed sources, and all of it is written, assembled, and edited by the editors at ScholarlyEditions™ and available exclusively from us. You now have a source you can cite with authority, confidence, and credibility. More information is available at <http://www.ScholarlyEditions.com/>.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Cell Culture Engineering** Gyun Min Lee, Helene Fastrup Kildegaard, 2020-01-13 Offers a comprehensive overview of cell culture engineering, providing insight into cell engineering, systems biology approaches and processing technology In Cell Culture Engineering: Recombinant Protein Production, editors Gyun Min Lee and Helene Fastrup Kildegaard assemble top class authors to present expert coverage of topics such as: cell line development for therapeutic protein production; development of a transient gene expression upstream platform; and CHO synthetic biology. They provide readers with everything they need to know about enhancing product and bioprocess attributes using genome-scale models of CHO metabolism; omics data and mammalian systems biotechnology; perfusion culture; and much more. This all-new, up-to-date reference covers all of the important aspects of cell culture engineering, including cell engineering, system biology approaches, and processing technology. It describes the challenges in cell line development and cell engineering, e.g. via gene editing tools like CRISPR/Cas9 and with the aim to engineer glycosylation patterns. Furthermore, it gives an overview about synthetic biology approaches applied to cell culture engineering and elaborates the use of CHO cells as common cell line for protein production. In addition, the book discusses the most important aspects of production processes, including cell culture media, batch, fed-batch, and perfusion processes as well as process analytical technology, quality by design, and scale down models. -Covers key elements of cell culture engineering applied to the production of recombinant proteins for therapeutic use -Focuses on mammalian and animal cells to help highlight synthetic and systems biology approaches to cell culture engineering, exemplified by the widely used CHO cell line -Part of the renowned Advanced Biotechnology book series Cell Culture Engineering: Recombinant Protein Production will appeal to biotechnologists, bioengineers, life scientists, chemical engineers, and PhD students in the life sciences.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Advances in New Technology for Targeted Modification of Plant Genomes** Feng Zhang, Holger Puchta, James G. Thomson, 2015-04-21 Over the past 50 years, biotechnology has been the major driving force for increasing crop productivity. Particularly, advances in plant genetic engineering

technologies have opened up vast new opportunities for plant researchers and breeders to create new crop varieties with desirable traits. Recent development of precise genome modification methods, such as targeted gene knock-out/knock-in and precise gene replacement, moves genetic engineering to another level and offers even more potentials for improving crop production. The work provides an overview of the latest advances on precise genomic engineering technologies in plants. Topics include recombinase and engineered nucleases-mediated targeted modification, negative/positive selection-based homologous recombination and oligo nucleotide-mediated recombination. Finally, challenges and impacts of the new technologies on present regulations for genetic modification organisms (GMOs) will be discussed.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**Frontiers in Plant Science: 2020 Highlights** Frontiers in Plant Science Editorial Office, 2021-04-30 The Editorial Office of Frontiers in Plant Science would like to thank all the Chief Editors, Associate Editors and Review Editors that played an integral part in Frontiers' innovative Collaborative Peer-Review process in 2020. In particular, we would like to recognize and thank Prof. Joshua L. Heazlewood – our now former Field Chief Editor, for his commitment, support and enthusiasm for the Plant Science field. Josh's dedication and leadership has helped Frontiers in Plant Science become the most cited journal in the field with a strong editorial community. Looking forward, we're excited to welcome Prof. Yunde Zhao, as our new Field Chief Editor in 2021. Having been with Frontiers in Plant Science since 2017, Yunde has contributed extensively to the development of the journal and will continue to ensure the journal goes from strength to strength.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**Handbook of Chemical Biology of Nucleic Acids** Naoki Sugimoto, 2023-07-29 This handbook is the first to comprehensively cover nucleic acids from fundamentals to recent advances and applications. It is divided into 10 sections where authors present not only basic knowledge but also recent research. Each section consists of extensive review chapters covering the chemistry, biology, and biophysics of nucleic acids as well as their applications in molecular medicine, biotechnology and nanotechnology. All sections within this book are: Physical Chemistry of Nucleic Acids (Section Editor: Prof. Roland Winter), Structural Chemistry of Nucleic Acids (Section Editor: Prof. Janez Plavec), Organic Chemistry of Nucleic Acids (Section Editor: Prof. Piet Herdewijn), Ligand Chemistry of Nucleic Acids (Section Editor: Prof. Marie-Paule Teulade-Fichou), Nucleic Acids and Gene Expression (Section Editor: Prof. Cynthia Burrows), Analytical Methods and Applications of Nucleic Acids (Section Editor: Prof. Chaoyong Yang), Nanotechnology and Nanomaterial Biology of Nucleic Acids (Section Editor: Prof. Zhen Xi), Nucleic Acids Therapeutics (Section Editor: Prof. Katherine Seley-Radtke), Biotechnology and Synthetic Biology of Nucleic Acids (Section Editor: Prof. Eriks Rozners), Functional Nucleic Acids (Section Editor: Prof. Keith R. Fox). The handbook is edited by outstanding leaders with contributions written by international renowned experts. It is a valuable resource not only for researchers but also graduate students working in areas related to nucleic acids who would like to learn more about their important role and potential applications.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**CRISPR-Cas in Agriculture: Opportunities and Challenges** Sandeep Kumar, Hiroshi Ezura, Vladimir Nekrasov, Linda Ann Rymarquis, 2021-05-28

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**

**Stress and Environmental Regulation of Gene Expression and Adaptation in Bacteria, 2 Volume Set** Frans J. de Bruijn, 2016-09-06 Bacteria in various habitats are subject to continuously changing environmental conditions, such as nutrient deprivation, heat and cold stress, UV radiation, oxidative stress, dessication, acid stress, nitrosative stress, cell envelope stress, heavy metal exposure, osmotic stress, and others. In order to survive, they have to respond to these conditions by adapting their physiology through sometimes drastic changes in gene expression. In addition they may adapt by changing their morphology, forming biofilms, fruiting bodies or spores, filaments, Viable But Not Culturable (VBNC) cells or moving away from stress compounds via chemotaxis. Changes in gene expression constitute the main component of the bacterial response to stress and environmental

changes, and involve a myriad of different mechanisms, including (alternative) sigma factors, bi- or tri-component regulatory systems, small non-coding RNA's, chaperones, CHRIS-Cas systems, DNA repair, toxin-antitoxin systems, the stringent response, efflux pumps, alarmones, and modulation of the cell envelope or membranes, to name a few. Many regulatory elements are conserved in different bacteria; however there are endless variations on the theme and novel elements of gene regulation in bacteria inhabiting particular environments are constantly being discovered. Especially in (pathogenic) bacteria colonizing the human body a plethora of bacterial responses to innate stresses such as pH, reactive nitrogen and oxygen species and antibiotic stress are being described. An attempt is made to not only cover model systems but give a broad overview of the stress-responsive regulatory systems in a variety of bacteria, including medically important bacteria, where elucidation of certain aspects of these systems could lead to treatment strategies of the pathogens. Many of the regulatory systems being uncovered are specific, but there is also considerable "cross-talk" between different circuits. *Stress and Environmental Regulation of Gene Expression and Adaptation in Bacteria* is a comprehensive two-volume work bringing together both review and original research articles on key topics in stress and environmental control of gene expression in bacteria. Volume One contains key overview chapters, as well as content on one/two/three component regulatory systems and stress responses, sigma factors and stress responses, small non-coding RNAs and stress responses, toxin-antitoxin systems and stress responses, stringent response to stress, responses to UV irradiation, SOS and double stranded systems repair systems and stress, adaptation to both oxidative and osmotic stress, and desiccation tolerance and drought stress. Volume Two covers heat shock responses, chaperonins and stress, cold shock responses, adaptation to acid stress, nitrosative stress, and envelope stress, as well as iron homeostasis, metal resistance, quorum sensing, chemotaxis and biofilm formation, and viable but not culturable (VBNC) cells. Covering the full breadth of current stress and environmental control of gene expression studies and expanding it towards future advances in the field, these two volumes are a one-stop reference for (non) medical molecular geneticists interested in gene regulation under stress.

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**Human Reproductive and Prenatal Genetics** Peter C.K. Leung, Jie Qiao, 2023-03-22 \*\*Selected for Doody's Core Titles® 2024 in Clinical Genetics\*\* *Human Reproductive and Prenatal Genetics*, Second Edition provides application-driven coverage of key topics in human reproductive and prenatal genetics, including genetic control underlying the development of the reproductive tracts and gametogenesis, the genetics of fertilization and implantation, the genetic basis of female and male infertility, as well as genetic and epigenetic aspects of assisted reproduction. Also examined are the genetics and epigenetics of the placenta in normal and abnormal pregnancy, preimplantation genetic diagnosis and screening, and cutting-edge advances in noninvasive prenatal screening, prenatal genetic counseling, and bioethical and medicolegal aspects of relevance in the lab and clinic. This new edition has been fully revised to address new and evolving technologies in human reproductive genetics, with new chapters added on chromatin landscapes and sex determination, genetic alterations of placental development and preeclampsia, metabolism and inflammation in PCOS, pre-implantational genetic testing, maternal genetic disorders, bioethics, and future applications. - Features chapter contributions from leading international scientists and clinicians - Provides in-depth coverage of key topics in human reproductive and prenatal genetics, including genetic controls, fertilization, placental development, embryo implantation, in vitro culture of the human embryo for the study of post-implantation development, and more - Identifies how researchers and clinicians can implement the latest genetic, epigenetic, and -omics-based approaches - Includes all new chapters on evolving technologies and recent genetic discoveries of relevance to reproductive medicine

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*CRISPR/Cas Tool Kit for Genome Editing* Aftab Ahmad, Sultan Habibullah Khan, Zulqurnain Khan, 2022-01-01 This book discusses CRISPR/Cas- one of the most powerful tools available to scientists

for genome editing. CRISPR/Cas is not only a genome editing tool, but researchers have also engineered it for gene regulation, genome imaging, base editing and epigenome regulations. This book describes the entire toolkit for CRISPR/Cas. The opening section gives an introduction to the technique and compares it with other genome editing tools. Further section gives a historical perspective of the tool, along with its detailed classification. The next chapters describe bioinformatic tools in CRISPR/Cas, and delivery methods for CRISPR/Cas. The book also discusses about the applications of CRISPR/Cas beyond genome editing and use of CRISPR for rewriting genetic codes. The book dedicates a section to the use of CRISPR in plants. The book culminates with a chapter on the current status, challenges and shortcomings of the CRISPR/Cas genome editing tool. The book would be highly interesting to students and researchers in molecular biology, biochemistry, biotechnology, food science, agriculture and plant sciences.

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**CRISPR-aided bioengineering for value-added product development** Anindya Bandyopadhyay, Michael Köpke, Tae Seok Moon, 2024-01-08

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*Genome Engineering for Crop Improvement* Bidyut Kumar Sarmah, Basanta Kumar Borah, 2021-04-18 This book serves the teachers, researchers and the students as a handy and concise reference as well as guidebook while designing and planning for use of the advanced technologies for crop improvement. The content of the book is designed to cover the latest genome engineering techniques for crop improvement. The conventional breeding has got its limitations such as non-availability of desired genes within the genepool. In many cases, breeding has been highly used and it has nearly reached its highest limit so far as the productivity and production of crops are concerned. However, with increasing need of food and decreasing resources, including water, land, labour, etc., to feed the growing population, the alternative available ways of increasing crop productivity need to be explored and exploited. Genome engineering has a wide scope that includes technologies such as genetic engineering and transgenesis, RNA technologies, CRISPR, cisgenics and subgenics for better productivity and more efficient biotic and abiotic stress management. Therefore, the book is planned to enlighten the readers with the advanced technologies with examples and case studies, whenever possible. Efforts will be made to emphasize on general efforts on various major food crops; however, it would also be made clear that such efforts could be taken as proofs of concepts and that this could be extrapolated keeping the demand in mind.

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Therapeutic Gene Correction Strategies Based on CRISPR Systems or Other Engineered Site-specific Nucleases Ayal Hendel, Rasmus O. Bak, 2023-05-16

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity:**  
*Bioinorganic Chemistry* Rosette M. Roat-Malone, 2020-03-17 Introduces students to the basics of bioinorganic chemistry This book provides the fundamentals for inorganic chemistry and biochemistry relevant to understanding bioinorganic topics. It provides essential background material, followed by detailed information on selected topics, to give readers the background, tools, and skills they need to research and study bioinorganic topics of interest to them. To reflect current practices and needs, instrumental methods and techniques are referred to and mixed in throughout the book. *Bioinorganic Chemistry: A Short Course, Third Edition* begins with a chapter on Inorganic Chemistry and Biochemistry Essentials. It then continues with chapters on: Computer Hardware, Software, and Computational Chemistry Methods; Important Metal Centers in Proteins; Myoglobins, Hemoglobins, Superoxide Dismutases, Nitrogenases, Hydrogenases, Carbonic Anhydrases, and Nitrogen Cycle Enzymes. The book concludes with chapters on Nanobioinorganic Chemistry and Metals in Medicine. Readers are also offered end-of-section summaries, conclusions, and thought problems. Reduces size of the text from previous edition to match the first, keeping it appropriate for a one-semester course Offers primers and background materials to help students feel comfortable with research-level bioinorganic chemistry Emphasizes select and diverse topics using extensive references from current scientific literature, with more emphasis on molecular biology in

the biochemistry section, leading to a discussion of CRISPR technology Adds new chapters on hydrogenases, carbonic anhydrases, and nitrogen cycle enzymes, along with a separate chapter on nanobioinorganic chemistry Features expanded coverage of computer hardware and software, metalloenzymes, and metals in medicines Supplemented with a companion website for students and instructors featuring Powerpoint and JPEG figures and tables, arranged by chapter Appropriate for one-semester bioinorganic chemistry courses, *Bioinorganic Chemistry: A Short Course*, Third Edition is ideal for upper-level undergraduate and beginning graduate students. It is also a valuable reference for practitioners and researchers in need of a general introduction to the subject, as well as chemists requiring an accessible reference.

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**Capillary Gel Electrophoresis** Andras Guttman, László Hajba, 2021-12-04 *Capillary Gel Electrophoresis and Related Microseparation Techniques* covers all theoretical and practical aspects of capillary gel electrophoresis. It also provides an excellent overview of the key application areas of nucleic acid, protein and complex carbohydrate analysis, affinity-based methodologies, micropreparative aspects and related microseparation methods. It not only gives readers a better understanding of how to utilize this technology, but also provides insights into how to determine which method will provide the best technical solutions to particular problems. This book can also serve as a textbook for undergraduate and graduate courses in analytical chemistry, analytical biochemistry, molecular biology and biotechnology courses. - Covers all theoretical and practical aspects of capillary gel electrophoresis - Excellent overview of the key applications of nucleic acid, protein and complex carbohydrate analysis, affinity-based methodologies, micropreparative aspects and related microseparation methods - Teaches readers how to use the technology and select methods that are ideal for fundamental problems - Can serve as a textbook for undergraduate and graduate courses in analytical chemistry, analytical biochemistry, molecular biology and biotechnology courses

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**Oligonucleotide Synthesis** Piet Herdewijn, 2008-02-04 A collection of powerful new techniques for oligonucleotide synthesis and for the use of modified oligonucleotides in biotechnology. Among the protocol highlights are a novel two-step process that yields a high purity, less costly, DNA, the synthesis of phosphorothioates using new sulfur transfer agents, the synthesis of LNA, peptide conjugation methods to improve cellular delivery and cell-specific targeting, and triple helix formation. The applications include using molecular beacons to monitor the PCR amplification process, nuclease footprinting to study the sequence-selective binding of small molecules of DNA, nucleic acid libraries, and the use of small interference RNA (siRNA) as an inhibitor of gene expression.

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**CRISPR Crops** Aftab Ahmad, Sultan Habibullah Khan, Zulqurnain Khan, 2021-01-08 This book compiles the latest applications of the cutting-edge gene editing tool CRISPR/Cas in the area of crop improvement. It begins with an introduction to the technique and its application in crop plants. Next, it gives an updated overview of available delivery methods, design tools and resources in CRISPR/Cas. The book subsequently reviews the applications of CRISPR/Cas in connection with e.g. insect stress, disease stress, abiotic stress, nutritional and yield improvement in crop plants, etc. It also discusses the various regulatory, ethical and social aspects of the technique that must be kept in mind when designing experiments. In closing, the book summarizes the status quo and outlines future prospects for the tool in crop improvement and food security. Given its scope, the book will especially benefit students and researchers in food science, biotechnology, agriculture and the plant sciences.

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**Targeted Genome Editing Using Site-Specific Nucleases** Takashi Yamamoto, 2015-01-05 This book serves as an introduction to targeted genome editing, beginning with the background of this rapidly developing field and methods for generation of engineered nucleases. Applications of genome

editing tools are then described in detail, in iPS cells and diverse organisms such as mice, rats, marine invertebrates, fish, frogs, and plants. Tools that are mentioned include zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and CRISPR/Cas9, all of which have received much attention in recent years as breakthrough technologies. Genome editing with engineered nucleases allows us to precisely change the target genome of living cells and is a powerful way to control functional genes. It is feasible in almost all organisms ranging from bacteria to plants and animals, as well as in cultured cells such as ES and iPS cells. Various genome modifications have proven successful, including gene knockout and knock-in experiments with targeting vectors and chromosomal editing. Genome editing technologies hold great promise for the future, for example in biomedical research, clinical medicine, and generation of crops and livestock with desirable traits. A wide range of readers will find this book interesting, and with its focus on applications in a variety of organisms and cells, the book will be valuable for life scientists in all fields.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Biotechnologies for Gene Therapy** Yang H. Yun, Kristine E. Yoder, 2022-06-02 The purpose of this book is to highlight some of latest developments and applications of CRISPR, RNA, and DNA to treat diseases ranging from cancers to cardiovascular and degenerative disorders. It also features innovations of the delivery methods for nucleic acids ranging from nanodevices made from DNA and pseudo amino acids to viral vectors. This is an ideal book for academics, clinicians, and students interested in gene therapy.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Precision Medicine, CRISPR, and Genome Engineering** Stephen H. Tsang, 2017-11-11 This book presents descriptive overviews of gene editing strategies across multiple species while also offering in-depth insight on complex cases of application in the field of tissue engineering and regenerative medicine. Chapters feature contributions from leaders in stem cell therapy and biology, providing a comprehensive view of the application of gene therapy in numerous fields with an emphasis on ophthalmology, stem cells, and agriculture. The book also highlights recent major technological advances, including ZFN, TALEN, and CRISPR. Precision Medicine, CRISPR, and Genome Engineering is part of the highly successful Advances in Experimental Medicine and Biology series. It is an indispensable resource for researchers and students in genetics as well as clinicians.

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Reprogramming the Genome: CRISPR-Cas-based Human Disease Therapy** Vijai Singh, 2021-06-15 Reprogramming the Genome: CRISPR-Cas-based Human Disease Therapy, presents the collation of chapters written by eminent scientists worldwide. CRISPR-Cas9 is a key technology for targeted genome editing and regulation in a number of organisms including mammalian cells. It is a rapid, simple, and cost-effective solution. CRISPR-Cas system has recently gained much scientific and public attention. This volume covers CRISPR-Cas9 based mammalian genome editing, creating disease models, cancer therapy, neurological, heredity, blood disorders, defective gene correction, stem cells therapy, epigenetic modifications, patents, ethics, biosafety and regulatory issues challenges and opportunities. This book is a key source of information on mammalian genome editing available in a single volume. This book will be useful for beginners in mammalian genome editing and also students, researchers, scientists, policymakers, clinicians and stakeholders interested in genome editing in several areas. Offers basic understanding and a clear picture of mammalian genome editing through CRISPR-Cas systems Discusses how to create mammalian disease models, stem cell modification, epigenetic modifications, correction of defective gene in blood disorders, heredity, neurological disorders and many more Discusses the application of CRISPR-Cas9 systems in basic sciences, biomedicine, molecular biology, translational sciences, neurobiology, neurology, cancer, stem cells, and many more

**a programmable dual rna guided dna endonuclease in adaptive bacterial immunity: Next Generation Plant Breeding** Yelda Ozden Çiftçi, 2018-09-26 Following the green revolution and transgenic crop development, another revolutionary progress has been experienced in plant

breeding in the last decade with the application of marker-assisted selection (MAS), next-generation sequencing (NGS), and gene editing techniques together with omic technologies, including genomics, transcriptomics, proteomics, and phenomics. Thus, this book is structured into two sections: Marker-Assisted Breeding and RNA-seq and Gene Editing in Plants, which aim to provide a reference for students, instructors, and scientists on recent innovative advances in plant-breeding programs to cultivate crops for tomorrow.

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CRISPR People Henry T. Greely, 2022-03-01 What does the birth of babies whose embryos had gone through genome editing mean—for science and for all of us? In November 2018, the world was shocked to learn that two babies had been born in China with DNA edited while they were embryos—as dramatic a development in genetics as the 1996 cloning of Dolly the sheep. In this book, Hank Greely, a leading authority on law and genetics, tells the fascinating story of this human experiment and its consequences. Greely explains what Chinese scientist He Jiankui did, how he did it, and how the public and other scientists learned about and reacted to this unprecedented genetic intervention. The two babies, nonidentical twin girls, were the first “CRISPR’d” people ever born (CRISPR, Clustered Regularly Interspaced Short Palindromic Repeats, is a powerful gene-editing method). Greely not only describes He’s experiment and its public rollout (aided by a public relations adviser) but also considers, in a balanced and thoughtful way, the lessons to be drawn both from these CRISPR’d babies and, more broadly, from this kind of human DNA editing—“germline editing” that can be passed on from one generation to the next. Greely doesn’t mince words, describing He’s experiment as grossly reckless, irresponsible, immoral, and illegal. Although he sees no inherent or unmanageable barriers to human germline editing, he also sees very few good uses for it—other, less risky, technologies can achieve the same benefits. We should consider the implications carefully before we proceed.

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### **Introduction**

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