

building a paper model of crispr-cas9 answer key

building a paper model of crispr-cas9 answer key offers a unique and interactive way to understand the intricate mechanisms of the CRISPR-Cas9 gene-editing system. This educational tool enables learners and researchers alike to visualize the components and processes involved in targeted DNA modification through a tangible, hands-on approach. Constructing a paper model requires detailed knowledge of the CRISPR-Cas9 structure, including the Cas9 enzyme, guide RNA, and DNA target sequence. This article provides a comprehensive answer key to building a paper model of CRISPR-Cas9, covering essential materials, step-by-step assembly instructions, and scientific background. Additionally, it addresses common challenges and troubleshooting tips to ensure accuracy and educational value. The following sections will guide readers through the process, from understanding the biological basis to the practical aspects of model construction.

- Understanding the CRISPR-Cas9 System
- Materials and Tools Required
- Step-by-Step Guide to Building the Paper Model
- Scientific Explanation of Each Component
- Common Challenges and Troubleshooting

Understanding the CRISPR-Cas9 System

The CRISPR-Cas9 system is a revolutionary gene-editing technology derived from a natural defense mechanism in bacteria. It allows precise modification of DNA sequences by utilizing a guide RNA to direct the Cas9 nuclease to a specific genomic location. This section explains the biological components and function of CRISPR-Cas9, setting the foundation for building an accurate paper model. Key elements include the Cas9 protein, which acts as molecular scissors, and the guide RNA that determines target specificity.

Components of CRISPR-Cas9

The CRISPR-Cas9 complex consists primarily of the Cas9 enzyme and a single-guide RNA (sgRNA). The sgRNA is engineered by combining CRISPR RNA (crRNA) and trans-activating crRNA (tracrRNA) sequences. The Cas9 protein binds to the sgRNA, forming a ribonucleoprotein complex capable of scanning DNA for complementary sequences adjacent to a protospacer adjacent motif (PAM).

Mechanism of DNA Targeting and Cleavage

Once the Cas9-sgRNA complex locates the target DNA sequence, the enzyme induces a double-strand break at a precise location. This break activates cellular DNA repair pathways, enabling gene editing through non-homologous end joining or homology-directed repair. Understanding this mechanism is crucial for accurately representing the dynamic interactions in a paper model of CRISPR-Cas9.

Materials and Tools Required

Preparing to build a paper model of CRISPR-Cas9 requires selecting appropriate materials and tools that facilitate precision and durability. This section outlines the essential supplies needed to create detailed and functional model components.

Essential Materials

- High-quality cardstock or heavy paper for structural stability
- Colored paper or markers to differentiate components such as Cas9, sgRNA, and DNA
- Scissors or precision craft knives for cutting intricate shapes
- Glue sticks or liquid adhesive to assemble parts securely
- Ruler and pencil for accurate measurements and markings
- Templates or printable patterns specifically designed for CRISPR-Cas9 modeling

Optional Tools for Enhanced Detailing

Additional tools can improve the model's accuracy and educational value. These include tweezers for handling small paper parts, scoring tools to create clean folds, and colored pens for labeling distinct regions of the model.

Step-by-Step Guide to Building the Paper Model

This section provides a detailed, sequential approach to assembling the paper model of CRISPR-Cas9. Each step corresponds to constructing specific components and integrating them into the complete structure.

Step 1: Preparing the Templates

Begin by printing or drawing templates for the Cas9 enzyme, sgRNA, and DNA strands on cardstock. Ensure that each part is scaled correctly to maintain proportionality. Carefully cut out the shapes using scissors or a craft knife.

Step 2: Folding and Shaping Components

Score fold lines to create three-dimensional forms representing the protein domains and RNA structures. Fold along the scored lines to achieve the desired shapes, such as the lobes of the Cas9 enzyme and the stem-loop structures of the sgRNA.

Step 3: Assembling Individual Elements

Use glue to attach tabs and secure folds, forming the three-dimensional Cas9 protein and the guide RNA. Similarly, assemble the DNA double helix segments, paying attention to base pairing patterns to illustrate the target sequence accurately.

Step 4: Integrating the Components

Attach the sgRNA to the Cas9 protein model, replicating the natural ribonucleoprotein complex. Position the DNA segment adjacent to the complex, highlighting the recognition and cleavage site. Use colored markers to emphasize the PAM sequence and cleavage points.

Step 5: Final Adjustments and Labeling

Make any necessary adjustments to ensure the stability and clarity of the model. Label each component clearly to facilitate understanding of the CRISPR-Cas9 mechanism during presentations or educational sessions.

Scientific Explanation of Each Component

To maximize the educational impact, the paper model should accurately represent the functional aspects of the CRISPR-Cas9 system. This section provides a scientific description of each component depicted in the model.

Cas9 Enzyme Structure and Function

The Cas9 protein is a large endonuclease consisting of multiple domains responsible for DNA binding and cleavage. Its bi-lobed architecture includes the recognition lobe (REC) and the nuclease lobe (NUC), which contains the HNH and RuvC domains. These domains coordinate to cleave the target DNA strands during gene editing.

Guide RNA Configuration

The guide RNA directs Cas9 to the complementary DNA sequence. It contains a spacer region complementary to the target DNA and structural elements necessary for Cas9 binding. The sgRNA in the model should illustrate these secondary structures, including the scaffold region.

DNA Target and PAM Recognition

The DNA substrate contains the target sequence and an adjacent PAM motif, typically “NGG” in the case of *Streptococcus pyogenes* Cas9. The model should highlight the PAM site as it is critical for Cas9 binding and cleavage specificity.

Common Challenges and Troubleshooting

Building a paper model of CRISPR-Cas9 can present several challenges related to complexity, accuracy, and assembly. This section addresses common issues and offers solutions to improve the building experience and final product quality.

Ensuring Structural Stability

One frequent challenge is maintaining the model’s structural integrity, especially when working with small or delicate parts. Using heavier cardstock and applying adhesive carefully can prevent deformation and detachment of components.

Maintaining Proportional Accuracy

Scaling components correctly is essential to represent the biological system faithfully. Double-check measurements and use precise cutting tools to avoid discrepancies in size that could mislead learners about the relative dimensions of Cas9, sgRNA, and DNA.

Clarifying Complex Interactions

Visualizing the dynamic interaction between Cas9, sgRNA, and DNA can be difficult in a static paper model. Incorporating color coding, labeling, and detachable parts can enhance comprehension of the molecular mechanism.

Troubleshooting Assembly Errors

If parts do not fit together as intended, review the template design and folding instructions. Adjust folds or trim excess paper carefully to improve fitting without compromising the model’s integrity.

Tips for Effective Presentation

- Use clear labels and legends to explain each component.
- Incorporate descriptive notes about the gene-editing process.
- Demonstrate the model's function during educational sessions to reinforce learning.

Frequently Asked Questions

What materials are needed to build a paper model of CRISPR-Cas9?

You will need colored paper or cardstock, scissors, glue or tape, markers or pens for labeling, and printed templates of the CRISPR-Cas9 components.

How can I accurately represent the Cas9 protein in a paper model?

Use colored cardstock to create a three-dimensional shape resembling the Cas9 protein structure; include key domains such as the recognition lobe and nuclease lobe using different colors or labels.

What is the best way to illustrate the guide RNA in the paper model?

Use a contrasting color and shape, such as a long strip or folded paper, to represent the guide RNA, and label it clearly to show its role in targeting specific DNA sequences.

How do I model the target DNA in the CRISPR-Cas9 paper model?

Create two parallel strips of paper representing the DNA strands, with complementary base pairs drawn or labeled, and position them near the guide RNA and Cas9 protein to demonstrate interaction.

Can I include the PAM sequence in my paper model, and how?

Yes, the PAM (Protospacer Adjacent Motif) sequence is critical; indicate it on the target DNA strand using a distinct color or label to highlight its importance in Cas9 binding.

How do I demonstrate the cleavage activity of Cas9 in a paper

model?

You can show cleavage by making a small cut or gap in the DNA strands at the cleavage site, or use arrows and labels to indicate where Cas9 cuts the DNA.

Are there printable templates available for building a CRISPR-Cas9 paper model?

Yes, several educational websites and scientific outreach resources provide free or purchasable printable templates designed to build accurate CRISPR-Cas9 paper models.

What educational concepts can be taught using a CRISPR-Cas9 paper model?

The model can help explain gene editing mechanics, DNA-protein interactions, molecular biology concepts like nucleic acid base pairing, and the function of guide RNA and PAM sequences.

How detailed should my paper model be for classroom use?

For classroom use, a balance between detail and simplicity is best; include major components like Cas9, guide RNA, target DNA, and PAM sequence, with clear labels to facilitate understanding.

Can the paper model be used to demonstrate different types of CRISPR-Cas systems?

While the model typically represents the Cas9 system, it can be adapted with modifications to illustrate other CRISPR-Cas systems by changing protein shapes or RNA structures accordingly.

Additional Resources

1. CRISPR-Cas9: A Molecular Toolkit for Genome Editing

This book provides a comprehensive overview of the CRISPR-Cas9 system, explaining its biological components and mechanisms. It is an excellent resource for understanding the structure and function of Cas9, which is essential for creating accurate paper models. Detailed illustrations and diagrams support readers in visualizing the molecular interactions that can be translated into physical models.

2. Paper Models in Molecular Biology: Techniques and Applications

Focusing on the art of building paper models in biology, this book covers various techniques to create detailed and accurate molecular representations. It includes step-by-step guides on crafting complex structures like proteins and nucleic acids, which can be adapted for CRISPR-Cas9 models. The book emphasizes precision and educational value in model construction.

3. Visualizing CRISPR-Cas9: From Molecular Structure to Paper Model

This title bridges the gap between molecular biology and hands-on modeling by guiding readers through the process of translating CRISPR-Cas9 structures into paper models. It discusses the molecular details of the CRISPR complex and offers practical advice on scaling, folding, and

assembling paper components. The book is ideal for educators and students interested in interactive learning tools.

4. Genome Editing Explained: CRISPR-Cas9 and Beyond

While primarily focused on the science of genome editing, this book provides detailed structural information on CRISPR-Cas9 that is useful for model makers. It covers the protein domains, guide RNA, and DNA interaction sites, which are critical features to replicate in a paper model. The clear explanations support a deeper understanding of the model's biological significance.

5. 3D Paper Engineering for Science Education

This book explores the principles of three-dimensional paper engineering tailored for scientific subjects. It offers creative strategies to construct intricate paper models, including molecular machines like CRISPR-Cas9. Readers will find inspiration and technical tips to enhance the realism and functionality of their paper models.

6. Constructing Molecular Models: A Hands-On Guide

Designed for students and educators, this guidebook details the practical aspects of building molecular models using various materials, including paper. It highlights the importance of accuracy in representing molecular shapes and interactions, with chapters dedicated to nucleic acid-protein complexes such as CRISPR-Cas9. The book encourages experimentation with different modeling techniques.

7. The CRISPR Revolution: Science, Ethics, and Education

This book delves into the impact of CRISPR technology and offers educational tools to teach its concepts, including model-building activities. It features sections on creating tactile learning aids like paper models to help visualize gene-editing processes. The ethical discussions provide context to the educational use of CRISPR models.

8. Biomolecular Structures: From X-Ray Crystallography to Paper Models

Focusing on the structural determination of biomolecules, this book explains how to interpret crystal structures for model construction. It guides readers in converting complex 3D data of molecules like Cas9 into simplified, accurate paper models. The text bridges advanced scientific data and accessible educational modeling.

9. DIY Bio Models: Crafting Scientific Concepts with Paper

This creative guide encourages the use of paper crafts to represent various biological concepts, including gene-editing tools like CRISPR-Cas9. It offers templates, folding techniques, and assembly instructions tailored for scientific accuracy and classroom engagement. The book is perfect for hobbyists and educators seeking innovative teaching aids.

[Building A Paper Model Of Crispr Cas9 Answer Key](#)

Building a Paper Model of CRISPR-Cas9: A Comprehensive Guide for Educators and Students

This ebook provides a detailed, step-by-step guide to constructing an accurate and engaging paper model of the CRISPR-Cas9 gene editing system, highlighting its mechanism and significance in biotechnology and medicine. The guide is designed for educators seeking innovative teaching tools and students wanting a hands-on understanding of this groundbreaking technology.

Ebook Title: Unlocking the Code: A Paper Model Approach to Understanding CRISPR-Cas9

Contents:

Introduction: What is CRISPR-Cas9? Its mechanism and significance.

Chapter 1: Gathering Materials and Tools: A detailed list of necessary supplies and tools.

Chapter 2: Constructing the Cas9 Protein: Step-by-step instructions for building the Cas9 protein model.

Chapter 3: Building the Guide RNA (gRNA): Instructions for creating the gRNA component of the system.

Chapter 4: Assembling the CRISPR-Cas9 Complex: Detailed steps for combining the Cas9 and gRNA models.

Chapter 5: Representing the Target DNA: How to construct a paper model of the target DNA sequence.

Chapter 6: Demonstrating the Gene Editing Process: Illustrating the binding and cutting mechanisms visually.

Chapter 7: Applications and Ethical Considerations: Exploring the uses and ethical implications of CRISPR-Cas9.

Conclusion: Recap and further exploration of CRISPR-Cas9 technology.

Detailed Outline Explanation:

Introduction: This section will define CRISPR-Cas9, explaining its function as a gene editing tool, its bacterial origins, and its revolutionary impact on various fields, including medicine, agriculture, and biotechnology. It will briefly introduce the concept of the paper model as a learning tool. Recent advancements in CRISPR technology will also be mentioned.

Chapter 1: Gathering Materials and Tools: This chapter provides a comprehensive list of materials needed for the project, including different types of paper (e.g., colored construction paper, cardstock), scissors, glue, rulers, markers, and potentially templates that can be downloaded. It will also include tips on sourcing materials cost-effectively.

Chapter 2: Constructing the Cas9 Protein: This section will guide users through the process of building a 3D paper model of the Cas9 protein. It will likely involve using pre-designed templates or providing instructions for creating one based on a simplified representation of the protein's structure. The importance of specific domains within the Cas9 protein (e.g., RuvC and HNH nuclease domains) will be emphasized.

Chapter 3: Building the Guide RNA (gRNA): This chapter will focus on building the gRNA model, explaining its crucial role in targeting the specific DNA sequence. The design of the model should visually represent the guide RNA's structure and its complementary binding to the target DNA.

Chapter 4: Assembling the CRISPR-Cas9 Complex: This chapter provides step-by-step instructions for assembling the Cas9 protein and gRNA models to create a functional representation of the CRISPR-Cas9 complex. The interaction between the two components should be clearly

demonstrated.

Chapter 5: Representing the Target DNA: This chapter describes how to construct a paper model of the target DNA double helix. This model can be simplified, perhaps using colored strips of paper to represent the nucleotide bases. The specific target sequence can be chosen to represent a gene of interest.

Chapter 6: Demonstrating the Gene Editing Process: This section will guide users through a visual representation of the CRISPR-Cas9 complex binding to the target DNA and performing the gene editing process. This might involve showing how the Cas9 protein unwinds the DNA, and then how the guide RNA facilitates the cutting of the DNA at the targeted site.

Chapter 7: Applications and Ethical Considerations: This chapter delves into the diverse applications of CRISPR-Cas9 technology in medicine (e.g., gene therapy for genetic diseases), agriculture (e.g., improving crop yields), and biotechnology (e.g., developing new drugs). It will also address the ethical concerns and potential risks associated with gene editing technology. Recent research on both successful applications and limitations of CRISPR will be reviewed.

Conclusion: The conclusion will summarize the key concepts covered in the ebook, emphasizing the importance of hands-on learning and the value of the paper model in understanding complex biological processes. It will encourage further exploration of CRISPR-Cas9 technology through online resources and research papers. It will point to relevant websites and research institutions.

Frequently Asked Questions (FAQs)

1. What age group is this ebook suitable for? This ebook is suitable for high school students, undergraduate students, and educators teaching biology or biotechnology.
2. Can I adapt this model for different gene editing targets? Yes, you can modify the target DNA model to represent different genes or sequences.
3. Are there printable templates available? Yes, downloadable templates for the Cas9 protein, gRNA, and target DNA will be provided as supplementary material.
4. How accurate is this simplified paper model? The model is a simplified representation, focusing on the key components and mechanisms of CRISPR-Cas9.
5. What are the limitations of using a paper model to teach CRISPR-Cas9? The paper model cannot fully represent the complex three-dimensional structure and dynamic interactions of the molecules.
6. How can I incorporate this activity into a classroom setting? This activity can be used as a hands-on project, group assignment, or demonstration.
7. Where can I find more information about CRISPR-Cas9 technology? Many reputable sources provide comprehensive information about CRISPR-Cas9, such as the National Institutes of Health (NIH) website and scientific journals.

8. What are the potential safety concerns associated with CRISPR-Cas9 technology? Off-target effects (unintended gene edits) and ethical implications are major concerns.
9. Are there any alternative methods for visualizing CRISPR-Cas9? Yes, computer simulations and animations are also effective tools for understanding this complex system.

Related Articles:

1. CRISPR-Cas9: A Revolution in Gene Editing: A broad overview of the technology, its history, and its impact.
2. The Mechanism of CRISPR-Cas9 Gene Editing: A detailed explanation of the molecular mechanisms involved in the process.
3. Ethical Considerations of CRISPR-Cas9 Technology: A discussion of the ethical implications and potential risks associated with gene editing.
4. Applications of CRISPR-Cas9 in Medicine: A review of the use of CRISPR-Cas9 in treating genetic diseases.
5. CRISPR-Cas9 in Agriculture: An exploration of how CRISPR-Cas9 is used to improve crop yields and create disease-resistant plants.
6. Off-Target Effects of CRISPR-Cas9: A discussion of the unintended gene edits that can occur with CRISPR-Cas9.
7. Advanced CRISPR-Cas Systems: An exploration of newer and more sophisticated versions of the CRISPR-Cas system.
8. Comparing CRISPR-Cas9 to Other Gene Editing Techniques: A comparison of CRISPR-Cas9 with other gene editing methods, such as TALENs and ZFNs.
9. The Future of CRISPR-Cas9 Technology: A look at the potential future applications and advancements of CRISPR-Cas9.

building a paper model of crispr cas9 answer key: *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

building a paper model of crispr cas9 answer key: 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.

building a paper model of crispr cas9 answer key: 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.

building a paper model of crispr cas9 answer key: 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.

building a paper model of crispr cas9 answer key: Biodefense in the Age of Synthetic Biology National Academies of Sciences, Engineering, and Medicine, Division on Earth and Life Studies, Board on Life Sciences, Board on Chemical Sciences and Technology, Committee on Strategies for Identifying and Addressing Potential Biodefense Vulnerabilities Posed by Synthetic Biology, 2019-01-05 Scientific advances over the past several decades have accelerated the ability to engineer existing organisms and to potentially create novel ones not found in nature. Synthetic biology, which collectively refers to concepts, approaches, and tools that enable the modification or creation of biological organisms, is being pursued overwhelmingly for beneficial purposes ranging from reducing the burden of disease to improving agricultural yields to remediating pollution. Although the contributions synthetic biology can make in these and other areas hold great promise,

it is also possible to imagine malicious uses that could threaten U.S. citizens and military personnel. Making informed decisions about how to address such concerns requires a realistic assessment of the capabilities that could be misused. *Biodefense in the Age of Synthetic Biology* explores and envisions potential misuses of synthetic biology. This report develops a framework to guide an assessment of the security concerns related to advances in synthetic biology, assesses the levels of concern warranted for such advances, and identifies options that could help mitigate those concerns.

building a paper model of crispr cas9 answer key: *A Crack In Creation* Jennifer A. Doudna, Samuel H. Sternberg, 2017-06-13 BY THE WINNER OF THE 2020 NOBEL PRIZE IN CHEMISTRY | Finalist for the Los Angeles Times Book Prize "A powerful mix of science and ethics . . . This book is required reading for every concerned citizen—the material it covers should be discussed in schools, colleges, and universities throughout the country."— New York Review of Books Not since the atomic bomb has a technology so alarmed its inventors that they warned the world about its use. That is, until 2015, when biologist Jennifer Doudna called for a worldwide moratorium on the use of the gene-editing tool CRISPR—a revolutionary new technology that she helped create—to make heritable changes in human embryos. The cheapest, simplest, most effective way of manipulating DNA ever known, CRISPR may well give us the cure to HIV, genetic diseases, and some cancers. Yet even the tiniest changes to DNA could have myriad, unforeseeable consequences, to say nothing of the ethical and societal repercussions of intentionally mutating embryos to create "better" humans. Writing with fellow researcher Sam Sternberg, Doudna—who has since won the Nobel Prize for her CRISPR research—shares the thrilling story of her discovery and describes the enormous responsibility that comes with the power to rewrite the code of life. "The future is in our hands as never before, and this book explains the stakes like no other." — George Lucas "An invaluable account . . . We owe Doudna several times over." — Guardian

building a paper model of crispr cas9 answer key: *Next Steps for Functional Genomics* National Academies of Sciences, Engineering, and Medicine, Division on Earth and Life Studies, Board on Life Sciences, 2020-12-18 One of the holy grails in biology is the ability to predict functional characteristics from an organism's genetic sequence. Despite decades of research since the first sequencing of an organism in 1995, scientists still do not understand exactly how the information in genes is converted into an organism's phenotype, its physical characteristics. Functional genomics attempts to make use of the vast wealth of data from -omics screens and projects to describe gene and protein functions and interactions. A February 2020 workshop was held to determine research needs to advance the field of functional genomics over the next 10-20 years. Speakers and participants discussed goals, strategies, and technical needs to allow functional genomics to contribute to the advancement of basic knowledge and its applications that would benefit society. This publication summarizes the presentations and discussions from the workshop.

building a paper model of crispr cas9 answer key: *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.

building a paper model of crispr cas9 answer key: *The Code Breaker* Walter Isaacson, 2021-03-09 A Best Book of 2021 by Bloomberg BusinessWeek, Time, and The Washington Post The bestselling author of *Leonardo da Vinci* and *Steve Jobs* returns with a “compelling” (The Washington Post) account of how Nobel Prize winner Jennifer Doudna and her colleagues launched a revolution that will allow us to cure diseases, fend off viruses, and have healthier babies. When Jennifer Doudna was in sixth grade, she came home one day to find that her dad had left a paperback titled *The Double Helix* on her bed. She put it aside, thinking it was one of those detective tales she loved. When she read it on a rainy Saturday, she discovered she was right, in a way. As she sped through the pages, she became enthralled by the intense drama behind the competition to discover the code of life. Even though her high school counselor told her girls didn’t become scientists, she decided she would. Driven by a passion to understand how nature works and to turn discoveries into inventions, she would help to make what the book’s author, James Watson, told her was the most important biological advance since his codiscovery of the structure of DNA. She and her collaborators turned a curiosity of nature into an invention that will transform the human race: an easy-to-use tool that can edit DNA. Known as CRISPR, it opened a brave new world of medical miracles and moral questions. The development of CRISPR and the race to create vaccines for coronavirus will hasten our transition to the next great innovation revolution. The past half-century has been a digital age, based on the microchip, computer, and internet. Now we are entering a life-science revolution. Children who study digital coding will be joined by those who study genetic code. Should we use our new evolution-hacking powers to make us less susceptible to viruses? What a wonderful boon that would be! And what about preventing depression? Hmmm...Should we allow parents, if they can afford it, to enhance the height or muscles or IQ of their kids? After helping to discover CRISPR, Doudna became a leader in wrestling with these moral issues and, with her collaborator Emmanuelle Charpentier, won the Nobel Prize in 2020. Her story is an “enthralled detective story” (Oprah Daily) that involves the most profound wonders of nature, from the origins of life to the future of our species.

building a paper model of crispr cas9 answer key: **Preparing for Future Products of Biotechnology** National Academies of Sciences, Engineering, and Medicine, Division on Earth and Life Studies, Board on Chemical Sciences and Technology, Board on Agriculture and Natural Resources, Board on Life Sciences, Committee on Future Biotechnology Products and Opportunities to Enhance Capabilities of the Biotechnology Regulatory System, 2017-07-28 Between 1973 and 2016, the ways to manipulate DNA to endow new characteristics in an organism (that is, biotechnology) have advanced, enabling the development of products that were not previously possible. What will the likely future products of biotechnology be over the next 5–10 years? What scientific capabilities, tools, and/or expertise may be needed by the regulatory agencies to ensure they make efficient and sound evaluations of the likely future products of biotechnology? *Preparing for Future Products of Biotechnology* analyzes the future landscape of biotechnology products and seeks to inform forthcoming policy making. This report identifies potential new risks and frameworks for risk assessment and areas in which the risks or lack of risks relating to the products of biotechnology are well understood.

building a paper model of crispr cas9 answer key: *Safety of Genetically Engineered Foods* National Research Council, Institute of Medicine, Board on Agriculture and Natural Resources, Food and Nutrition Board, Board on Life Sciences, Committee on Identifying and Assessing Unintended Effects of Genetically Engineered Foods on Human Health, 2004-07-08 Assists policymakers in evaluating the appropriate scientific methods for detecting unintended changes in food and assessing the potential for adverse health effects from genetically modified products. In this book, the committee recommended that greater scrutiny should be given to foods containing new compounds or unusual amounts of naturally occurring substances, regardless of the method used to create them. The book offers a framework to guide federal agencies in selecting the route of safety

assessment. It identifies and recommends several pre- and post-market approaches to guide the assessment of unintended compositional changes that could result from genetically modified foods and research avenues to fill the knowledge gaps.

building a paper model of crispr cas9 answer key: Editing Humanity Kevin Davies, 2020-10-06 One of the world's leading experts on genetics unravels one of the most important breakthroughs in modern science and medicine. If our genes are, to a great extent, our destiny, then what would happen if mankind could engineer and alter the very essence of our DNA coding? Millions might be spared the devastating effects of hereditary disease or the challenges of disability, whether it was the pain of sickle-cell anemia to the ravages of Huntington's disease. But this power to "play God" also raises major ethical questions and poses threats for potential misuse. For decades, these questions have lived exclusively in the realm of science fiction, but as Kevin Davies powerfully reveals in his new book, this is all about to change. Engrossing and page-turning, *Editing Humanity* takes readers inside the fascinating world of a new gene editing technology called CRISPR, a high-powered genetic toolkit that enables scientists to not only engineer but to edit the DNA of any organism down to the individual building blocks of the genetic code. Davies introduces readers to arguably the most profound scientific breakthrough of our time. He tracks the scientists on the front lines of its research to the patients whose powerful stories bring the narrative movingly to human scale. Though the birth of the "CRISPR babies" in China made international news, there is much more to the story of CRISPR than headlines seemingly ripped from science fiction. In *Editing Humanity*, Davies sheds light on the implications that this new technology can have on our everyday lives and in the lives of generations to come.

building a paper model of crispr cas9 answer key: RNA Nanotechnology Bin Wang, 2014-04-02 In the past few decades there has been incredible growth in bionano-related research, which has been accompanied by numerous publications in this field. Although various compilations address topics related to deoxyribonucleic acid (DNA) and protein, there are few books that focus on determining the structure of ribonucleic acid (RNA) and using RNA as building blocks to construct nanoarchitectures for biomedical and healthcare applications. *RNA Nanotechnology* is a comprehensive volume that details both the traditional approaches and the latest developments in the field of RNA-related technology. This book targets a wide audience: a broad introduction provides a solid academic background for students, researchers, and scientists who are unfamiliar with the subject, while the in-depth descriptions and discussions are useful for advanced professionals. The book opens with reviews on the basic aspects of RNA biology, computational approaches for predicting RNA structures, and traditional and emerging experimental approaches for probing RNA structures. This section is followed by explorations of the latest research and discoveries in RNA nanotechnology, including the design and construction of RNA-based nanostructures. The final segment of the book includes descriptions and discussions of the potential biological and therapeutic applications of small RNA molecules, such as small/short interfering RNAs (siRNAs), microRNAs (miRNAs), RNA aptamers, and ribozymes.

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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.

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Molfino, Flavia Zucco, 2008-08-05 Johannes Klumpers Biotechnologies, such as genetic engineering, cloning and biodiversity, raise many legal and ethical concerns, so it is important that people understand these issues and feel able to express their opinions. This is why the European Commission has been, for a number of years, supporting actions to improve communication among scientists in these diverse areas. The project 'Women in Biotechnology' (WONBIT), financed under the 6th Framework programme of the European Commission, is an excellent example of what can be done to target opinion-formers such as scientists, economists and lawyers in bottom-up activities, and to encourage a debate on gender issues triggered by developments in the life sciences. WONBIT gave rise to a successful international conference highlighting the importance of adopting good practices and ethical considerations in parallel with the rapid pace of progress in biotechnology - from a woman's point of view. In particular, the conference addressed women in decision-making positions in biotechnology with specific reference to scientific excellence, social competencies and management qualities as well as issues relating to environment, society and the younger generation. But it did not stop there: a key part of the conference was dedicated to stimulating public debate among non-specialists, which has led to a number of recommendations to policy-makers on better communication in biotechnology, on taking better account of the gender aspects of research, and on involving more women in the decision-making process that surrounds developments in biotechnology.

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Gene Editing in Plants, Volume 149 aims to provide the reader with an up-to-date survey of cutting-edge research with gene editing tools and an overview of the implications of this research on the nutritional quality of fruits, vegetables and grains. New chapters in the updated volume include topics relating to Genome Engineering and Agriculture: Opportunities and Challenges, the Use of CRISPR/Cas9 for Crop Improvement in Maize and Soybean, the Use of Zinc-Finger Nucleases for Crop Improvement, Gene Editing in Polyploid Crops: Wheat, Camelina, Canola, Potato, Cotton, Peanut, Sugar Cane, and Citrus, and Gene Editing With TALEN and CRISPR/Cas in Rice. This ongoing series contains contributions from leading scientists and researchers in the field of gene editing in plants who describe the results of their own research in this rapidly expanding area of science. - Shows the importance of revolutionary gene editing technology on plant biology research and its application to agricultural production - Provides insight into what may lie ahead in this rapidly expanding area of plant research and development - Contains contributions from major leaders in the field of plant gene editing

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National Academies of Sciences, Engineering, and Medicine, Division on Earth and Life Studies, Board on Agriculture and Natural Resources, Committee on Genetically Engineered Crops: Past Experience and Future Prospects, 2017-01-28 Genetically engineered (GE) crops were first introduced commercially in the 1990s. After two decades of production, some groups and individuals remain critical of the technology based on their concerns about possible adverse effects on human health, the environment, and ethical considerations. At the same time, others are concerned that the

technology is not reaching its potential to improve human health and the environment because of stringent regulations and reduced public funding to develop products offering more benefits to society. While the debate about these and other questions related to the genetic engineering techniques of the first 20 years goes on, emerging genetic-engineering technologies are adding new complexities to the conversation. Genetically Engineered Crops builds on previous related Academies reports published between 1987 and 2010 by undertaking a retrospective examination of the purported positive and adverse effects of GE crops and to anticipate what emerging genetic-engineering technologies hold for the future. This report indicates where there are uncertainties about the economic, agronomic, health, safety, or other impacts of GE crops and food, and makes recommendations to fill gaps in safety assessments, increase regulatory clarity, and improve innovations in and access to GE technology.

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basic understanding and clear picture of genome editing CRISPR-Cas systems in different organisms - Explains how to create an animal model for disease diagnosis/research and reprogram CRISPR for removal of virus, bacteria, fungi, protozoan, and many more - Discusses the advances, patents, applications, challenges and opportunities in CRISPR-Cas9 systems in basic sciences, biomedicine, virology, bacteriology, molecular biology, and many more

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Books of 2018 One of Science Friday's Best Science Books of 2018 "Extraordinary"—New York Times Book Review Magisterial—The Atlantic Engrossing—Wired Leading contender as the most outstanding nonfiction work of the year—Minneapolis Star-Tribune Celebrated New York Times columnist and science writer Carl Zimmer presents a profoundly original perspective on what we pass along from generation to generation. Charles Darwin played a crucial part in turning heredity into a scientific question, and yet he failed spectacularly to answer it. The birth of genetics in the early 1900s seemed to do precisely that. Gradually, people translated their old notions about heredity into a language of genes. As the technology for studying genes became cheaper, millions of people ordered genetic tests to link themselves to missing parents, to distant ancestors, to ethnic identities... But, Zimmer writes, "Each of us carries an amalgam of fragments of DNA, stitched together from some of our many ancestors. Each piece has its own ancestry, traveling a different path back through human history. A particular fragment may sometimes be cause for worry, but most of our DNA influences who we are—our appearance, our height, our penchants—in inconceivably subtle ways." Heredity isn't just about genes that pass from parent to child. Heredity continues within our own bodies, as a single cell gives rise to trillions of cells that make up our bodies. We say we inherit genes from our ancestors—using a word that once referred to kingdoms and estates—but we inherit other things that matter as much or more to our lives, from microbes to technologies we use to make life more comfortable. We need a new definition of what heredity is and, through Carl Zimmer's lucid exposition and storytelling, this resounding tour de force delivers it. Weaving historical and current scientific research, his own experience with his two daughters, and the kind of original reporting expected of one of the world's best science journalists, Zimmer ultimately unpacks urgent bioethical quandaries arising from new biomedical technologies, but also long-standing presumptions about who we really are and what we can pass on to future generations.

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Frontier resonates as a powerful reminder that scientific progress and public well-being alike depend on the successful symbiosis between science and government. This timely new edition presents this iconic text alongside a new companion essay from scientist and former congressman Rush Holt, who offers a brief introduction and consideration of what society needs most from science now. Reflecting on the report's legacy and relevance along with its limitations, Holt contends that the public's ability to cope with today's issues—such as public health, the changing climate and environment, and challenging technologies in modern society—requires a more capacious understanding of what science can contribute. Holt considers how scientists should think of their obligation to society and what the public should demand from science, and he calls for a renewed understanding of science's value for democracy and society at large. A touchstone for concerned citizens, scientists, and policymakers, *Science, the Endless Frontier* endures as a passionate articulation of the power and potential of science.

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