HEALTHCARE TECHNOLOGIES

How Scientists Drew Weissman (MED'87, GRS'87) and Katalin Karikó Developed the Revolutionary mRNA Technology

inside COVID Vaccines

It started with a chance encounter, and led to worldwide acclaim for the two researchers

Drew Weissman (MED'87, GRS'87) and Katalin Karikó pioneered the mRNA technology that is fundamentally reshaping the landscape of vaccine development and the future of gene therapies. Photo by Peggy Peterson/Courtesy of Penn Medicine

NOVEMBER 18, 2021

BY TING YU

28 COMMENTS SHARE THIS

An astonishing number of world-changing medical breakthroughs have come to humanity by way of serendipity. Mishaps and lucky breaks gave us X-rays, insulin, and, most famously, penicillin, discovered in 1928, when a Scottish biologist returned from a summer holiday to find the bacteria cultures in his lab destroyed by a peculiar mold. Modern medicine was transformed in an instant.

But the story of how scientist Drew Weissman (MED'87, GRS'87) and his research partner Katalin Karikó developed the revolutionary mRNA technology that powers the world's most effective COVID-19 vaccines was a much slower burn—one that

easily could have flickered out. Their decades-long crusade has been marked by rejection, crushing setbacks, and dogged perseverance. Chance had nothing to do with it. Except, perhaps, for how they met.

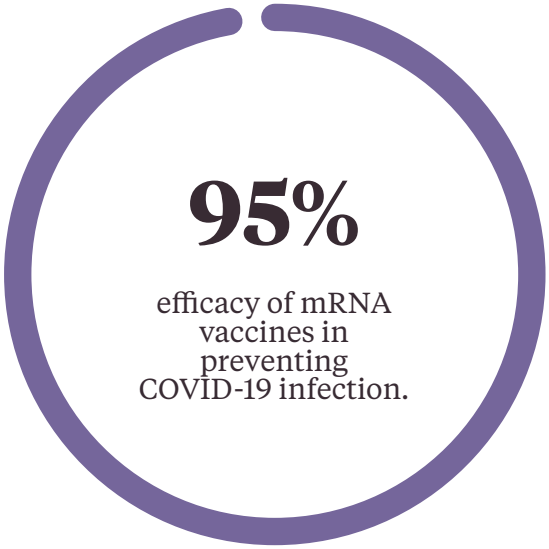
It was 1998. Weissman, an immunologist with a PhD in microbiology, had recently accepted a position at the University of Pennsylvania and was trying to figure out how to make a better vaccine. Most traditional vaccines work by injecting an inactive, weakened, or small fragment of a pathogen—called an antigen—to trigger an immune response that the body remembers and can jump-start if the invader returns. But developing such vaccines can take years, and live pathogens pose health risks to those with compromised immune systems.

Weissman was especially intrigued by a single-stranded molecule called messenger RNA, or mRNA, which brings our cells the DNA blueprint for making proteins so that the body can function. If we could manipulate those instructions, could mRNA be harnessed to create an entirely new kind of vaccine—one that could generate immunity without ever bringing a pathogen into the body?

One day, while waiting at the office to photocopy articles from a research journal, Weissman struck up a conversation with Penn biochemist Karikó. The two scientists realized they shared a particular interest. “I had always wanted to try mRNA,” Weissman says, “and here was somebody at the Xerox machine telling me that’s what she does.”

What followed was a partnership that has lasted for more than two decades. During that time, they pioneered the mRNA technology that is fundamentally reshaping the landscape of

vaccine development and the future of gene therapies. Not only have the new mRNA vaccines proven to be more effective and safer than traditional vaccines, they can be developed and reengineered to take on emerging pathogens and new variants with breathtaking speed. Using mRNA technology, Pfizer-BioNTech designed its coronavirus vaccine in a matter of hours.

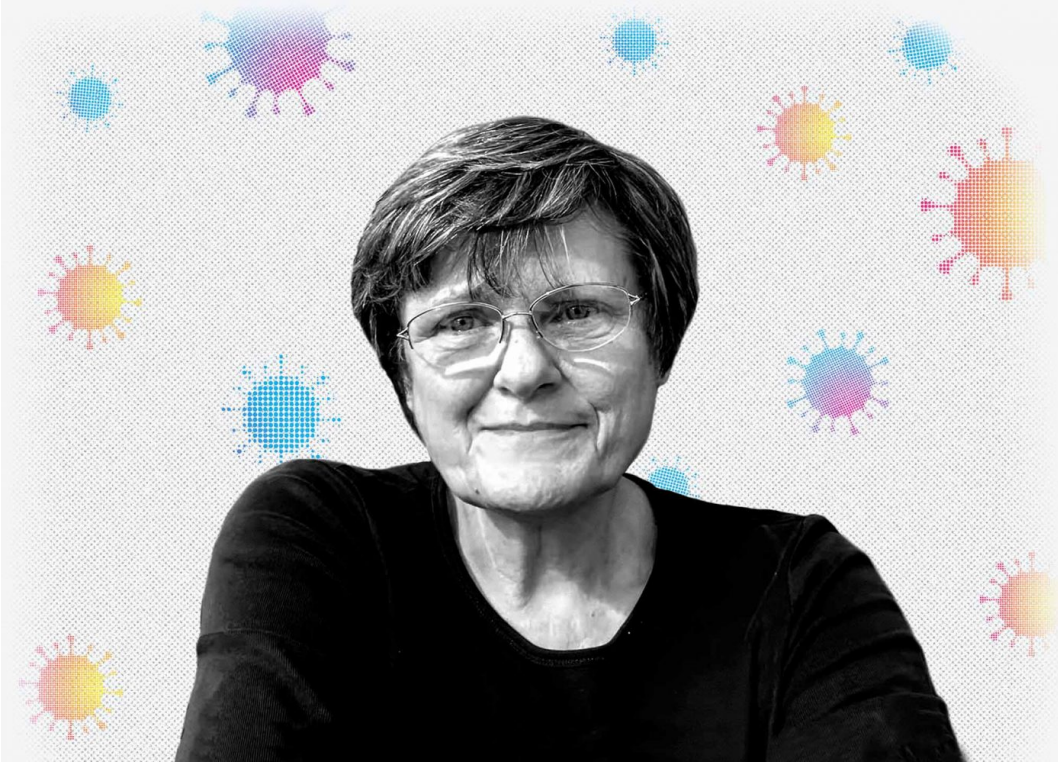


Now, Weissman and Karikó are being hailed for their work. Earlier this year, Brandeis University and the Rosenstiel Foundation honored the scientists with the Lewis S. Rosenstiel Award for Distinguished Work in Basic Medical Research. In September, they won a Breakthrough Prize in Life Sciences from the Breakthrough Prize Foundation. And Columbia University awarded them the Louisa Gross Horwitz Prize, bestowed annually for groundbreaking work in medical science. Of the 106 previous Horwitz Prize winners, nearly half have gone on to receive Nobel Prizes.

Cracking mRNA's Code

From the start, Weissman and Karikó believed mRNA was the key to unlocking a new generation of vaccines and therapeutics. Theoretically, it could instruct any cell in the body to make any desired set of proteins. But practically, there were many obstacles. Synthetic mRNA was notoriously unstable and tended

to break down before it could do its job. The closest attempt came in 1990 when researchers from the University of Wisconsin showed that injected mRNA could generate proteins in mice. Many scientists, however, were skeptical that this process could be replicated in humans.



Katalin Karikó had been captivated by mRNA since the earliest days of her career.
Photo by Zume Press, Inc./Alamy

For her part, Karikó had been captivated by mRNA since the earliest days of her career. She left her native Hungary in 1985, when funding dried up for her lab, taking a low-level postdoctoral position at Temple University. Four years later, Karikó moved to Penn, where she would spend the next decade making sporadic discoveries with mRNA but consistently failing to win grants. She was forced to move from lab to lab, going wherever she could find someone willing to fund her research.

By the time she met Weissman, at the copy machine, Karikó had been demoted and was adrift without funding or a lab. But

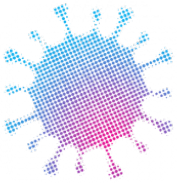
Weissman didn't care about her lack of grants or credentials. "I never say no to anything," he says. "RNA had been tried by others and didn't work very well, but I wanted to try it."

Karikó brought her synthetic mRNA to his lab. Weissman injected it into mice. Then he waited to see what would happen. The results were unexpected and discouraging. The mRNA set off a harmful inflammatory immune response in the mice. They grew sick, and some died. "Kati got depressed because it meant that mRNA couldn't be used as a therapeutic," Weissman recalls. "You can't give something that makes people sick."

But neither scientist was ready to give up on the promise of mRNA. They spent years investigating the cause of the inflammation and years more experimenting with how to prevent it.

In 2005, they had a breakthrough.

By altering one of mRNA's four building blocks, known as nucleosides, Weissman and Karikó found that their modified mRNA could fly under the radar of the body's immune system, no longer causing inflammation. It was a game changer, and they both knew it.



How Do mRNA Vaccines Work?

Understanding the virus that causes COVID-19. Coronaviruses, like the one that causes COVID-19, are named for the crown-like spikes on their surface, called spike proteins. These spike proteins are

With this hurdle cleared, the clinical applications for synthetic mRNA seemed infinite. Custom-tailored mRNA, once injected into the body, could order cells to produce any desired sequence of proteins.

There were "enormous possibilities," Weissman says. The scientists believed their technology had the potential to transform medicine, opening the door to countless new vaccines, therapeutic proteins, and gene therapies.

ideal targets for vaccines.

What is mRNA? Messenger RNA, or mRNA, is genetic material that tells your body how to make proteins.

What is in the vaccine? The vaccine is made of mRNA wrapped in a coating that makes delivery easy and keeps the body from damaging it. The vaccine does not contain any virus, so it cannot give you COVID-19. It cannot change your DNA in any way.

How does the vaccine work? The mRNA in the vaccine teaches your cells how to make copies of the spike protein. If you are exposed to the real virus later, your body will recognize it and know how to fight it off. After the mRNA delivers the instruct-ions, your cells break it down and get rid of it.

Information courtesy of US Centers for Disease Control and Prevention

The idea may have been too radical to grasp. Several leading medical journals turned down their report of their findings before it was published, in 2005, by the journal *Immunity*. The researchers braced for the shock waves their study would generate in the scientific community.

"I told Kati our phones are going to ring off the hook," Weissman recalls. "But nothing happened. We didn't get a single call."

The researchers were deeply frustrated at the lack of interest. Still, they secured patents, and in 2006 launched a company called RNARx that focused on developing mRNA therapeutics for a wide range of diseases. But eventually funding ran out and the company shut down.

The pair forged ahead, and five years after they published their groundbreaking findings, their discovery caught the attention of two biotech newcomers, Moderna of Cambridge, Mass., and Germany's BioNTech. Both companies eventually licensed Weissman and Karikó's patents. (Karikó was hired by BioNTech in 2013, and the company would later partner with US pharmaceutical giant Pfizer on vaccine development. The two companies also now support Weissman's lab.)

By the time ominous reports of a mysterious virus began emerging from Wuhan, China, in late 2019, Moderna and BioNTech had been working on developing mRNA influenza vaccines and other therapies for years. As soon as China released the genome sequence for the new coronavirus, both companies began racing toward a vaccine.

Would mRNA Vaccines Work in People?

The Pfizer-BioNTech and Moderna vaccines deployed the same clever mechanism. A shot of specially coded mRNA would instruct certain cells to manufacture the notorious COVID-19 spike protein, enabling the cells to briefly masquerade as the virus and teach the immune system to recognize it. Within weeks of injection, the mRNA would break down naturally without a trace, leaving in its wake a powerful immunity against

the coronavirus.

Although Weissman was confident in the science—he had worked on 20 different vaccines in animal models with great success—he was anxious to see the results of the human trials. “In science, we know that what works in mice rarely works in humans, and what works in [monkeys] sometimes works in humans,” Weissman says. “So I was very nervous [about] whether it would work in people.”

Results from the human clinical trials showed the vaccines to be remarkably safe, with 95 percent efficacy in preventing COVID-19 infection. Weissman was elated. In December 2020, he and Karikó received their first vaccine shots together at the University of Pennsylvania.

“It was an emotional moment,” he says, reflecting on their long struggle to show the world the promise of this extraordinary molecule. “There were a lot of down times, a lot of soul-searching, a lot of figuring out why things weren’t working. But we never lost hope because we both saw the incredible potential that mRNA had.”

Since COVID vaccines were first granted emergency use authorization from the Food and Drug Administration in December 2020, nearly 219 million Americans have been immunized, with the vast majority receiving either the Pfizer-BioNTech or Moderna vaccines.

> “There were a lot of down

> times, a lot of soul-searching, a lot of figuring out why things weren't working. But we never lost hope."
>
> Drew Weissman

Columbia's David Ho, one of the country's leading virologists, calls their research "an essential precursor" to the COVID vaccines "that have made a huge impact on the pandemic." Others in the scientific community believe Weissman and Karikó deserve the Nobel Prize for their groundbreaking discoveries with mRNA.

Weissman takes it all in stride. "We knew from the beginning that what we were doing had huge potential," he says, "but every scientist's work isn't like that. If RNA had not worked, no one would have heard of Kati and me, and we would've retired and gone off to our nursing homes."

The Future of mRNA Technology

These days, Weissman seems a bit wistful for a time when he could work in relative anonymity. "I was and still am quiet and shy and not very outgoing," he says. "I've always enjoyed working in my lab alone without much attention. The reporters, awards committees, everybody imaginable wanting to talk to

me—it's been the hardest thing."

With what little leisure time he has, Weissman likes to unwind by engineering more domestic innovations. "When he's having trouble finding a solution to something, he builds rooms onto our house," says his wife, Mary Ellen, a child psychologist. The couple has two daughters, Rachel and Allison.

"I build screen porches, kitchens, bathrooms, playrooms," Weissman says. "I enjoy building. I'm sure I got that from my dad." His father was an engineer who owned a company that designed optical mirrors for satellites. His mother was a dental hygienist.

Weissman describes a carefree childhood growing up in Lexington, Mass., "playing kickball in the streets and roaming around the neighborhood causing trouble." In high school, his talent for science came into focus. "I was always interested in biology and took the top science classes," he says.

He studied biochemistry and enzymology at Brandeis University and earned an MD/PhD in immunology and microbiology from Boston University in 1987. After a residency in Boston, he pursued a fellowship at the National Institutes of Health, where he worked closely with Anthony Fauci (Hon.'18), now director of the NIH's National Institute of Allergy and Infectious Diseases, whom he describes as "one of the great drivers of my research interest."

Weissman has been dismayed by the partisan vitriol directed at his former mentor. "I see it as very sad. I never imagined that people would attack Tony for trying to save lives and do the right thing," he says. "The United States is absolutely ridiculous in

how they've handled this vaccine and the pandemic itself. And the continued politicization of it is terrible."

Weissman is working on a pan-coronavirus vaccine—one that will protect against every variant that will likely appear—as well as about 20 other vaccines for diseases from malaria to HIV. Photo courtesy of Penn Medicine

His frustration with how the United States is managing the pandemic has led him to focus on vaccine access for the rest of the world. Weissman is currently working with the governments of Thailand, Malaysia, South Africa, and Rwanda, among others, to develop and test lower-cost COVID vaccines.

To Weissman, the new COVID variants present a compelling challenge. The beauty of mRNA vaccines, he says, is that tweaking the code to work against Delta or other new strains "is a simple thing. It takes a few weeks to make a brand-new vaccine."

He has set his sights on a more ambitious target: a pan-coronavirus vaccine. "There have been three coronavirus epidemics in the past 20 years," he explains. "You have to assume there are going to be more. We're now working on a vaccine that will protect against every variant that will likely

appear. Our thinking is that we'll use it as a way to immunize the world—and prevent the next pandemic from happening in the future."

So far, the results in mice, which were published in the journal *Nature* in August, have been promising. But Weissman is hardly stopping with coronaviruses. He's working on about 20 other vaccines for diseases from malaria to HIV, with several moving into clinical trials. His lab is also exploring new gene therapies to treat immune deficiencies like cystic fibrosis and genetic liver diseases.

One of the most promising projects focuses on curing sickle cell anemia, a chronic genetic disorder that disproportionately affects people of African descent. The existing treatment is a labor-intensive procedure that involves removing bone marrow from the patient, treating it with an altered virus designed to deliver a healthy version of the sickle cell gene, and then putting the marrow back into the patient. "The problem with that is 200,000 people are born with sickle cell in sub-Saharan Africa every year," Weissman says, "and it's half a million dollars per treatment."

Using mRNA technology, Weissman has developed a gene therapy that can treat sickle cell anemia with a single shot. "We've taught [the mRNA] how to target bone marrow stem cells, so they fix the gene and cure the disease," he says. The therapy has been successful in mice and will move into monkey trials soon.

"Once we get the sickle cell therapy working, there are a couple of hundred other bone marrow genetic diseases it can be applied to," he says, along with liver and lung genetic disorders. In time,

he believes mRNA gene therapies can bring hope to research on devastating neurological diseases such as Alzheimer's and Parkinson's that have seen disappointingly few advances.

Meanwhile, biotech companies like Moderna and BioNTech are charging forward on a mind-bending spectrum of mRNA applications, including personalized cancer vaccines and autoimmune therapies.

Weissman generally comes across as pragmatic and self-effacing, but as he looks to the future, he sounds genuinely awed by the staggering potential of the technology he and Karikó invented: "It really is exciting. It's limitless."

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Ting Yu is a Boston-area freelance writer and editor. Profile

Comments & Discussion

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There are 28 comments on *How Scientists Drew Weissman (MED'87, GRS'87) and Katalin Karikó Developed the Revolutionary mRNA Technology inside COVID Vaccines*

ELIZABETH GIBBS NOVEMBER 28, 2021 AT 2:29 PM

Compare how big Pharma is intending to cash in on research developed in universities with NIH funding with Jonas Salk who purposely did not patent the polio vaccine formula. And Moderna is playing hard nosed business monolith by refusing to share the formula with an African gentech company who can make the vaccine available for use in Africa in a year. Without the exact formula it will take 3 years. In Africa the vaccine rate is at 1% for a country that has spawned a new variation that's spreading rapidly. Moderna says it intends to build a lab in Africa to produce the vaccine. But at what price? And how many people die while Moderna makes obscene profits?

Reply Link

LOUIS ZACZKIEWICZ DECEMBER 31, 2021 AT 12:29 PM

Hi Elizabeth,
The production of pharmaceuticals requires many controls to be in place,

mandated by regulations for the safety of those receiving them. It is not like giving someone a food recipe or car repair instructions and having them come out perfect. Look back at the recall which happened in 01Sep2021 where “An investigation carried out by Moderna and the Spanish manufacturer Rovi found that the issue was caused by incorrect assembly due to a visual misjudgment of the required 1mm gap between the stopper lids on the vials and the machinery that is used to insert them.”

See https://www.reuters.com/world/asia-pacific/japans-takeda-says-human-error-caused-contamination-moderna-vaccines-2021-10-01/

When something goes wrong in the technical transfer of the formula, who gets the blame? Setting up a manufacturing facility takes specialized facility design (cleanrooms, sterile manufacturing areas, high purity utilities) and specialized manufacturing equipment (production and purification under precisely controlled parameters), the components of which are typically custom-built using exacting parameters including materials of construction and validated software. Once the equipment and facilities are actually built, the installation, operation and performance of how they work and their specifications must be rigorously challenged. Then there are the Quality Control procedures to test and qualify the raw materials (chemicals) and all components which come in contact with any phase of the product along the manufacturing process. Each of these have precise specifications, approved suppliers, defined chain-of-custody (including strict temperature requirements) and documentation requirements just to get them into the door. Once they arrive, each shipment (even if the chemical is the same lot as previously received) must be tested onsite to prove identity using validated test procedures. This is all part of a well-controlled Quality Management System which identifies trends, responds to any deviation in the facility typically within 1 day with appropriate corrective and preventive actions.
Product is tested multiple times along the production and purification processes for many parameters using strictly controlled procedures to ensure the final product is the same every time. Once it is pure, the product goes into the final containers using validated sterile processes, equipment and components. Each filling process is strictly validated with controlled training procedures of qualified operators to ensure the things like those which happened at the Rovi plant do not happen.
Then there are the strict stability testing protocols to ensure the product meets the release specifications through the validated expiration date. The

facility is audited both internally by the company or outside consultants and regulators from around the world.
This is just a brief summary of what it takes to get pharmaceuticals made. You may have noticed I frequently use the term "validated." That process is strictly defined by the industry to ensure the whole manufacturing and distribution process is always in a state of control.
For these companies to make the product at their fully-controlled facilities and distribute them throughout the world is much more efficient, safer for patient and faster than sharing the formula. Even the 3-year estimate to get a new facility up and running with trained operators is highly aggressive.
In summary, this is not like making a copycat Rolex or smartphone. The people who manufacture, test and control these vaccines have worked (and are still working) massive number of hours (holidays & weekends included) to keep the facilities running 24 x 7. The profits being made help the facility to expand to increase production and expand the mRNA technology to new uses.
I hope that puts thing into perspective.

Reply Link

EVA S SZABO NOVEMBER 30, 2021 AT 12:58 PM

This is a fascinating article about true research, and how it has positively impacted the entire world's population. I am wondering whether or not Dr. Weissman is continuing to work with Ms. Kariko ? It seems that she is hardly mentioned in the article, with chief focus on Dr. Weissman. Without her synthetic mRNA, the vaccine would not have been developed at this time.

That means continued high death rates across the world. I was just wondering why more of her was not in the article.

Reply Link

CYNTHIA K BUCCINI DECEMBER 3, 2021 AT 5:18 PM

Hi Eva,

Thank you for your note. We focused on Dr. Weissman because he is a BU alum, and Bostonia is the alumni magazine of Boston University. We did, however, want to include Dr. Kariko because her role is just as important.

All my best,

Cindy Buccini
Editor

Reply Link

ABA KAMAU DECEMBER 27, 2021 AT 3:43 PM

Dr Kariko now works for BioNTech

Reply Link

HAROLD CAMPBELL, MPH, D.ED APRIL 25, 2022 AT 9:26 PM

See https://pubmed.ncbi.nlm.nih.gov/16111635/ for Kariko and Weissman's original article in 2005 where Katalin Kariko is the lead author.

It is inexcusable for a university to so neglect Katalin's dominant role in the discovery of this revolutionary therapeutic.

Reply Link

FATEN SALIM DECEMBER 17, 2021 AT 9:41 AM

Why are many people refusing to take the vaccine on the pretense that it has not been researched clinically and thoroughly, knowing that it takes years of collecting statistics to confirm its safety short and long term ? How can they be reassured of its safety

This article shed light on very good information explaining the science behind the vaccine and also dispelling a lot of the conspiracy arguments, however. Many are still
Worries because the mRNA technology is new, and like anything new, people like to wait and see, especially that there are some cases that have go very sick after the vaccine and some deaths have occurred.

Reply Link

SANDY WUERCH JANUARY 8, 2022 AT 4:49 AM

Agree 100% Society is all part of the testing.This makes me wonder why

they are hunting and blaming those who choose not to be vaccinated.It feels like a bad Sci Fi movie when I see these witch hunts in the media.This scares me more than anything I have been watching for the last 2 years

Reply Link

CRAIG A. BRADLEY DO RETIRED. DECEMBER 19, 2021 AT 8:47 AM

Fabulous, exciting article. I had wanted to know. is it applicable to cancer? Is this what we are hearing in the news about new vaccine therapy.

Reply Link

MARY E SLOCUM DECEMBER 29, 2021 AT 6:37 PM

Thank you for this well-researched and well-written story of mRNA technology and the scientists behind it. Let's find ways to make the vaccines that use this technology available to everyone, everywhere. Until we do, the Coronavirus will be with us.

Congratulations to Dr Weissman for working with countries to get mRNA vaccines and treatments for diseases such as Sickle Cell into the hands of people who need them but for now don't have access to them. How can we support his work in this area?

Thank you!

Reply Link

RUTH MCAUGHEY AUGUST 27, 2022 AT 12:24 PM

Dr. Kariko's idea to use messenger RNA to fight disease was considered too radical for investors to fund. Dr. Weissman joined UPenn in 1997 and met Dr. Kariko at the photocopy machine.

Sadly, Dr. Weissman is afforded a title and Dr. Kariko is called Ms suggesting that even in 2022 we are impeded by our assumptions (i.e, immigrant Ph.D female biochemist must be the assistant to the male).

Moderna suing Pfizer suggests her post doctoral research will be ignored in legal arguments about intellectual property since U. Penn. Pulled her

funding & she was hired

Reply Link

KATHARINE WOOD DECEMBER 30, 2021 AT 8:45 AM

Fascinating article. What true heros these two scientists are! It is sad, but all too common, how short sighted others have been during the many years of research and development of mRNA. Many less dedicated scientists would have given up long ago.

Reply Link

LB JANUARY 2, 2022 AT 6:04 AM

Female scientist is born in small town in Hungary. She grows up in a two room house with no running water, tv, or refrigerator. By the 8th grade, she's ranked third-best in her country in biology for her age group. In the late 1970's she defends her PhD thesis on RNA while pregnant. She works in obscurity for years, being ignored or outright dismissed, and defunded by male colleagues. She soldiers on. The lab where she works is closed. In 1985, she escapes communism by stuffing money into her child's teddy bear, leads her family out of the country, and goes to work in America. By the late 1980's, she has a working prototype of the idea, to help with treatments at two different labs, one using mRNA in heart surgery, and another to treat cerebrovascular spasms in the brain.

Male scientist bumps into female scientist at the copy machine. She offers to help him with his research. She tells him about mRNA, touting its vast potential. She offers to make mRNA for one of his experiments. Man actually listens and works with her a bit. Together, they publish their results.

Later, when this is talked about, make scientist leads entire article, female scientist becomes footnote.

Katalin Karikó invented this, others contributed later to manufacturing it to be sure, but she is the originator and as the Senior Vice President of BioNTech, is the driving force behind the mRNA COVID vaccine, and should be referred to as such.

She is not someone who "also worked on it" that you "generously" think should

be included as an afterthought.

Reply Link

IRENE DELBONO JANUARY 28, 2022 AT 4:02 PM

I so agree with you! I am sure there are lots of Bostonia articles that don't relegate a male colleague to footnote status.

Reply Link

JOHN CARTER JANUARY 3, 2022 AT 5:19 AM

This article is complete rewrite of history. No mention of Dr Malone who claims to have discovered in-vitro and in-vivo RNA transfection at the Salk Institute in 1987, and that he later invented mRNA vaccines in 1988.This pre-dates anything cited here.

Reply Link

SAMUEL TUNES JANUARY 4, 2022 AT 4:27 AM

I concur.

Reply Link

CHRIS JANUARY 10, 2022 AT 1:28 AM

100% correct

Reply Link

CONNOR DAVIS JANUARY 18, 2022 AT 2:31 AM

Dr. Malone worked on methods to more effectively deliver naturally occuring RNA and mRNA through the cell membrane using lipids (paper from 1989). His team transfected luciferase (an enzyme derived from fireflies) into mouse cells in vitro (and they glowed), followed by a study of on mice in-vivo the following year. This is different from engineering the mRNA itself to affect specific cellular machinery – which is what Weissman and Kariko worked on. His claim of inventing mRNA vaccines is disputed since it took a collective work to develop all the components necessary for the final products we have today; including in-silico simulations, mRNA

sequencing/editing, bulk nanoparticle lipid production, etc.

Reply Link

ERIC COSH FEBRUARY 2, 2022 AT 1:15 PM

Dr. Malone's ego keeps getting in the way of any praise that he should deservingly receive. No one person invented or delivered the mRNA sequencing. It took teams from everywhere to get to where we are.

Reply Link

SERDAR DUZGOREN JANUARY 3, 2022 AT 5:51 AM

I wish I could ask a few questions to prof Weissman:

1) Could any skilled scientist engineer a HIV (or any lethal pathogen) with a modified Coronavirus spike protein?

2) Could anyone engineer a few Coronavirus variants (such as Sarscov-2, Beta, Delta, Omicron, Pi, ...) each with a bit different spike protein (those different parts at each variant actually to be the common part with the lethal one's spike protein)?

3) Could viruses be modified not to mutate (so as not to become resistant and erase the whole of humanity)?

Is it possible to achieve a SELECTIVE depopulation plan by first engineering a HIV with a modified Coronavirus spike protein then creating a few Corona viruses, spikes a bit different from each other? After all the necessary variants are released, to "decide" to produce a multi valent mRNA, made of each variant's different parts (which was placed intentionally to be taken as reference in building mRNA sequence of the spike of that HIV)?

If the answer is yes, then, An intended immunisation can be given to desired younger and healthier parts of populations by calculated delivery times to each country, by avoiding the World Health Organization's priority, old, sick, handicap people's vaccination time!
This method can be used at any time by 'any bad guys' by creating a lethal pathogen with a modified coronavirus spike protein made of unique parts of existing variants and then using a "multivalent mRNA" and then releasing that

lethal pathogen and eliminating all who didn't receive THAT injection!

Every condition necessary to achieve such a plan are already exist: Global vaccination, Variants with unique spike protein parts, mRNA technology (which is the only way to produce that desired Protein by a multivalent mRNA), WHO priority groups' different vaccination times (for the right vaccine to reach to desired qualified people)

The only missing step is 'another variant to be released (saying that "it is more dangerous" and therefore current vaccines needs to be updated!) and producing an multivalent mRNA or a pan or universal coronavirus vaccine!

I am sure they didn't think an multivalent mRNA vaccine could be used to achieve such a plan
when they developed it!
Could you please ask these questions to Prof. Weissman an Kariko?
The usage of multivalent mRNA leaves an open door for the described biological attack method to be achieved! This risk should not exist!

PRECAUTION for such a biological attack possibility not to become reality;
Requesting authorities to not let use of any chimeric mRNA sequence, which would encode a never existing new protein shape with no reference existing virus protein to compare with, in vaccines by explaining how it could be used in the described way! Also, requesting authorities to decide which vaccine is the most efficient and use only that vaccine on everybody! Proclaiming that 'every citizen deserves the same, best possible treatment'. Mentioning also that, 'vaccine equity' would assure avoiding the usage of different vaccines on different age and health grouped people, to achieve the described method of a global, FUTURE biological attack, resulting in a TARGET SELECTIVE depopulation!

Reply Link

MIRYAM VACAS JANUARY 4, 2022 AT 4:22 PM

This mRNA technique inevitably reminds me of the CRISPR/Cas9 technology. I think they are really similar in terms of the applications, as they can cure, for instance, genetic diseases such as sickle cell anemia.
However, they are slightly different with regards to the way they interfere with our body cells: while CRISPR/Cas9 aims to manipulate the cell DNA, mRNA

produces the correct version of the protein that causes the disorder (without any changes in the genes).

However, mRNA is definitely promising in the area of immunology. It has been scientifically proven that the efficacy of mRNA vaccines, just as this article says, boosts up measurably. Moreover, this vaccines have more variability, that is to say, a greater chance of an immune response against a virus, as the mRNA may be designed to cover distinct strains of the infectious pathogen.

I have connected dots and learnt a lot reading this article.I am faithful this mRNA method will save millions of lives in the future, just as it is doing now.

My best congratulations to both of these incredible and hard-working researchers, they really deserve the whole humanity gratitude particularly during this pandemic time.

Miryam Vacas, 12th grade High School student
Barcelona, Spain

Reply Link

KIERSTEN LOCHERIE JANUARY 30, 2022 AT 12:15 AM

Dr Malone discovered in-vitro and in-vivo RNA transfection at the Salk Institute in 1987, and that he later invented mRNA vaccines in 1988.This predates anything cited here.

Reply Link

ERIC COSH FEBRUARY 2, 2022 AT 1:21 PM

You might want to check up on facts Kiersten. Yes, Dr. Malone did investigate work very early on before almost anyone else had with mRNA, like almost any discovery of almost anything, it takes a team to come up with final solutions. Maybe stop listening to podcasts on Spotify.

Reply Link

JP MORGENSTERN MARCH 9, 2023 AT 5:26 PM

Indeed, the real breakthrough that enabled Robert Malone to transfect

RNA in vitro into cells was the cationic lipid developed by Phil Felgner (second author on Malone's paper) who used it to transfect DNA in vitro into cells (https://www.pnas.org/doi/pdf/10.1073/pnas.84.21.7413). Once Felgner had demonstrated one could use a cationic lipid as a means to get a large nucleic acid (DNA) to traverse the cellular and nuclear membranes to deliver it into cells, it wasn't that much of an intellectual leap for Malone to swap RNA for DNA.

Reply Link

ACTUAL DATA FEBRUARY 2, 2022 AT 4:56 PM

So, is this article saying that the vaccine went straight from mice, to men? No testing on primates? This "modification of the nucleosides in mRNA molecules" is potentially concerning. Down regulation of any immunological response could have risks. Were studies conducted that could prove that our body's response to cancers was not impacted?

Reply Link

WILLIAM MAHER APRIL 4, 2022 AT 6:27 PM

As to who invented the mRNA vaccine technology, here is the answer verbatim from Dr. Robert Malone (Patrick Bet-David Podcast Episode 113 – YouTube January 6, 2022 343,000 views)
PBD : Why are you saying that you're the inventor?
Robert Malone : The reason I'm saying it is because I have 9 issued patents that have my name on it from 1988
PBD : And this is public information?
Robert Malone : It's widely available and never cited [As is of course the case here in this thread] cont. –So, for instance the Nature article of "The Tangled History of mRNA Vaccines,"...I provided that author with access to deep information, including the primary invention disclosure, which I validated by... enabling him to speak to the scientist Mark Kindy that cross-signed it–I think it was 1987 or 1988... None of these articles have cited the patents that have been part of this mainstream press narrative... in her first mRNA-related paper, in which she[Katalin Kariko] not only cites my work...she lists in the acknowledgements appreciation for my interaction with her[!!!]

Reply Link

CARMEL HOURIGAN OCTOBER 8, 2022 AT 8:31 AM

I'd like to understand why I've developed adverse effects from the mRNA vaccine, dose 2, if the inflammatory problems seem to have been sorted out. My doctor, who sees many vaccine-injured patients, said I should avoid all vaccines for 2 years after serious adverse effects after Pfizer. This doctor said the injuries are caused by inflammation. The symptoms began soon after the second dose.

I wonder if there is something people could do to prevent this strong inflammatory response before receiving these vaccines. I see the potential with this technology, but I'm now worried about receiving any further vaccines.

Reply Link

KATHY BEST MARCH 23, 2023 AT 7:39 AM

It's ironic that when a question is asked in regards to testing on anything besides mice/when complications from or adverse reactions are mentioned, there is no answer provided. This is key to overall effectiveness.

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