

THE CRISPR Whisperer

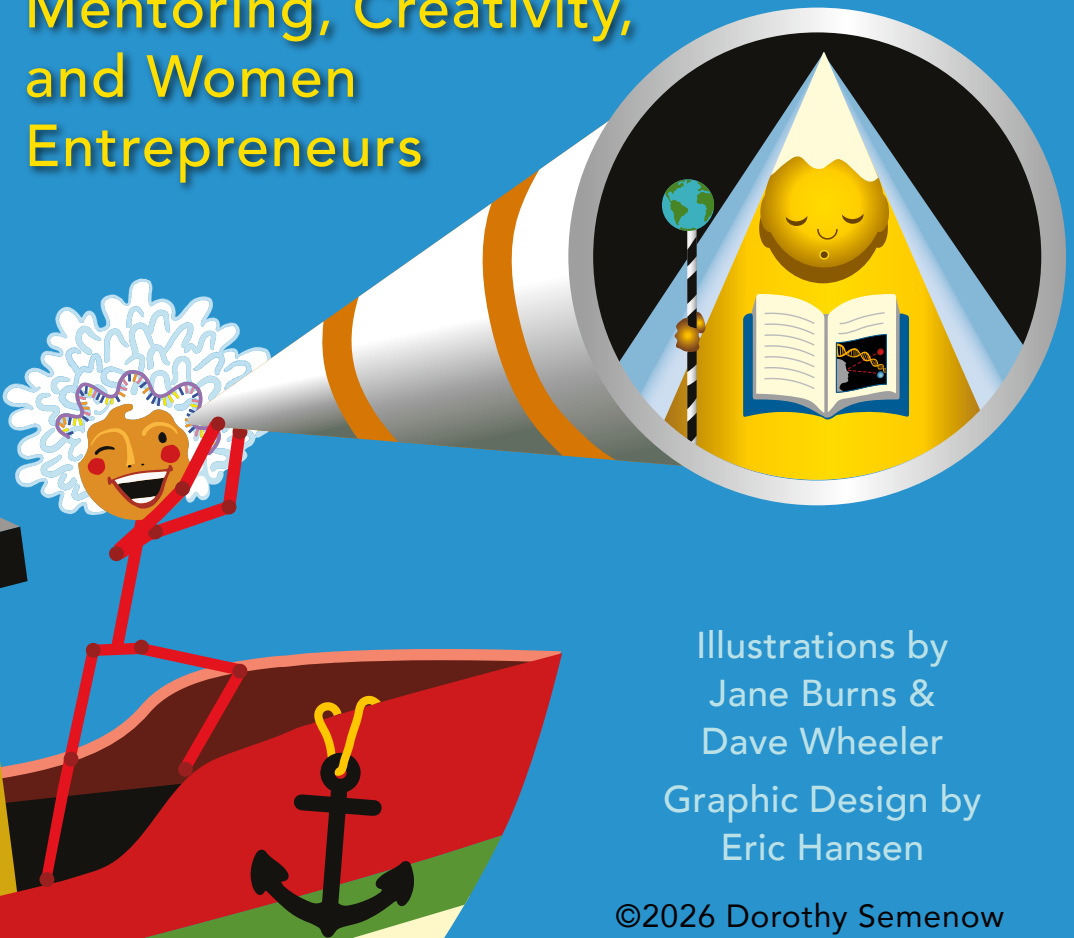
PICTURE Series

for Ages 11 to 111

By Dorothy Semenow, PhD

Episode 02

Mentoring, Creativity,
and Women
Entrepreneurs



Illustrations by
Jane Burns &
Dave Wheeler

Graphic Design by
Eric Hansen

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THE CRISPR Whisperer

PICTURE Series



Episode 02

Mentoring, Creativity,
and Women Entrepreneurs

Written by
Dorothy Semenow, PhD

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Episode 02 Mentors (Pittsburgh)
DEDICATION

**To The Memory of
Aunt Bess Wolk**

Brother Joel Semenow

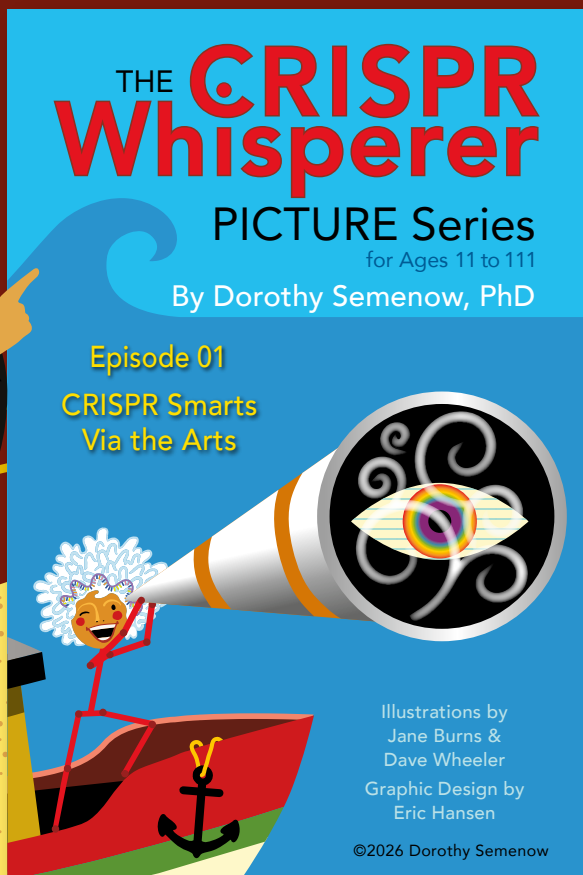
The Breckenridges:
Peg, Harv, Jean, Alan



You Don't Have To Be a Scientist
To Think Like One!

NEVER HEARD OF CRISPR?

Check out what Doc Dorotheanna, the CRISPR Whisperer, has cooked up for you!



Learn about the super-powerful tool that can alter DNA, the blueprint of life!



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MENTORING, CREATIVITY & WOMEN ENTREPRENEURS

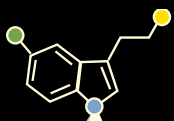


MENTORING



Who is
YOUR
Guru?

MENTORS





Mentoring

Bibliomentors: Role Models in Books, Films, & Videos

Many women lead heroic lives, and here, we showcase 7 awesomely gutsy science pioneers: Joanne Kamens, Nina Vsevolod Fedoroff, Barbara McClintock (via Fedoroff), Chao-Ting Wu, Francis Hamilton Arnold, Beth Shapiro, and Anna Jane Harrison.

Their powerful stories offer “biblio-mentors”—role models accessible anytime, anywhere. At first, you might feel too far removed from these trailblazers in terms of background or experience for their insights to apply to you. But give it time. With reflection, you’ll likely uncover guidelines and inspiration that resonate with your own interests.



Mentoring Hooks Can Be Found in Books



The rise of social media has amplified the power of bibliom-entoring. And with chatbots becoming more human-like, they've added a new dimension, making it feel as though you're interacting with a mentor in real-time.

Joanne Kamens

Mentoring and Networking Guru Joanne Kamens is a sci heroine on many fronts. With a Harvard PhD in genetics, her career spans academia, pharma, biotech, and nonprofit sectors. And always, activism, focused on Diversity, Equity, and Inclusion DEI.

Her stellar 3-part video series on peer mentoring groups can be accessed at <https://www.youtube.com/watch?v=lxz3t7Qilck> each focusing on different aspects of mentoring:

- 1. What is a Peer Mentoring Group?***
- 2. How to Start a Peer Mentoring Group***
- 3. Mentoring Best Practices***

Kamens' video, "Not Networking 101: Building Relationships for Success" delivers a masterclass in transforming networking into meaningful, lasting connections. Packed with practical advice and colorful real-world examples, this video is a must-watch for anyone eager to forge authentic connections that matter.

Kamens' dedication to mentoring and advocacy for DEI comes from hard-won, firsthand experience. Here's one ordeal she endured that took 28 years—and an act of Congress—to fix.

"When I had my second baby in 1994 while working in pharma I needed to find a place to make breast milk. My office was all windows so I asked if I could put posters up for privacy. They said no - it was not allowed.

"So my boss had a closed office and offered to switch but they also said, no that's not allowed. They told me they would put a chair in the bathroom for me (UGH, would you eat your lunch in the bathroom I told them).

"I spent about 8 weeks trying to find a private place to pump then gave up. I then spent about 7 years trying to get a 300 sq foot closet made into a pumping room. We had a very under occupied building, but it was always some I left that company after 15 years - never thought to just leave and say 'I'm outta here, you jerks!'

"But when I recently told this story to a young friend—a woman who is passionate about her career— she said 'Eww, when the person told me to pump in a bathroom I would have given 2 weeks notice on the spot.' And you know, I believe she really would have. So that's a big change. I have big hope in the young folk who won't take it any more."

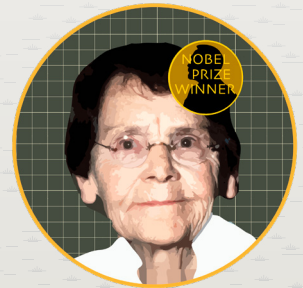


That same spirit of change finds support in legislative backup, notably the Providing Urgent Maternal Protections for Nursing Mothers Act (PUMP Act), signed into law on December 29, 2022.



Nina Vsevolod Fedoroff

Nina V. Fedoroff is best known for her pioneering work in plant genetics. Building on Nobel Laureate Barbara McClintock's landmark discovery of jumping genes, first announced in 1948, she unraveled the molecular biology of how those rascals disrupt genomes.



Beyond the lab, Fedoroff has been a thoughtful champion for using biotechnology wisely in agriculture and served as the Science and Technology Adviser to the U.S. Secretary of State. Her many honors include the U.S. National Medal of Science, the nation's highest award for scientific achievement.

In her captivating 1996 autobiographical essay "Science: Two Women Geneticists," about Barbara McClintock and herself, Fedoroff looks back on the improbable path that carried her from a difficult childhood to a life in science. This account draws on that essay.

She grew up in a family of displaced Russian nobility—scientists, clerics, and diplomats who had fled the czars and started over in America. It was, as she put it, a “dysfunctional” clan, one that clung to its nineteenth-century customs and sent girls a clear message: they weren’t worth much. But that didn’t discourage Fedoroff’s ambitions. As she described her childhood self and her mother’s reaction to her, “I was a stubborn, independent, ornery kid, something my mother missed no opportunity to tell anyone who’d listen.”

By 16 she was taking college-level history courses and teaching music; by 17 she was married, pregnant, and out of school. Determined to keep learning, she persuaded her school to let her take the state exams on her own—and graduated first in her class. She then talked her way into Syracuse University while her Air Force husband served overseas, arranging childcare for her baby during the day and attending classes herself. “Reading and thinking and writing were my sanity,” she later wrote.

Her husband didn’t see it that way. When he returned and discovered her “perfidy,” he demanded she quit and move with him on his next assignment. When she refused to leave school so near the end of term, “my husband beat me unconscious, cleaned out the account in which I’d saved a few hundred dollars for the second semester, and left town.”

Enter Fedoroff’s first white knight: Syracuse University’s financial-aid officer, who bent the rules to hand her a scholarship—a lifeline. Her family offered nothing; she’d broken their rules for girls, and they were ashamed of her.

But she kept breaking rules. As drawn to music as to books, she left college—with her baby, Natasha—for Philadelphia to study under the great master flutist, William Kincaid. To stay afloat, she leveraged her knowledge of Russian into a job at *Biological Abstracts*, which became her second lifeline.

But worse lay ahead. Divorce was hard to get, the pill barely existed, and abortion was illegal. Still married, she met another man—and had another child. Her life was a wreck. Slowly Fedoroff pulled things back together: she gave the baby up for adoption, got a divorce, eventually won back her scholarship, and returned to Syracuse, determined to do something useful and become a doctor.

She took a bunch of science courses, landed a \$600 NSF summer undergrad research award, and her professor took her along to the scientific hub at Woods Hole. By day she worked in the lab; by night, she translated to make ends meet. More than that, she met famous scientists, like James Watson, tried out leading-edge microscopy, and sampled lectures “on every imaginable subject.”



Rocky patches be damned, Fedoroff kicks ahead!

The upshot, as she put it, "I was hooked: science was to be my thing, experiments my way of life."

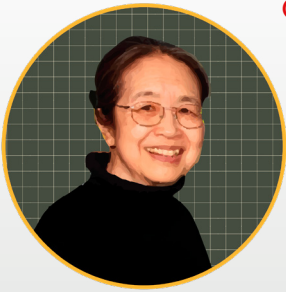
An NSF fellowship helped to support Fedoroff as she earned her PhD at Rockefeller University. Still, it wasn't smooth sailing. In her words, "I had a tough time getting my career off the ground; at times I thought I'd blown it altogether. I'd married again—badly again. I'd had another child, another treasure." Then Lady Luck delivered her to the Carnegie Institute of Washington for a postdoc.

Near the end of that stint, she was invited to present her work at Cold Spring Harbor Lab, where the meeting that would set the future course of her research occurred. As she tells it, "Late in the day I ran into a tiny elderly woman. Although I didn't know her, I guessed immediately that this must be Barbara McClintock...I was very much taken with the lucidity of McClintock's casual discourse...It didn't fit her reputation for impenetrability, and I was curious—curious enough to find the old *Carnegie Year Books* where her writings had appeared, and I started to read them upon my return to Baltimore."

When Fedoroff was later offered a staff position at Carnegie, she committed to working out the molecular biology of maize's amazing jumping genes—a project aiming to confirm and extend McClintock's discovery of those genes. Yet doing it turned out to be much harder than she'd imagined. Remembering that dismal time, she said, "Barbara and I couldn't agree on anything—she just thought I was doing everything wrong. I think the summer's nadir came when my son's summer camp director called and announced, 'Your son has impetigo. Please come and get him and don't bring him back.'"

After months of frustration, Fedoroff finally broke through. As she later reflected, "Well, I did succeed in the end, and the rewards of persisting have been enormous"

"So that is my tale, or almost all of it. It has a wonderful personal postscript. Last November my appointment as Willaman Professor of Life Sciences at [Penn State] was announced in the Eberly College's alumni magazine, [with my picture and...story]. Two days after the magazine was mailed out, I got a telephone call. The caller said simply: 'My name is Jim Rathmell, and I think you're my mother.' Jim, my second son, was adopted by a Penn State family—his adoptive father was an agriculture extension agent. Jim graduated from Penn State the only one of four adopted siblings to attend university." He went on to do research in biochemistry, attended medical school, and became an anesthesiologist."



Chao-Ting Wu

Chao-Ting Wu is the Director of the Personal Genetics Education & Dialogue (PGED), which she co-founded in 2006 to spark conversations and raise awareness about the benefits and impacts of personal genetics.

Wu has been a juror at the Sundance Film Festival, and PgED teams up with talented film and TV storytellers to help them weave genetics into their stories.

As a Sundance "Big Conversation: Breaking Barriers" panelist in January 2025, Wu shared a pivotal breakthrough she pulled off on her path to tenure at Harvard. You can watch her recount this compelling story at the 27-minute mark on YouTube: <https://www.youtube.com/watch?v=MdcvIv-lhuk&t=2s>.

Wu entered science when women were still struggling to gain ground. She was carving out her own path with independent research, but the sticky label of faculty wife (in the genetics department) relegated her to an inferior status.

The powers that be made it clear: they didn't want her there. She was kept out of the main building, cooped up in a tiny basement lab much smaller than needed to do her work, without access to equipment others used. Worst, they wouldn't allow her to have students, and even pressured her to give up her faculty position for a lower-ranking (non-independent) research assistant role. And she wasn't invited onto committees, so lacked a presence on campus.

Still, she focused on the work. "When you love something, you close the door, and it's just you and the bench," she said. And despite the institutional opposition, she made real discoveries—recognized nationally and internationally, just not within her own department.

She never learned how to fight back—until the movies taught her. Friday nights, during their dates, her husband showed her movie after movie of people standing up for what they wanted to do and succeeding. Looking back, she declared, "The movies give you a sense of success, and they teach you things. So I really want to thank the film industry again because if I had not seen those movies, I really don't know how I would have fought—not only fighting and succeeding but being okay with fighting and succeeding.

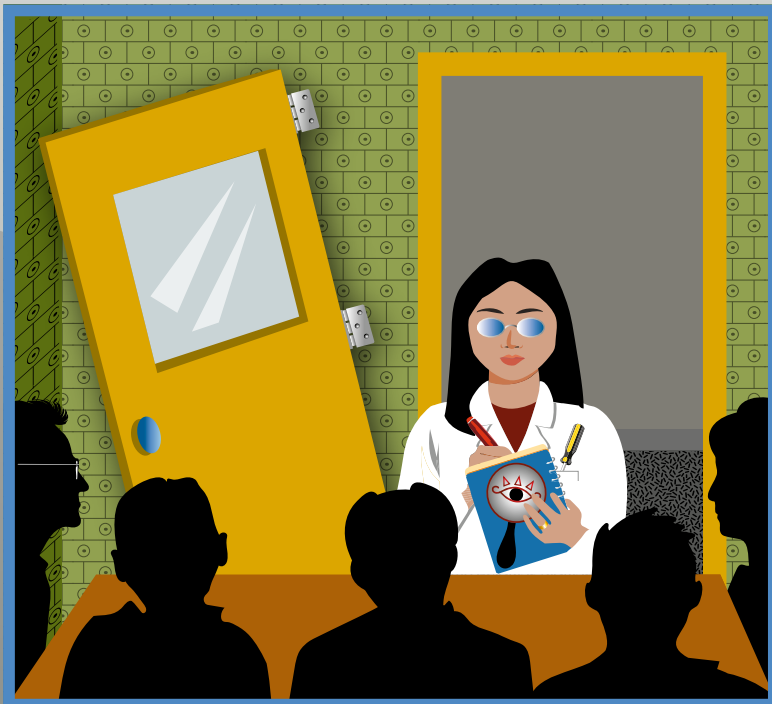
"So things progress. Science was great, administratively [it] was terrible, and then the time came for promotion around 2001. They sent out these letters to people, some who know you, many who don't, and they say, 'Here's their CV, this is how long they've been here, here's what they produce. Should they be promoted?'

"Now I knew that if the world knew what little I had, that I would meet proportionately what you need to meet in order [...] be promoted. And I told my then department chair, 'I think this will work if you put in a paragraph describing how I was treated on this campus.'

Wu knew there was going to be a meeting with the chair and several senior faculty to decide whether she could include a statement about her working conditions in that letter. She also knew the chair would never allow it, but the meeting had to happen.

"So I walked into the room—it was a small room—and for some reason, I left the door open. Now, I'd like to think it's because I saw a movie and it taught me to be clever, and sometimes I like to tell the story that way, but in all honesty, I can't be sure.

"But I left the door open, and when I sat down, I realized everyone was nervous... And then someone said, 'Will you please close the door?' And I said, 'I don't want to close the door.' And they said, 'Close the door.' And I said I felt uncomfortable closing that door, and I think that made them think I had someone standing outside recording the conversation. And then someone went and closed the door, and I said, 'Oh no!' I went and opened the door, and this went on—[close and open the door]—for a while."



Ting Wu Triumphs Over Closed Doors!

Everyone grew more agitated, and the meeting began. The chair asked the senior faculty whether their letter should include a statement of the conditions under which Wu worked.

"I heard, 'This is unprecedented, and we will not allow it,' and I heard my mouth saying, 'Well, what you did to me was unprecedented!' And one of the faculty just put her head on the table... So one by one, each of the senior faculty explained why they agreed with the chair, and it was clear no one was going to support my petition to have the conditions included.

"I had a notebook... and I told them, 'You know, these meetings are so disturbing to me. I have a lab, I have people who depend on me when I go home. Sometimes, I can't remember who said what because it's so discombobulating. I'd like to write down all your reasons. I must have this in my notes.'

"So I took my notebook, I opened it, and I took my pen and looked at the first senior faculty member... and I said, 'Will you mind please repeating what you said? I will write down your reasons and these conditions.'"

Silence.

Then, something shifted. The first professor, about to explain her stance again, hesitated—and changed her mind. Then the second did the same. Then the third. By the end of the meeting, they had all reversed course, and the chair was livid.

Years later, one faculty member admitted he had been too afraid of retaliation to back her at first. But in the moment, when they realized their words would be on record, they couldn't ignore what was right.

Reflecting on that day, Wu said: "But when push comes to shove, and they realize someone's going to record what they're doing, I really think they reach the core of what they think is right and wrong. So anyway, that was my story. And I hope you're never in that situation."

Frances Hamilton Arnold



Frances Hamilton Arnold was awarded the 2018 Nobel Prize in Chemistry for her pioneering work in directed evolution to engineer enzymes—changing them to work faster, greener, and more efficiently.

Arnold's technique takes nature's trial-and-error and puts it on fast-forward. It creates many slightly different versions of a protein by mutating its DNA, tests them to find the best ones for specific purposes, then repeats the process on those. Over several rounds, this produces proteins for jobs, such as breaking down plastics, boosting biofuels, sharpening gene tools, and many more. WOW!



Arnold team lends a helping hand:
Enzymes need guidance to be top brand!

Arnold's candid and unconventional autobiography appears at <https://www.nobelprize.org/prizes/chemistry/2018/arnold/biographical/> where she reflects on her unique path to success.

During Nobel week in Stockholm, she shared her perspective in interviews. Selected quotes appear below; italics added are mine, for emphasis.

- "Give up the thought that you have control. You don't. The best you can do is adapt, anticipate, be flexible, sense the environment and respond."
- "If you're going to change the world, you've got to be fearless."
- "If I fail at one thing, I'll either try again, or I'll move onto the next problem."...So that's one way to get around the problem of failure."
- "I was used to being the only woman in everything... I didn't even think about it. Men were my role models; there's nothing wrong with that."
- "I've been called pushy and aggressive and all the negative words that are rarely applied to men with the same traits. But it doesn't bother me."
- "I try not to give too much advice because specific advice doesn't help. My path is different from your path, but don't be afraid of a path, take it... Do something, right, even if you don't know what it is and where it will lead you. Do it. Do something and do it as well as you can. If you don't like it, take another path."

Arnold's Major Takeouts

Ask the questions: "What makes that interesting? How does it lead to some new information I can use—DO something with?"

Let go of the need to control everything, and have a plan for what to do if things don't work out—whether that means trying again or moving on to a new project. In the latter case, being ready to pivot—like a basketball player—makes the pivot itself possible.

And underneath it all, indifference to naysayers criticisms—or yay-sayers cheers—of your work or personality traits is a large asset, but hard to bag.



Beth Shapiro

Beth Shapiro, renowned for her groundbreaking work with ancient DNA, has carved out a reputation as a fearless innovator. A masterful science communicator, she views involving the public as central to her role as a scientist and continually finds ways to translate complex concepts for non-experts.

As the Chief Scientific Officer at Colossal biosciences, she was the leading scientific mind behind the project to "de-extinct" the dire wolf in 2024 and 2025; that breakthrough was featured on the cover of Time Magazine for April 7, 2025.

Shapiro's main tip for how not to and how to start a talk? "Don't start by overwhelming your audience with data or boring them with excessive nuances. Start with an interesting story, then build from there."

How she got hooked on ancient DNA is just such a story. When Alan Cooper at Oxford University offered her the opportunity to study ancient DNA in Siberia, she jumped at the chance. "The field of ancient DNA combined all the stuff I was interested in: ecology, deep history, DNA, and storytelling...The field was brand new, bursting with enthusiasm and excitement...A career in ancient DNA promised to be different, definitely cool, and hopefully useful...And I really wanted to go to the Arctic."

Reflecting on that pivotal moment, she says, "I wouldn't be where I am today if I hadn't been willing to take risks."

Still, over 2 decades later, Shapiro shares that she is surprised to still be working in the field: "I tried for a long time not to work on ancient DNA anymore because it's highly competitive, and there are some people in the field that have quite large egos, but I just kept getting pulled back into it."

"All I've done the whole time is follow what I'm genuinely interested in and try not to be a jerk, have lots of collaborations, and be open to taking risks, even if they seem kind of crazy—even if they seem like bad ideas." In March 2024, Shapiro began a 3 year sabbatical from UCSC at startup Colossal Biosciences, the de-extinction company that she says she essentially runs.



Beth Shapiro: Always Angling Different!

Jill Banfield

In 1997, Jill Banfield, a geologist curious about how microbes shape rocks, teamed up with microbiologist Ken Nealson to host a groundbreaking geomicrobiology conference. The turnout was small, the venue less than ideal, and not everyone was on board at first—but against the odds, a whole new scientific field was born!



Forever hellbent Bancroft never fritters,
She'll nail your microbiome's tiny critters!

Even as an undergraduate and graduate student in geology, Banfield's peers noticed her knack for seeing patterns others couldn't see. But when her findings didn't fit microbiologists' established ideas, they were quick to dismiss them, chalking it up to the sloppy technique of this Jill-come-lately, so lacking in formal microbiology training. Over and over, they tried—and failed—to prove her wrong.

Through it all, Banfield stood firm. What she saw in minerals couldn't be explained by inorganic chemical reactions alone. There had to be living entities involved. Yet her microbiologist colleagues weren't interested in bridging disciplines or challenging their assumptions. For them, naysaying was the order of the day.

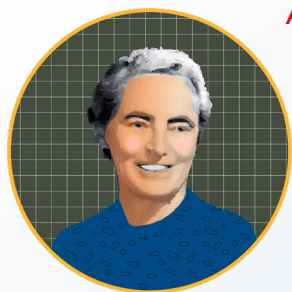
Banfield, however, was not to be deterred, neither then nor in 2001, when she produced her biggest innovation, "genome-resolved metagenomics." GRM is a pioneering method for uncovering microbial genomes by sequencing entire natural microbial communities and then reconstructing individual genomes from that data—a huge breakthrough because most microbes cannot be grown in the lab, so had previously remained unknown.

The GRM technique opens new roads for scientists to discover microbes with genes that can help save the planet, feed humanity, and cure disease.

Here's a girl stepping up, building her science chops and mentoring skills along the way. In her first stage, she's inspired by the picture, ready to take on the mentor's role herself.



Stepping Up to Storied Heights



Anna Jane Harrison

Anna Jane Harrison, my mentor and lifelong friend since our days at Mount Holyoke College (MHC), was the best teacher I ever had. But her impact extended far beyond the classroom. She was an accomplished researcher and a passionate advocate for communicating science to the public and policymakers alike.

Harrison grew up on a poor farm in Missouri, where life was tough. Her parents instilled in her the importance of never leaving a community task unfinished; such commitment to service became a guiding principle throughout her life. Her sense of responsibility, notably toward the less fortunate, was a cornerstone of her career.

Her dedication to improving chemical education was equally unwavering. She cared as deeply for all students as she did for the advancement of chemistry itself. In the classroom, she aimed to reach the weakest student, making sure no one was left behind.

Much like Barbara McClintock, who felt one with the corn kernels she studied, Harrison seemed to merge with the minds of her students. One student recalled, “It was like she was right there in my mind with me, always telling me what I needed to ask next.” This wasn’t some magical talent—it was the result of diligent preparation, often 40 hours for a single lecture.

Harrison’s approach extended beyond academic instruction. She had an uncanny ability to sense when a student wasn’t connecting with her style and adjusted her approach, minimizing comments on their lab reports and letting her supportive actions speak for themselves.

Her belief in fostering independence permeated all areas of her life—even her relationship with her beloved horses. As an accomplished horsewoman, she ensured her horses never grew too dependent on her, often enlisting substitute riders. With her students and mentees, she was always ready to provide practical help and offer opportunities for growth, without allowing them to rely too heavily on her

As ACS president, she addressed the struggles of those whose livelihoods had been disrupted by changes in the chemical industry. Her leadership reflected her lifelong sense of duty to others and her conviction that science should serve the public good.



Twice Outpaced—Third Try, First Place

Lesley Baumann, Bob Paltrow

(The creators of this illustration invoked artistic license to depict Harrison riding without a helmet. But, to stay safe, you be sure to wear yours when you ride!)

Initially, Harrison dismissed the idea that women faced discrimination in science, based on her own supportive environment at MHC—a department renowned for its leading-edge research as well as teaching. But one question changed her mind: “What if you wanted to compete in the Big University research league—would your access be as open as an equally qualified man’s?” The question struck a chord. She grasped the challenges women face in science and, from then on, advocated tirelessly for women’s rights in the field.

Ambitious women often face internal as well as external obstacles. Caring too much about what others think of them or their work is a major bugaboo. Harrison, whose work as President of ACS and AAAS attracted press coverage, avoided that trap by not reading articles about herself. One way or another, all the mentors featured here found ways to cut their own paths, no matter what others thought.

Harrison served as a role model, offering guidance through example rather than direct advice. Her legacy is that of a truly remarkable teacher who enriched her students, elevated her profession, and positively impacted society.



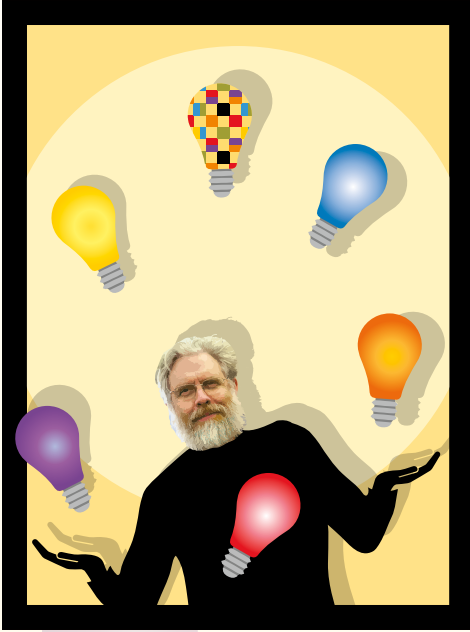
Dorothy Semenow (AI), Bob Paltrow

The paths of these science heroines take many forms, yet a common theme runs through their stories: the courage to forge their own paths, no matter the cost. Their message is clear: embrace your passions, invest fully in your pursuits, boldly take risks, and treat failure as a vital part of growth. Be a rebel with a cause—and make it count!

Does anything in the above accounts apply in your life?

Mentors Can Be Any Sex, Gender, or Ethnic Group

George Church



George Church is a beacon of mentorship in the scientific community, known both for his wide-ranging breakthroughs in genetics and his commitment to fostering a spirit of inclusivity and support among his mentees.

Luhan Yang

Among Church's mentees is Luhan Yang, co-founder with Church of eGenesis (U.S., 2015) and Qihan Biotech (China, 2017). The 2 companies joined forces to confront one of medicine's most ambitious challenges: making the transplantation of animal cells, tissues, and organs safe and effective for humans—with CRISPR as a central tool.



Yang's route to this point wasn't straightforward. In an interview with Sarah O'Meara for Nature, she shared her struggles and how Church's mentorship was pivotal. "I almost did not graduate from Harvard, because I failed my qualification examination.



"The major problem was my poor English—some of my professors had difficulty in understanding me. Growing up in a small, remote town in China, I did not have a lot of opportunities to practice English. In high school, I was selected to take part in the China National Biology Olympiad.

This was a huge honor, but meant that I had to spend most of my time [on biology], leaving little time to focus on English. So I failed my qualification exam, and I was asked to take English classes for a year to stay at Harvard. I was also not allowed to spend extra time in the laboratory until my English improved."

The turning point came when Church intervened. "He told the other professors that he could understand what I was trying to communicate, and instead of having me take language classes, he said he would help me practice English," Yang remembered. This gesture of support and understanding from Church marked the beginning of a series of weekly discussions that ranged from science to culture, nurturing Yang's confidence and leadership skills. "He rebuilt my confidence and taught me how to truly be a great mentor and leader."

Denitsa Milanova

Denitsa Milanova, CEO of Marble Therapeutics, cofounded with George Church, credits Church with her training as an entrepreneur as well as her scientific capability in anti-aging research.

In an interview with aging research and ai expert Alex Zhavoronkov for an October 2022 *Forbes* article, entitled, "This Harvard

Female Scientist Wants To Use Genetics To Reverse The Age Of Your Skin,"

Milanova recounted the path she had traveled. After growing up in Bulgaria and moving to Florida for college, she earned her master's and doctorate in mechanical engineering at Stanford, then joined Church's

lab for a postdoc, where she quickly focused on aging research.



"George took a chance on me when I had no background in aging research and taught me how to take risks and pursue groundbreaking science...And this is the best way to tackle big problems, starting with the basic science, but also being comfortable for things to take time and even failing before succeeding."

"I am a big optimist and even a little bit of a dreamer by nature, but I do get anxious about fundraising. I think some fear of failure and a certain level of anxiety actually helps me, it motivates me to deliver. I force myself to maintain a "no limitations" mindset, both in science and business.

"What keeps me highly motivated is the certainty that rejuvenation is fundamentally possible, that we have the tools, and is worth doing—it is one of the biggest problems of our time."

Milanova's team at Marble is developing methods to drive rejuvenation of skin cells with gene therapy and is working on a product that could reverse wrinkles like a genetic Botox. "Over the long term we have no shortage of ambition. Skin is the start, because that's where we could get the right data. But I want all tissues, all ages made to act young."

Mentors Can Be Any Age: Never Too Young or Too Old

Sibling Mentors

Children in families with more than one child often experience mentoring early, with the older child filling the mentor role and the younger becoming the mentee. These relationships—formed during a period of urgent, not yet controllable emotions—can have far-reaching, long-lasting effects.

I know this firsthand. My brother Joel, 3-½ years older than me, was my first mentor. He carried extra weight as the "man of the house," since our parents separated and my father never lived with us after I was born. During his weekly visits, our father focused entirely on him. To me, it felt like he was anointing Joel as his stand-in.



Joel was a relentless tease. "What big ears you have!" "What a big nose you have!" When I asked where I came from, he didn't hesitate: "It's my fault that you're here. Mom asked me if I wanted a brother or a sister, and I, like a fool, said a sister."

He was the bane of my existence and secret idol. I felt competitive, always trying to catch up, yet I wanted to feel close to him too. When he, at the grand old age of 6, started school, I felt a fierce "me too" urge. I begged him to teach me what he was learning. Looking back, I think he delighted in his newfound elevation from pupil to teacher.

And what a teacher Joel was. Teachers were supposed to be fair, and fair he was. His teasing waned, and even tenderness crept in. I loved it. Learning to read, write, and do arithmetic made me feel bigger. Feelings of closeness briefly replaced my rivalry. Joel seemed to notice, too. He regarded me with a new respect. Hours, sometimes even days, passed without his proclaiming, "Girls can't do anything!"

Upon turning 17, Joel rushed to serve in World War II. He survived Navy signalman duty on a ship's deck at the landing on Okinawa, only to fall victim to the polio epidemic in the summer of 1949. We were both counselors at a camp in the Poconos and were just getting reacquainted after the silence of his adolescence and Navy service. The Salk polio vaccine arrived 6 years later.



Joel was a star, and I basked in his glow. He wrote an exciting poem, "The Burglar," which my classmates clamored for me to recite at every Show & Tell.

The Burglar

Nothing moves within the rich man's house,
A shadow in the yard is still as a mouse.

A clash of thunder and pouring rain,
The shadow rushes for the windowpane.
He feels about for the lock of tin,
The window is open and he crawls in.

A shadow about six feet tall,
Creeping along toward the safe in the wall.
The man is a criminal as it may seem,
There is a sharp click and a flashlight gleam.

He makes a face which isn't funny
And opens the safe to get the money.
He hears a noise and whirls around,
There is a shot, a man falls to the ground.

The house is awakened at twelve in the night
The shadow runs as if in flight.
A telephone call and before you can look,
The police are out to catch the crook.

Across the way is a mountain ridge,
Which may be reached by crossing a bridge.
A machine gun rattles with a biff
The crook's car skids and goes over the cliff.

That all happened in one day
And may show you crime doesn't pay.

—Joel Semenov, Age 9, 1935—

Mentors Can Expand Your Perspective

Jamie Metzl



*In his books **Hacking Darwin** (2019) and **Superconvergence** (2024), futurist Jamie Metzl isn't just imagining what's ahead—he's beckoning us to navigate 3 simultaneous revolutions already underway: genetics, biotech, and artificial intelligence (AI). What makes Metzl's perspective so compelling is both the scope of his vision and the specifics he brings to life—examples that make the future feel startlingly real.*



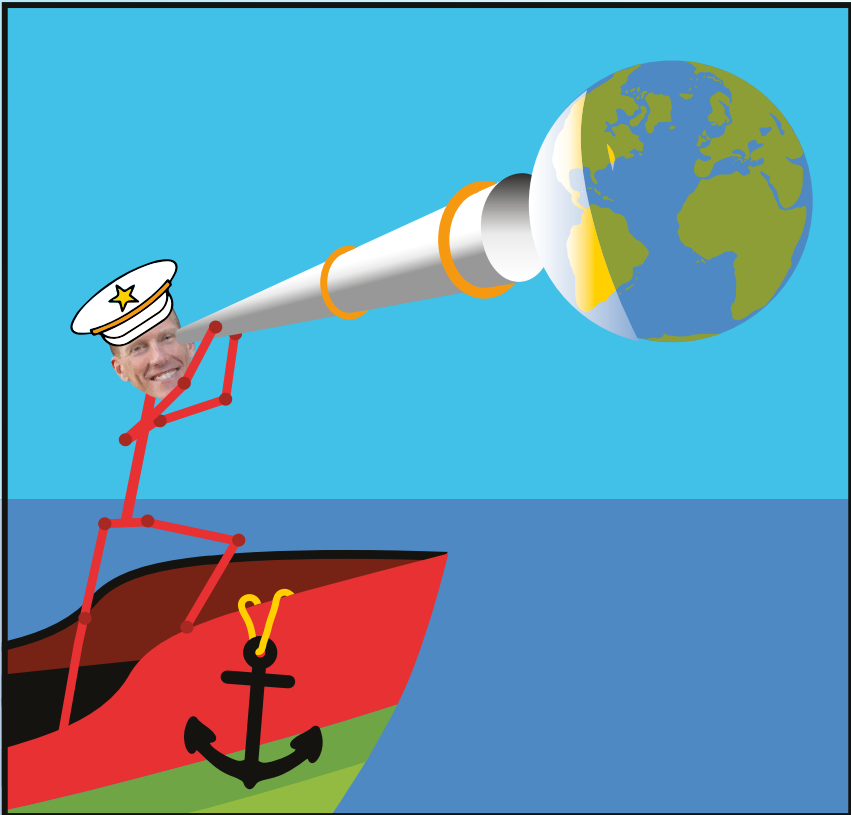
Metzl reminds us that the human genome isn't sacred; it's a work in progress, just like the genetic codes of all species on Earth. DNA sequences are constantly evolving, and with AI-powered analysis of vast datasets leading the charge, it's only a matter of time until scientists master the "rules" of biology and rewrite them, gaining the power to design life itself.

Imagine redesigning crops to produce more food using fewer resources, reducing the need to destroy wild habitats. Or engineering biodegradable plastics, sustainable biofuels, and DNA-based storage materials to curb pollution and global warming. These aren't distant dreams—they're the concrete solutions already emerging from the revolutionary triad.

"Meanwhile," to quote Adrian Wolfson's excellent review of *Superconvergence* in *Science Magazine* (June 2024), "artificial intelligence (AI) can free up human time. By 2022, DeepMind's AlphaFold program had predicted the structures of 214 million proteins—a feat that would have taken as long as 642 million years to achieve using conventional methods. As Metzl comments, this places 'millions of years back into the pot of human innovation time.' The ability to hack human biology using AI will also have a tremendous impact on ... human health span and life span, not least through AI-designed drugs, he predicts."

Metzl doesn't shy away from the shadows cast by these advances. Our understanding of ecosystems remains preliminary, and the darker sides of human ambition loom large. To steer us through these uncharted waters, Metzl calls for a new "North Star"—a shared manifesto for life. He envisions an international body, free of political entanglements, to establish governance guidelines for these transformative technologies. His solution: a global summit to align humanity on the rules for reshaping life itself.

Metzl makes the future feel urgent yet actionable. He broadens our perspective to encompass both what the future holds and how we will shape it—what kind of stewards will we be for the world we're creating.



Mentoring Insights from Doc Dorotheanna, The CRISPR Whisperer



Building on the guidance and wisdom of my mentors, I've developed a set of mentoring tips.

I'm a chemist, psychologist, and creator of the DNA Ahead Board Game™. While adding CRISPR to that game, I got so fascinated by her huge potential that I anointed myself "The CRISPR Whisperer" and created this Series.

I have credentials—doctoral degrees in Chemistry (Biology Minor) and Psychology, and a license as a Psychologist in California—that enabled me to accumulate the experiences on which my tips are based.

My Psychology doctoral research focused on psychological factors related to creativity in scientists, a continuing theme in my practice, where I specialized in resolving blocks to success, especially for women and other groups underrepresented in science.

I taught chemistry, early on, at colleges and universities and science at a school for gifted children, and later, led therapy and T-groups in my private practice and university extension programs.

Mostly, I learned from my students and clients.

Top Tip: Mind Power Leap

What if you could break through barriers to success with just one mental shift, followed up by a lot of practice? The "Mind Power Leap" has done exactly that for students, workshop attendees, and psychotherapy clients.

For many, the stakes were high—passing exams in their weakest subjects was the only way to gain entry to careers they felt otherwise fully qualified for. But the old approach— anxiously trying to figure out what the teacher would ask— left them feeling powerless, as if the exam held all the control.

Through our discussions, they made behavioral changes that flipped the script. Instead of cowering at the prospect of the test, they began creating their own test questions, answers, and even grading criteria. Suddenly, the power was back in their hands, transforming them from passive test-takers to empowered test-makers!



Power Mind Leap, Success Will Reap!

This simple shift led to impressive results. Students who had once dreaded their weakest subjects found themselves excelling—some even reaching the top of their classes. Not only did they ace their exams, but they also began critiquing the flaws in the actual tests—offering improved questions more likely to incite problem-solving.

If you've ever felt that STEM subjects are out of reach, this method could change everything. Adopting the "teacher stance" shifts your mindset from confusion to mastery, helping you unlock new ways of learning both in and beyond the classroom. On a grander scale, it could help to foster much-needed science literacy throughout the world.

What's more, it's never too early—or too late—to start practicing this shift in thinking. Older siblings naturally fall into this role, helping younger ones, and teachers can embed this method into the classroom by encouraging students to tutor their peers. The benefits extend far beyond exams—building confidence, fostering helpfulness, and creating a culture of shared growth.

Might this shift in thinking help you overcome the challenges you're facing?

The Hidden Reach of Mentor Influence

When you're in a teaching or guidance role, you likely influence more people than you think, especially children. These "hidden mentees" soak up both positive and negative messages, often without you ever realizing it..

I was the recipient of such a message at the tender age of seven during singing class. We were seated based on our abilities, with the most talented singers in the back. One day, the teacher instructed my front-row classmates not to sing because someone was off-key. Already aware of my inability to carry a tune, I largely avoided music thereafter. Regrettably, I missed out on an integral aspect of our culture and the profound human connections that music fosters.

Motivations: The Long Haul of a Science Career

At its core, what keeps scientists going over the long haul is a deep passion for discovery—an insatiable drive to expand the boundaries of knowledge. Recognition can be sustaining to a degree, but other motivations often fade with time as trends shift.

Take chemistry in the 1950s, for instance. Back then, the miniaturization and mechanization of lab equipment made much of the traditional glassware obsolete. Along with it went the sensory joys that once defined the field: the satisfaction of hands-on manipulation, the aesthetic delight of watching colors change, the soothing gurgle of bubbling reactions, even the distinctive smells(!) of emitted gases. For some chemists who entered the field drawn to those experiences, the loss was enough to cause them to leave it.

Mentoring Tips for Seniors

At 95, having lived the elder life and mentored people of all ages, I feel qualified to offer a bit of advice to fellow seniors. We often find ourselves focusing on what we've lost and perhaps less on what we can still do.

But as I see it, creativity doesn't fade with the years. In fact, I find that while my short term memory dawdles, my so-called "right brain" is more active than ever! Ideas keep popping up, making me laugh, and solving problems—sometimes at surprising moments, like during my morning shower.



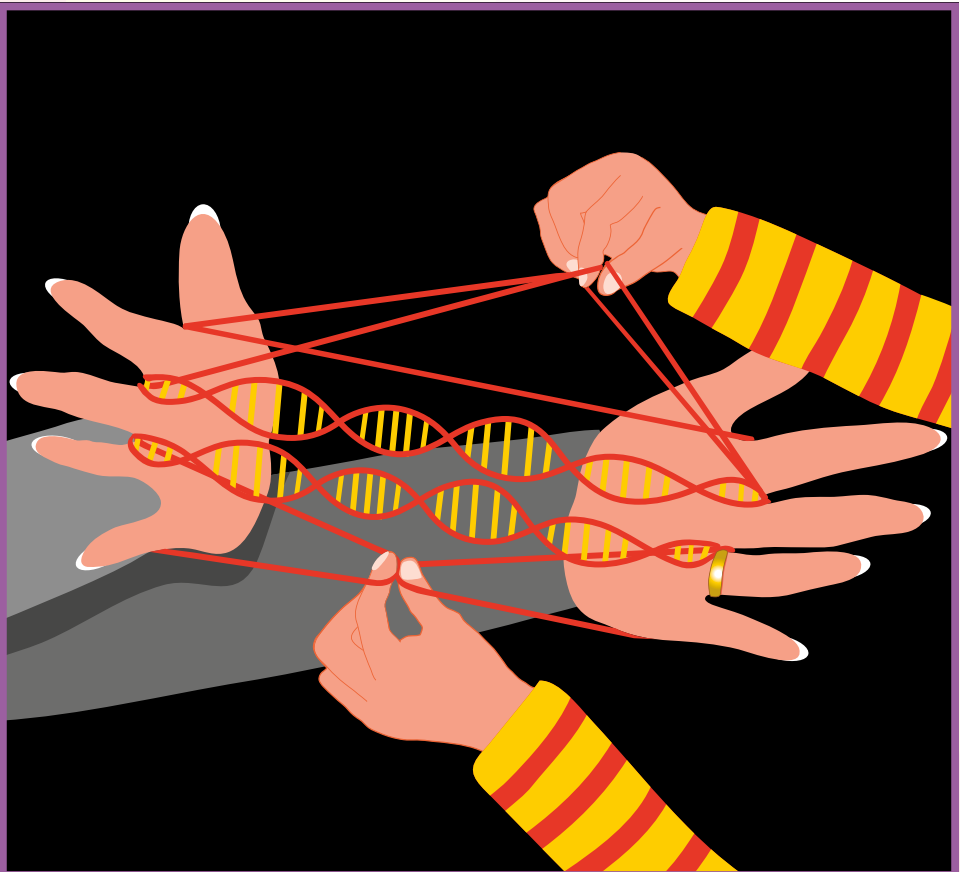
Taking your ideas seriously and working to develop them can give meaning to your life. In my experience, there's nothing quite like creating something that matters to serve as an antidote to the losses that come with aging.

And perhaps the most important part: creativity can keep laughter coming. It expresses that impish liveliness that still burns inside us elders, even as the world increasingly overlooks it.

Do you have a creative spark lying dormant? If so, it's time to fan it into a flame! Only 5 years from now, you'll look back at today and appreciate how much potential you had. Don't wait, get started!

Another valuable legacy for seniors is DNA banking. It preserves your genetic information for future testing, offering your family tools for disease screening, health risk analysis, identity confirmation, and ancestry research.

Unfortunately, end-of-life counseling often overlooks genetic counseling; but preserving a sample of your DNA could offer your loved ones access to better screenings or treatments in the future. Check out sites like AffinityDNA and SecuriGene to explore DNA banking.



Hand It Down!



CREATIVITY



Creativity

Your Creativity as Your Mentor!

Sound strange? Maybe, but hear me out—especially if you’ve ever poured yourself into a creative project so fully that it becomes a lens through which you see the world. It’s always there, shaping your experiences, pushing you to notice connections, and searching for the next piece of inspiration to make it whole.

A project like this doesn’t just sit quietly in the background. It makes demands—sometimes big ones. It asks you to step outside your comfort zone, maybe even to take on things you’ve tried and failed at before. Public speaking? Cold calls? Tackling those deep-seated fears of competition, rejection, or persistence when the going gets tough? Your project insists: Try again.

And somehow, for your project, you do it. Things you could never manage for yourself, you suddenly find the strength to do. It’s like that story of the mother who, with superhuman strength, lifts a car off her trapped child. Your project is that child—a part of you, but also something bigger than yourself. And in the process of caring for it, it cares for you.

Together, you and your project become a team. Mentor and mentee, egging each other on, exchanging feedback, and bringing out the best in each other. Your creativity isn’t just a tool—it’s a coach, a confidant, and a motivator all rolled into one.

Creativity in Science

A central goal of this Series is to spotlight your stakeholder role in the new era of genome engineering—and to inspire you to channel your curiosity and creativity into active participation in that role. To make it fun, so essential for engagement, we’ve chosen the STEAM approach, weaving the Arts (A) into STEM subjects with creativity at the forefront.

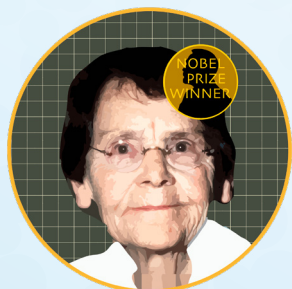
STEAMy creativity, however, isn’t just about creating art inspired by science—whether it’s pictures, music, stories, or films. It’s equally about acting on novel ideas to share the Series’ content and spread scientific thinking itself.

As a consultant, researcher, and mentor, I’ve seen firsthand how creativity builds bridges between ideas and action. I’m eager to share some of those insights with you!

This section explores the nature of creativity—its rewards, its process, and how it can be nurtured. Also included are some fun examples of active stakeholder participation in spreading the word about the world's genetic future.

Merging with Your Subject in the Creative Process

Creativity in science thrives at the intersection of imagination and analysis. It's about immersing yourself so deeply in a subject that it feels like entering into its world; and later, figuring out possible meaning of your results.



Nobelist Barbara McClintock captured this feeling during her groundbreaking studies of corn kernels. As she described in *A Feeling for the Organism* by Evelyn Fox Keller, "I wasn't outside. I was part of the system...I even was able to see the internal parts of the chromosomes. It's a feeling of actually being with them and knowing that they sense you are right there, giving you all their secrets."

Richard Feynman, too, found his creativity sparked by a vivid sense of immersion. As a child, his father encouraged imaginative problem-solving by challenging him to envision himself as a tiny person navigating the thick, forest-like fibers of their shag rug. In *Surely You're Joking, Mr. Feynman*, he recalled imagining how to find food, avoid danger, and stay safe in this miniature wilderness. These mental exercises shaped his ability to see problems from new angles, laying the foundation for his revolutionary insights.



Combining imagination with analysis doesn't just deepen understanding; STEAMy portrayals of the experience—a story, image, or song—help make complex ideas come alive for the audience. And the rewards don't end there. The creator also benefits in the many ways outlined next.

How Creating Benefits the Creator

Creating & Passion

Creating and passionate involvement go hand in hand, each fueling the other in a cycle that can start with either. But often, passion doesn't spring from something you feel innately gifted at—like music, art, math, or sports. Instead, it comes from practicing an activity. As your skills grow and pride in your progress builds, the activity itself starts to grow on you.

The Deep Fulfillment of Connecting with a Larger Purpose

For many creators, the journey isn't just about making something new—it's about connecting with a larger purpose. Whether it's spreading an idea, seeing the work's impact on others, or experiencing personal growth, this connection fuels a profound sense of self-fulfillment. Personally, I'd put it right up there with life's greatest joys—food, emotional intimacy, and sex. Creativity nourishes the soul in ways few other things can.

A Life-extending Force

In my experience, creating is life-sustaining. At 95, I can attest to its life-extending powers. It's truly mind over matter—proof that our passions can help us live longer.

A Defense Against Crippling Mental States

Many creators turn to their craft as a vital defense against depression or other debilitating mental states. In this role, creativity becomes a life-saver, providing a sense of purpose and a constructive outlet for emotions.

The Joys of Collaboration

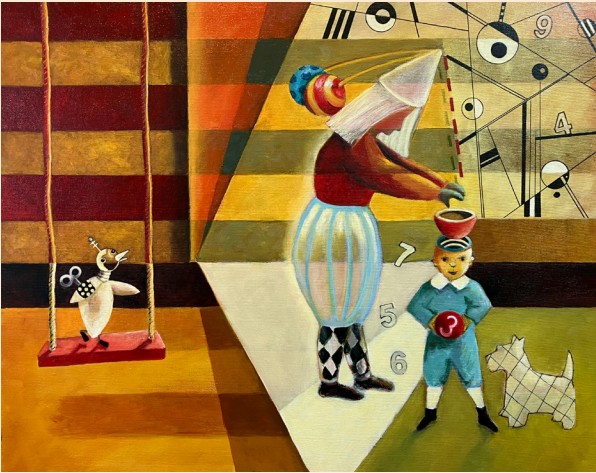
Have you ever heard creators rave about their partners—or experienced that magic yourself? You hand off your creation to a teammate, only to have it come back mind-blowingly better than you could have imagined.

For example, in this Series, I came up with the text and picture ideas, but the illustrators turned them into visuals beyond my wildest dreams. They're not just contributors—they're the stars who make the Series unique!

When conflicts arise, as they inevitably do, working through them together builds a sense of mastery and strengthens the bond between collaborators. Indeed, collaboration doesn't just fuel creativity—it can lead to lasting friendships. My main illustrator for this Series, for instance, didn't just bring my cherished vision to life—she's become my best buddy, with our friendship growing far beyond the project.

Jane Burns shares samples of her art, along with thoughts on what painting does for her just Ahead.

Series Illustrator Jane Burns on Her Creative Experience:



"When I paint I am expressing my innermost invisibles with intent to replenish/fix/heal/know and then carry on anew with my teetering self. Time travels upward and back, rather than forward while I paint. I love being suspended in that ethereal zone searching every which way for clues.

"In a perfect world I would need just one canvas and lotsa paint. And in that world I would simply paint as sustenance. I would paint atop that same painting twice daily or as directed by my mental circumstance."



In short, creating offers emotional fulfillment, sustenance, and mental well-being.



I urge you to generate STEAMy (and non-STEAMy) creations. May they make your soul sing! ("That is my most heartfelt dream for this Series," whispers the CRISPR Whisperer.)

STEAMY Creations and Active Experiences



While creativity might seem more obvious for producing 'STEAMy' art, it's just as essential for inspiring involvement by other means. In both realms, creative inputs drive the message home and inspire constructive action by recipients.

Whatever the route, the goal remains the same: to ignite curiosity and motivate engagement in a chain reaction involving creators and audiences.

Whether you're writing thought-provoking articles, joining forums, or engaging in public debates, you're nurturing stakeholder participation. By encouraging your audience to explore, question, and challenge ideas, you help foster deeper conversations and more informed decisions about applied science—such as genome engineering—that affects people's lives.



Sample Ideas for Creators of Concept Art

A Comic Strip: CRISPR as a Superhero

Imagine a comic strip where CRISPR takes center stage as a caped crusader. In each panel, she swoops in to tackle genetic problems—curing diseases, boosting crop yields, or rescuing endangered species. Armed with her trusty gene-editing tools, she takes down villainous mutations and restores order to the genome. With its mix of humor and heroics, this concept makes complex science both approachable and fun.

Greeting Cards with a CRISPR Twist

Picture a series of quirky greeting cards with playful CRISPR illustrations. On one, a tomato plant reclines on a therapist's couch, lamenting, "I just want people to like me more—I need to taste better, you know, more 'Tomato-y,' like in the old days." The therapist, wearing glasses and a thoughtful expression, responds, "Let's talk about some gene edits." These lighthearted cards make science relatable while sparking curiosity about genetic engineering.

An Animated Music Video: Singing Produce

Envision an animated music video starring fruits and vegetables celebrating their CRISPR transformations. A cheerful chorus of tomatoes, carrots, and apples dances across the screen, singing, "We're stronger, last longer, thanks to CRISPR's might!" With a catchy tune and vibrant animation, this concept makes scientific breakthroughs not just digestible, but stick-in-your-mind unforgettable.



Sample Ideas for Creators of Active Engagement Experiences

CRISPR Science Conversations

Host a small-group discussion at a local library, coffee shop, or online platform where participants share their thoughts and questions about CRISPR. Start with a brief, 5-minute overview of genome editing, then open the floor for questions, reflections, or real-world examples. A simple slideshow or handout can support this event—no specialized equipment required, just curiosity

Debate the Ethics: CRISPR Town Halls

Organize a CRISPR ethics debate where participants take on different roles—scientists, policymakers, farmers, patients, or environmentalists. Provide a list of scenarios and guiding questions to spark meaningful discussions on real-world dilemmas, like editing human embryos or genetically modifying endangered species. This interactive format turns complex topics into readily understandable, thought-provoking conversations.

CRISPR Trivia Nights

Plan a trivia event focused on genome engineering, with teams competing in categories like "CRISPR in Nature," "Famous Gene Edits," or "Bioethics Dilemmas." Tailor the difficulty to your audience, and all you need is a list of questions, a moderator, and a simple scoring system—PowerPoint or paper scorecards will do.

Social Media Challenges

Launch an online challenge inviting participants to create short videos, memes, or infographics explaining a CRISPR concept, addressing a bioethical question, or proposing a wish list for specific CRISPR uses that fall within the range of gene-editing capabilities. Platforms like TikTok, Instagram, or X are perfect for sharing these creations. This low-cost, high-impact activity taps into existing tools and encourages wide participation.

Conclusion: Creativity in Science

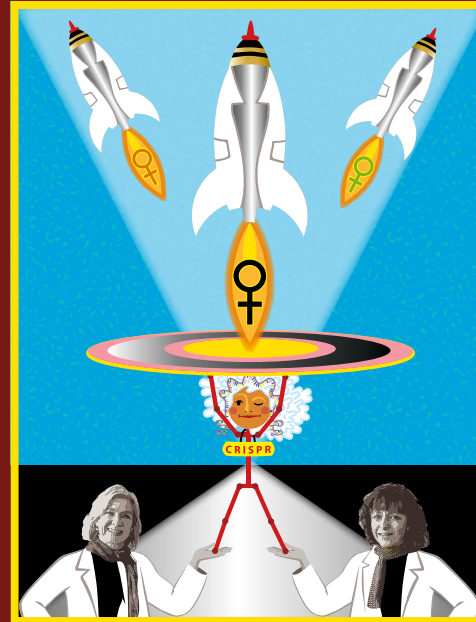
Whether you're crafting art or designing interactive experiences, science and creativity go hand in hand. Both open the door to deeper understanding and broader participation in the evolving world of genome engineering.



Take Out Message:

1. Pose Questions
2. Set Down Your Ideas and Opinions
3. Create
4. Spread the Word

CRISPR TECHNOLOGIES: WHERE WOMEN ENTREPRENEURS SOAR





Women Entrepreneurs: Sci Rebels With A Cause

CRISPR Technology: Where Women Entrepreneurs Soar

In the rapidly evolving world of biotechnology, CRISPR has not only revolutionized genetic engineering but has become a launchpad for a new generation of female entrepreneurs.

In 2020, Megha Satyanarayana, a science writer with a PhD in molecular biology, published an article in *Chemical & Engineering News*, "CRISPR Technology: Where Female Entrepreneurs Thrive." It cites a Google spreadsheet, "Women in CRISPR," which lists about 100 women, with hundreds more waiting to be added.



Satyanarayana's article explores why so many women are building their careers around CRISPR. One reason is clear: CRISPR is a game-changing technology, and those who aim to be at the forefront of science are drawn to its immense potential.

Moreover, the explosion of CRISPR-based companies has created a wave of new leadership opportunities. Women are stepping up to fill these roles, and many are starting companies of their own, carving out space in an exciting and expanding field.



The visibility of CRISPR's co-developers Jennifer Doudna and Emmanuelle Charpentier—boosted by their 2020 Nobel Prize in Chemistry—signals to women in science that their time has come.

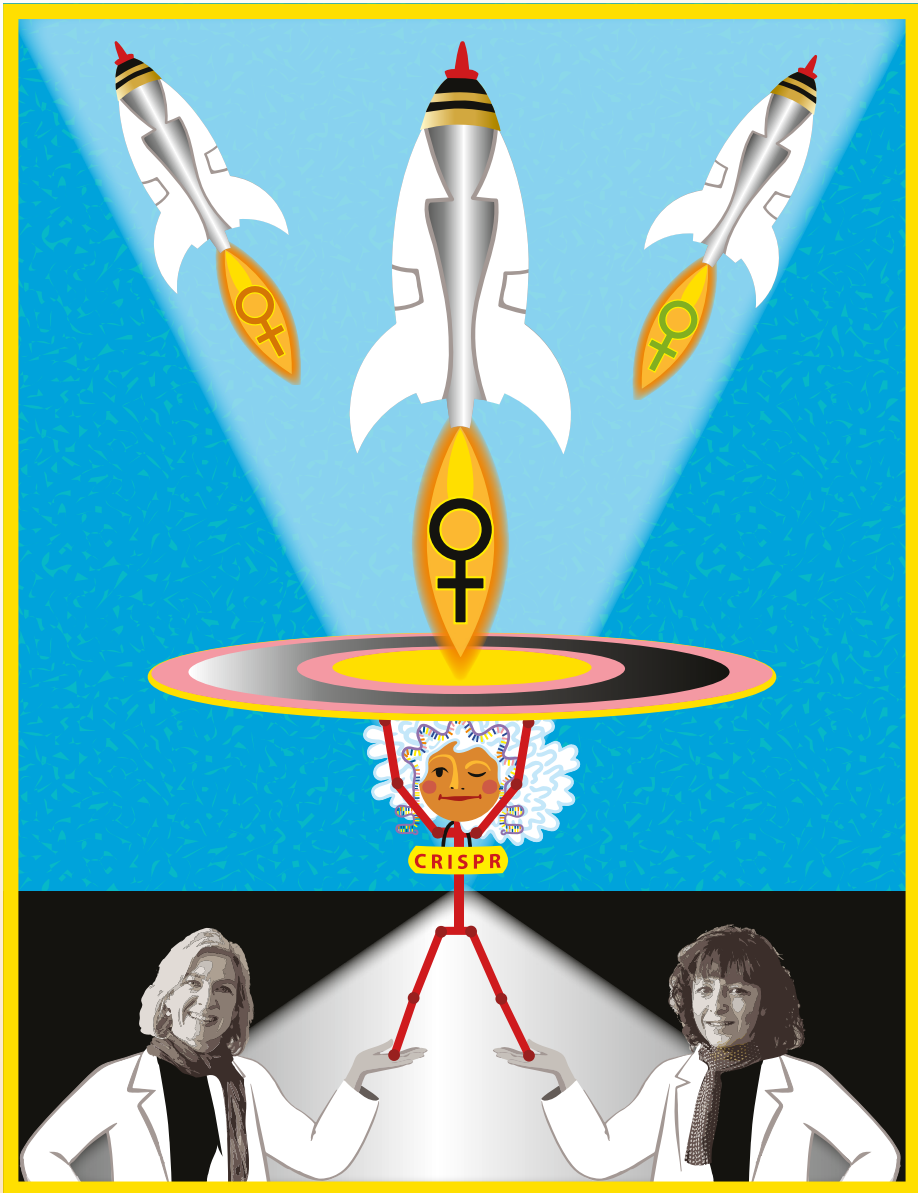




Honoring 2020 Nobelists
Jennifer Doudna & Emmanuelle Charpentier



Scientists aren't just addressing discrimination; they're also creating positive programs for lasting change. In 2022, the Innovative Genomics Institute (IGI) at UC Berkeley and UC San Francisco, founded by Jennifer Doudna, launched the Women in Enterprising Science (WIES) program. This initiative promotes gender equity in bioentrepreneurship, supporting scientists developing real-world solutions to global problems—and turning those ideas into commercial ventures that benefit the public.



HALLELUJAH,
Here Comes Moolah !!



Academia has made strides in how it treats its women scientists, but gender-based barriers still persist. With funding pouring into CRISPR—its market value is expected to hit \$5 billion by 2026—why not take the leap into spaces where they can call the shots and build the supportive culture they deserve?

Why not, indeed !



*WAIT, one more thing, a key ingredient for success—
Lady Luck shares the tip*



Lady Luck passes on a life-changing tip
from the great French scientist Louis Pasteur:
"Chance favors the prepared mind."

Bob Paltrow



Episode 02
Mentors, Creativity & Women Entrepreneurs
ACKNOWLEDGEMENTS

Kevin Davies for timely help that advanced the Series
toward publication

Nina Fedoroff for first and continuing support

Joanne Kamens for constant core support—amazingly
prompt and effective

Jamie Metzl for thinking big—and bringing that vision
to this Series

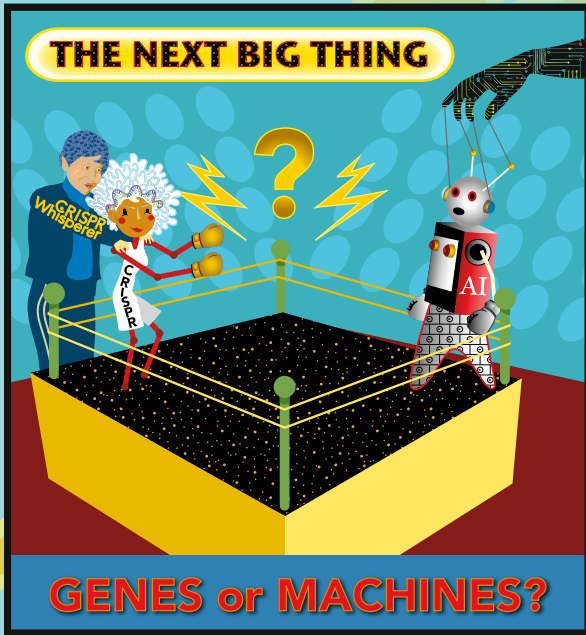
Beth Shapiro for showing what happens when you
take risks and deliver with panache

The PGED.org Team for co-hosting the Series,
extending its reach, and much more



Refreshed and recharged, she's set to go—
Next Stop: "Age Reversal" on the Arrow!

We close this episode with CRISPR pitching her unifying message—it's your invitation to visit the upcoming episodes of The CRISPR Whisperer Picture Series. We look forward to seeing you there!





CRISPR Whispers Picture Series EPISODES LIST

- 01 CRISPR Smarts Via the Arts
- 02 Mentoring, Creativity, and Women Entrepreneurs
- 03 Age Reversal
- 04 CRISPR Origins & History
- 05 "Dear CRISPR" Plea Letters
06. Critics Cavern
07. Science Lab
08. DNA Repairs & Upgrades Mall
09. Pest Control Corps
10. Extinction Controls & Returns Center
11. Super Seedy Greenhouse & Bioreactors
12. Indispensable CRISPR Support Centers
13. CRISPR Roots
14. CRISPR Foundation: Science Power
15. CRISPR Fun Activities

CRISPRwhisperer.org
and
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Personal Genetics Education & Dialogue