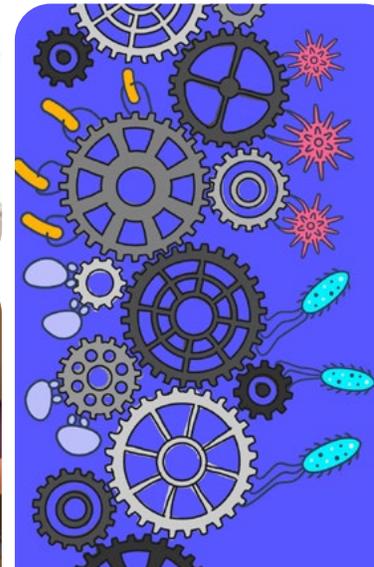


2022-2023

# IMPACT REPORT

Advancing genome research for a better world



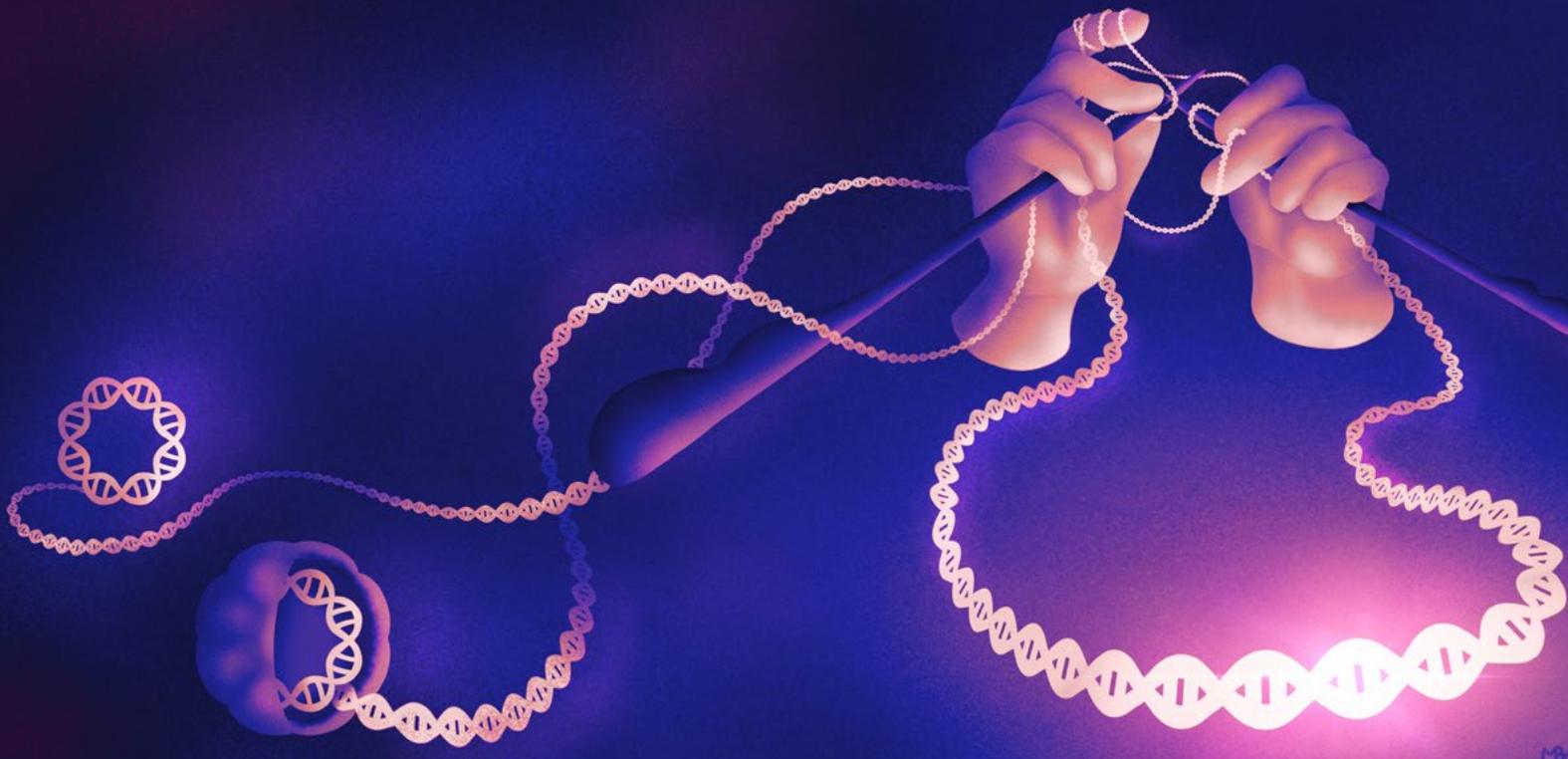


Illustration by Maya Peters-Kostman

# Table of Contents

LETTER FROM THE EXECUTIVE DIRECTOR.....2

IGI'S AUDACIOUS IDEA: MICROBIOME EDITING.....3

HUMAN HEALTH .....5

ACCELERATING CRISPR CURES.....6

CRISPR MEETS CLIMATE CHANGE .....7

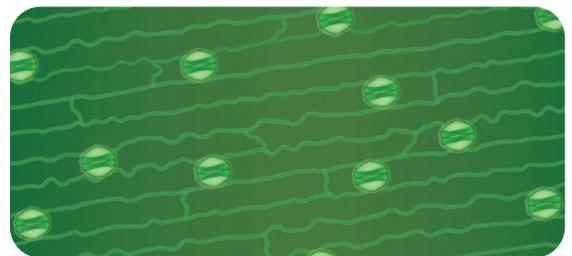
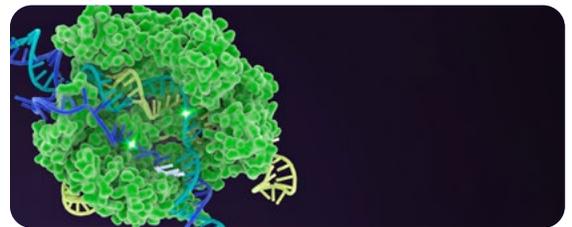
ENTREPRENEURSHIP .....8

DISCOVERY.....9

PUBLIC IMPACT.....10

OUTREACH & EDUCATION.....11

A GROWING INSTITUTE.....12





Inside  
IGI

# Letter From the Executive Director



2023 was a turning point in the world of CRISPR genome editing. In November, the first CRISPR-based therapy was approved — a major milestone for the field. CRISPR-edited tomatoes and mustard greens are available to consumers. It was just 11 years ago that IGI founder Jennifer Doudna and her colleagues published the paper that introduced the world to CRISPR genome editing, based on work done right here at UC Berkeley. The speed from paper to patient — and paper to produce section — is unprecedented.

This is the era we are in: the era of CRISPR's impact. Nearly immediately, CRISPR started changing the face of life science research. Over the last 10 years, we built on the original discovery, improving CRISPR technology, adding new tools to the toolkit, and showing the possibility in the laboratory. Now that work is moving out of the lab and translating into therapies, foods, diagnostics, climate change solutions, and more. The new approaches CRISPR has unlocked will redefine how we thrive over the next 100 years. This — the pipeline from discovery to impact — is the focus of the IGI.

At the IGI, we approach science differently than many academic institutions. Instead of a collection of loosely connected labs all pursuing independent research interests, we strategically target large, real-world problems and assemble the strongest teams of experts to take them on. The COVID-19 pandemic crystallized the value of this approach: when we come together to jointly tackle large problems, as we did during the pandemic, we can make a large impact quickly.

This type of thinking is why our ambitious new work on precision microbiome editing for health and climate was selected by the Audacious Project at TED, becoming the highest funded scientific initiative in the Audacious Project's history. To make this project a success, we need to tap expertise and collaborate across three UC campuses focusing on their core strengths: UC Berkeley for breakthrough tool development, UCSF for clinical health expertise, and UC Davis for agricultural and climate applications.

Rare disease has been a core focus of the IGI since it was founded, but in 2023, we joined a three-institute initiative, led by IGI Director of Human Health Alex Marson, focusing on breakthrough treatments for cancer. CRISPR Cures for Cancer brings together experts from UCSF, Gladstone Institutes, and the IGI at UC Berkeley. The goal of this new program is to accelerate the development of novel CRISPR-based or CRISPR-enhanced cancer therapies and rapidly move innovations to clinical translation after discoveries are made.

This is an incredibly exciting time for the field and an important moment for the IGI. The momentum in the field is palpable, and we will not only be part of building that future, we will continue to lead through new discoveries, collaborative science, and an unrelenting focus on solving society's greatest challenges.

Brad Ringeisen  
Executive Director, Innovative Genomics Institute





Jill Banfield



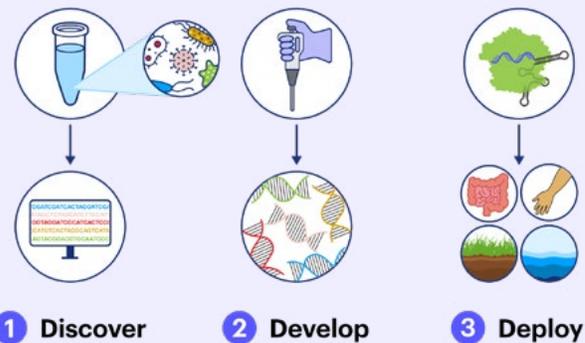
# TED

## IGI's Audacious Idea: Microbiome Editing

As an institute focused on CRISPR, we know that big impact can come from the smallest sources.

**M**icrobes exist in, on, and around us in communities called microbiomes. When these communities are in balance, they benefit us. But when they are out of balance, they can create problems for our health and our planet. In humans, dysfunctional gut microbiomes are associated with chronic diseases as diverse as asthma and Alzheimer's. In farm animals, the gut microbiome is the single largest source of global methane emissions, a major greenhouse gas.

Over the past year, the IGI launched an ambitious initiative focusing on a new field of research: precision microbiome engineering. Supported by generous funding from donors through the **Audacious Project at TED** and the **Shurl & Kay Curci Foundation**, IGI researchers are focusing on deepening our understanding of microbiomes, developing precision CRISPR-based editing tools, and applying them to real-world challenges in human health and agriculture.



### Metagenomics Meets CRISPR

In 2022, Jennifer Doudna, Jill Banfield, and their teams at the IGI demonstrated, for the first time, precision editing of bacteria directly within a natural human gut microbiome. This feat was made possible thanks to the combination of the two fields pioneered by their labs: **CRISPR genome editing** and **genome-resolved metagenomics**.

Researchers have historically tried to understand microbial function by studying one species at a time in the lab. But in nature, microbes live and work together in complex communities. With techniques pioneered by the Banfield lab, our researchers are able to study microbes in their natural communities, identifying the different species present and their genetic activity.

Learn more about the science behind precision microbiome editing [→](#)





# Audacious Applications

In addition to continuing to develop the tools to edit microbiomes precisely, a key part of the Audacious Project is to apply microbiome editing to two real-world problems in health and climate change.

## Problem 1: Childhood Asthma

**Asthma affects 300 million people worldwide, a number that increases 50% each decade and disproportionately affects lower-income children.** IGI researchers at UCSF have identified a strong link between a molecule produced in the gut microbiome and asthma development in children. The goal is to reach a point where a child at risk for asthma could receive a non-invasive therapy that precisely tunes their gut microbiome to eliminate asthma-inducing inflammation, changing their life trajectory.

## Problem 2: Livestock Emissions

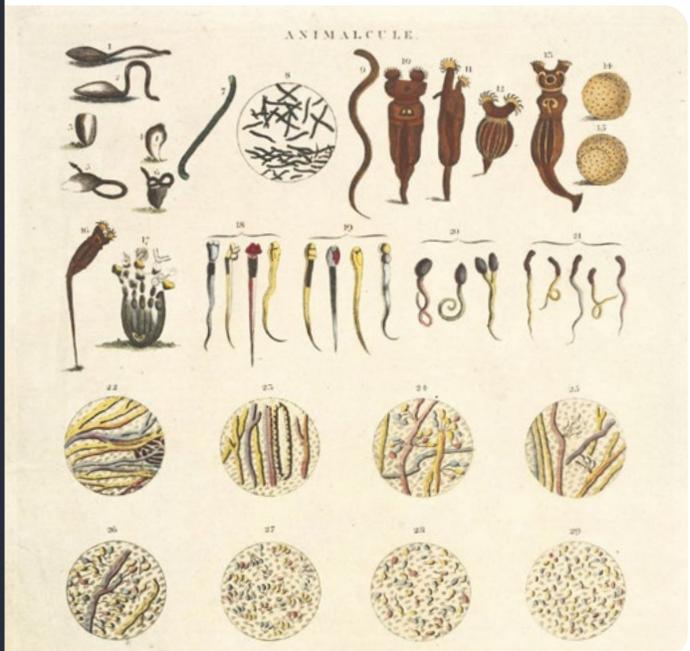
**Nearly 15% of all greenhouse gas emissions worldwide come from livestock production.** But the methane produced by livestock doesn't come directly from the animal: it comes from its gut microbiome. Certain microbiome compositions in livestock result in a 90% reduction of methane emissions, but achieving this currently requires daily feed supplements that can't scale to meet the size of the problem. The IGI team is working on a one-time treatment that targets the same microbial gene to reduce the methane emissions from livestock for a lifetime.

### Jill Banfield Wins Van Leeuwenhoek Medal

IGI Director of Microbiology Jill Banfield was awarded the 2023 van Leeuwenhoek Medal for her contribution to the understanding of microbial communities and interactions between microbes and the environment. This award — given out only once every 10 years — is the most prestigious in the field of microbiology. Previous winners include Carl Woese and Louis Pasteur. This is the first time the award has honored a woman in its 125-year history.



[Read more](#) →



# CRISPR For Human Health



**2023** was a milestone year for CRISPR in medicine. Just 11 years after IGI founder Jennifer Doudna and colleagues first described CRISPR genome editing, the MHRA in the UK and the FDA in the US approved the very first CRISPR-based therapy. This therapy, Casgevy, treats sickle cell disease and has shown remarkable results in clinical trials. Other CRISPR therapies are close on its heels, with more joining the pipeline each year — see IGI’s annual summary of [CRISPR clinical trials](#).

At the IGI, our researchers are discovering new therapeutic targets in the genome, engineering new delivery technologies for the next generation of CRISPR cures, and designing platform approaches to accelerate the development of CRISPR therapies for the 7000 known genetic diseases

## CRISPR Cures for Cancer

CRISPR is increasingly being looked to as a tool to improve cancer therapies. The new CRISPR Cures for Cancer initiative unites researchers at UCSF, Gladstone Institutes, and the IGI to develop cutting-edge treatments. This initiative aims to rapidly bring new treatments to clinical trials.

[Read more](#) →

## Fixing Immunodeficiencies

IGI’s Center for Translational Genomics is using robotics and platform technologies to do genomics on a larger scale than ever. The CTG draws on IGI’s scientists and physicians to create new ways to diagnose and treat inborn immunodeficiencies, addressing the needs of diverse patients.

[Read more](#) →

## Editing Multiple Genes Safely

Delivery is one of the biggest challenges for CRISPR therapeutics. IGI researchers have uncovered a novel way to deliver CRISPR to cells that is not only gentler on the cells, but allows researchers to do multiple rounds of edits safely when more than one edit is required.

[Read more](#) →

## Sickle Cell Therapy 2.0

The approval of Casgevy doesn’t mean the work on sickle cell is done. The IGI is working with UCSF Benioff Children’s Hospital and the UCLA Broad Stem Cell Research Center to develop next-generation therapies with enhanced efficiency, safety, and lower cost, to help increase access around the world.

## Inside IGI Health 2023

In September, we held the inaugural Inside IGI Health event. This all-day conference was designed to bring together the IGI community to highlight the latest ways IGI researchers are using genome engineering to solve humanity’s greatest problems and encourage the cross-fertilization and the culture of collaboration that makes IGI unique. Over 300 IGI members attended – including a surprise visit from UC Berkeley Chancellor Carol Christ.



# Accelerating CRISPR Cures

There are over 7000 known genetic diseases caused by mutations in single genes affecting over 400 million people worldwide. The vast majority of these diseases have no approved treatment today. Under the current model, it can take a decade or more to develop each new therapy. We can do better.

## The Li Ka Shing Center for Translational Genomics

IGI's Li Ka Shing Center for Translational Genomics (CTG) is a first-of-its-kind innovation hub for the development of targeted genome-editing treatments for unaddressed genetic diseases. The CTG team is creating a platform to accelerate the discovery of new genomic therapies, focusing on underfunded research areas and unmet needs.

### Research Spotlight: High-Throughput CRISPR Screens Accelerate Genomic Therapies

Dirk Hockemeyer and Hanqin Li, investigators in the CTG, and colleagues developed a novel screening method to look at thousands of potential mutations in the BRCA2 gene. Some variants are known to increase the risk of breast and ovarian cancers, but without a high-throughput screening method, the vast majority of variants haven't been studied. Methods like this allow CTG researchers to rapidly screen and develop therapies for multiple genetic diseases.

[Read more](#) →



## Kickstarting CRISPR Therapies for Neurodegenerative Diseases

25M in grant funding from the NIH is supporting a collaboration between IGI and the Ohio State University, aimed at treating neurodegenerative diseases like Huntington's and ALS with CRISPR, as well as developing new ways to test the effectiveness of treatments.

[Read more](#) →

## Interventional Genomics: Bringing CRISPR to the Doctor's Office

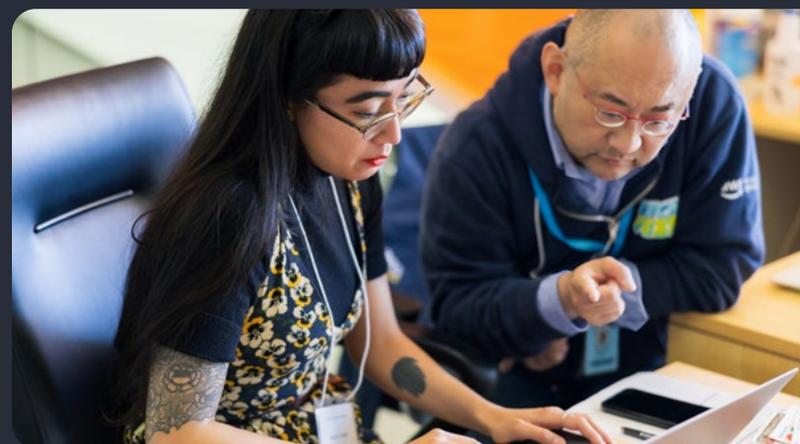
We envision a future where genomic disease diagnostics and CRISPR-based treatments are the standard of care available to all patients. This takes more than genomic therapies: it takes expertise, systems, and infrastructure similar to what has developed around other medical specialties. The IGI's Interventional Genomics Unit is laying the foundation by creating the diagnostic tools, data hubs, and workflows needed to incorporate interventional genomics into clinical practice.

[Read more](#) →

## IGI Hackathon Digs into the Mysteries of RNA

AI and machine learning are critical tools in genomics research. In 2023, the IGI held a hackathon in collaboration with UC Berkeley's Electrical Engineering and Computer Sciences Department. Over 30 Berkeley community members came together to use machine learning to come up with new ideas for modeling RNA structure and engineering the ribosome — the cellular machine that makes proteins.

[Read more](#) →





# CRISPR for Climate & Sustainable Agriculture



Fighting climate change requires every tool we have available. We know that CRISPR and other genomic technologies can help.

**IGI researchers are attacking the problem in three key ways:**

**Reducing** agricultural emissions so that we can feed a growing population sustainably

**Removing** carbon from the atmosphere using plants and storing long-term in soils

**Empowering** farmers to adapt to a changing climate while maintaining yields and preferred varieties

## CRISPR-Powered Carbon Removal

In the last 200 years, agricultural soils have lost a massive amount of carbon. IGI researchers are developing ways to use CRISPR genome editing to enhance the natural ability of plants and soil microbes to capture atmospheric carbon and put back into the soil in beneficial forms, supported by generous funding from the Chan Zuckerberg Initiative. The IGI team combines world-class experts in microbiology, plant genomics, and synthetic biology for this bold new approach.

### Research Spotlight: Why Climate Scientists are Sweet on Sorghum

Sorghum — a heat-loving, flood-tolerant cereal crop that can grow in low-nutrient soils — is a key piece of the IGI carbon removal project. Not only can it withstand weather extremes, but sorghum has unusually deep roots. The deeper the roots, the more carbon a plant can keep in the soil and out of the atmosphere. IGI researchers are using CRISPR to make those roots even denser and deeper.

[Read more](#) →

### Protecting Crops from Drought

Rice is a staple food for more than half the world's population and safeguarding rice from increasing drought is crucial. IGI's Director of Sustainable Agriculture, Brian Staskawicz, and his team are using CRISPR to create a new strain of rice that is more water efficient in greenhouse tests. Now, the rice is being grown in a field trial to see if the real-world matches what we see in the greenhouse.

[Read more](#) →

### Improving Photosynthesis

Plants capture atmospheric carbon dioxide through the process of photosynthesis. Enhancing photosynthesis could make plants grow bigger with greater yield and take more carbon dioxide out of the atmosphere. IGI researchers Kris Niyogi and Dave Savage are taking on this difficult challenge from multiple innovative angles.

[Read more](#) →

### Rice Breakthrough Could Benefit Small Farmers

Hybrid crop plants often show higher performance than their parent strains, a phenomenon called hybrid vigor, but the cost of planting hybrid crops each year puts them out of reach of many farmers in low- and middle-income countries. IGI researchers are working with an international team using a new way to propagate hybrids as clones, a breakthrough that could benefit small farmers.

[Read more](#) →



# Entrepreneurship

Success for the IGI involves both innovation and impact. Commercialization can be one of the most direct routes to making a real-world impact. In addition to licensing technologies that are developed in-house, IGI researchers have gone on to start important new companies in a range of fields, from CRISPR-based therapies to next-generation agricultural products.

While women have made great gains in STEM degrees in college in recent years, gender inequity is still extreme in the biotech space, particularly in leadership positions. The HS Chau Women in Enterprising Science (WIES) Program at the IGI is helping to change the game by supporting budding entrepreneurs who are committed to addressing gender inequity in the field.

In 2023, two WIES Fellows from the previous year, Navneet Matharu and Jenny Hamilton (pictured above with Jennifer Doudna), were selected to receive \$1 million in non-dilutive funding to support their entrepreneurial pursuits. Matharu is developing non-editing forms of CRISPR-based therapeutics for genetic diseases and Hamilton is developing a novel method of precisely delivering genome-editing therapies into human cells.

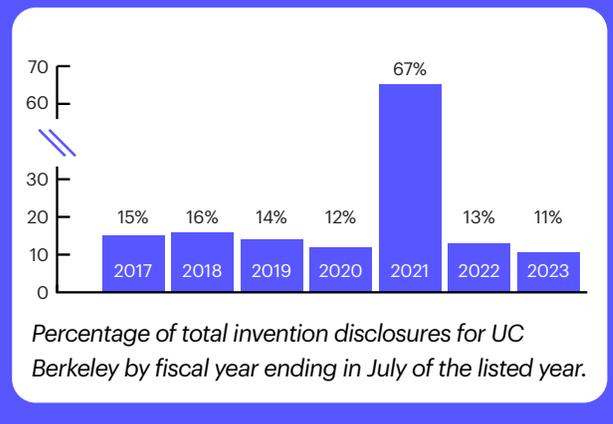
Read More [→](#)



## IGI Drives Innovation & Entrepreneurship

UC Berkeley is the number one public university in the world for generating startup founders, and the IGI is a key part of that success, training entrepreneurs in the biotechnology sector.

The IGI is also responsible for ~15% of the patent applications at UC Berkeley every year, with a growing portfolio of innovations in medicine, sustainable agriculture, climate technology, biomanufacturing, and life science research tools.



**22** New companies founded by IGI associates



**2000+** Employees at these companies



**\$3.5B** Raised  
\$10.3B net worth

**FIELDS:** Therapeutics, diagnostics, CRISPR delivery, agricultural traits, gene editing tools, gene regulation, cell therapy, agricultural waste, dyes, flavorings, biomanufacturing

# Discovery

Groundbreaking discovery continues at the IGI



The IGI was founded to develop CRISPR technology into applications in a way that could only happen in a top-tier research university setting. But you can't have applied science without basic, curiosity-driven research. Discovery is the engine that drives our ability to create real-world impact.

Over the past year, IGI labs published research that expanded the genome-editing toolkit, cast new light on earlier findings, and discovered novel genetic elements that play an important role in oxidizing methane.

## Meet the Borgs

Over the past year, Jill Banfield and members of her lab introduced the world to "Borgs," large DNA elements associated with the methane-oxidizing microbe, *Methanoperedens*. Borgs are challenging to classify — there has never been anything quite like them observed before — but, much like the Borg of Star Trek, they assimilate pieces of the genomes from their hosts.

Borg genomes contain genes that appear to assimilate pieces of the genomes from their hosts, making them an interesting study target as we attempt to address global methane emissions from agricultural soils, which are significant contributors to climate change.

[Read More](#) →

// This discovery started in deep mud and was brought to light by an analysis of around 10 billion DNA snippets. That such an approach could reveal something with potentially global ramifications! — Jill Banfield

## New Compact Genome Editors Found in Viruses

A collaboration between multiple IGI investigators including Jennifer Doudna, Jill Banfield, David Savage, and Brian Staskawicz found that the diversity of CRISPR systems in viruses is far richer than expected and could be a valuable source of new, efficient genome editors for use in humans, plants, and other organisms.

[Read more](#) →

## Improving CRISPR Precision

One of the possible results of CRISPR genome editing is unwanted changes at the edit site. New research from the IGI reveals that losses of large parts of the chromosome are common when editing human cells, and identifies a protocol to prevent chromosome loss.

[Read more](#) →

# Public Impact

Science should serve the public good. True impact requires incorporating societal, ethical, and environmental considerations into our scientific research — and not as an afterthought. Every IGI project includes public impact planning from the very beginning.

In 2023, we pursued ventures aimed at making sure our work can do the most good, for those who need it most.



Melinda Kliegman, Public Impact Director

## Training Global Scientists & Regulators

To fulfill the broader mission of the institute, IGI researchers and staff work internationally to train scientists to use genome editing to address local problems and to educate regulators on the technology, applications, and the global regulatory landscape.

**Africa:** IGI researchers went to Nairobi, Kenya to teach an innovative new course aimed at empowering scientists from across Africa to use CRISPR to adapt crop plants to local needs.

[Read more](#) →

**Southeast Asia:** IGI researchers went to the Philippines and Thailand to connect, talk, and teach about CRISPR with local scientists and biotech regulators.

[Read more](#) →



## Tackling the Affordability Crisis

A new IGI report aims to solve one of the trickiest challenges for genomic medicines: pricing. New CRISPR-based therapies are estimated to cost in the \$1-3 million range per patient, which leaves them inaccessible to many of the people who could benefit. IGI's Public Impact team brought together experts from diverse fields to chart new ways forward, producing a "10x Less Model" that could cut current prices for genomic therapies by a factor of 10.

[Read more](#) →

## Guiding Gene-Editing Regulation

The IGI is a leading voice on policy relating to CRISPR and genome editing in health and agriculture. In 2023, the IGI Public Impact team submitted comments and worked with regulators and policymakers at the White House, FDA, USDA, ARPA-H, and other agencies on topics including biotechnology regulations, manufacturing standards, artificial intelligence, and addressing rare diseases with genomic therapies.



**Brazil:** As part of a partnership with the D'Or Institute for Research and Education (IDOR), IGI Investigators are hosting two Brazilian postdocs, Bruno Solano and Thyago Leal, who are working on IGI projects related to sickle cell disease and neurodegenerative diseases.

# Outreach & Education

At the IGI, we strive to create a STEM future that is more diverse, welcoming, and inclusive. Our education and outreach work is aimed at supporting a more diverse pipeline of STEM students and researchers, with efforts from local to global in scope.

## Reimagining Women in STEM

IGI's online gallery reimagines women with remarkable STEM achievements by placing them in famous works of Western art. These images are intended to make the viewer pause, look closer, and reconsider assumptions.

[Browse the Gallery](#) →

This gallery was created by Kaylene Son, an undergraduate at UC Berkeley. The IGI Communications team works with student writers, translators, and artists to create articles, illustrations, and train the next generation of STEM communicators. Our students are always paid so that opportunities are available regardless of family income.



## CasPEDIA

CasPEDIA is a new wiki-style resource for STEM researchers and students. CasPEDIA entries include comprehensive information about structure, function, and sequences, as well as experimental considerations for the Cas enzymes that have been characterized. Like Wikipedia, users can suggest new entries as new proteins are discovered and described

[Explore CasPEDIA](#) →



## CRISPR Made Simple

CRISPR Made Simple is our primer on DNA, genetics, and genome editing for younger learners and anyone starting from scratch. It is fully online and available for free, in English and now with high-quality Spanish translation.

[Read More](#) →

## SEED Scholars

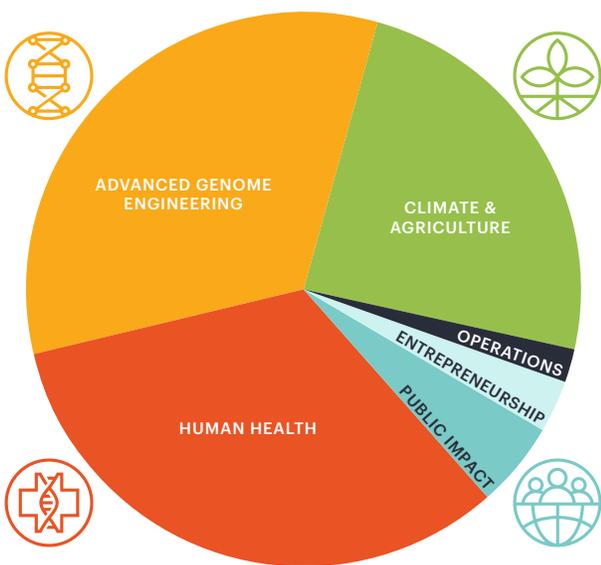
In conjunction with the **SEED Scholars Honors Program**, IGI has developed a plan to give undergraduate students from underrepresented backgrounds the chance to work in world-class laboratories. We are currently looking for a sponsor to help us realize this dream. Reach out if you're interested in getting involved!

# A Growing Institute

## Growth Through Gifts

The IGI's continued growth and broad portfolio of research projects is made possible through the generous support of philanthropic organizations and individuals who provide the funding not just for IGI's research programs, but also for the core institutional operations that support all of these programs and keep them on track.

The largest new source of funding in 2023 came through The Audacious Project at TED, where a group of generous donors provided \$70 million to the IGI to develop microbiome-editing technology and apply it to both human health and climate change.



New gifts and grants to the IGI over the past 12 months by area

## New Facilities

Lots of exciting changes have been happening to the IGI building over the past year. The Women in Enterprising Science Fellows have a brand-new facility, with both laboratory space and meeting rooms to continue their research while growing their entrepreneurial pursuits. The Center for Translational Genomics launched their state-of-the-art automation laboratory for IGI investigators working on rare diseases, and new laboratories devoted to microbiome editing and interventional genomics have joined our first floor labs.

The continued growth of the IGI is something to be celebrated, but there is only so much growth we can achieve inside our current building. We are excited to be working with campus on the plans for a new building one block away from the IGI Building.





[innovativegenomics.org](http://innovativegenomics.org)