All Science Moves

Please see the following tables to view all science mentor texts pertaining to each mini move.

Moves That Introduce: Science

Move	Mini-Mentor Text
Just-the-Facts	On Feb. 3 a train carrying hazardous materials derailed in East Palestine, Ohio. Some of the contents immediately caught fire. Three days later authorities released and burned off additional material from five tankers. These fires caused elevated levels of harmful chemicals in the local air, although the Environmental Protection Agency says that the pollution wasn't severe enough to cause long-term health damage. —Paul Krugman (2023), "Conspiracy Theorizing Goes off the Rails," *The New York Times*
Make the Case	Speaking two languages provides the enviable ability to make friends in unusual places. A new study suggests that bilingualism may also come with another benefit: improved memory in later life. Studying hundreds of older patients, researchers in Germany found that those who reported using two languages daily from a young age scored higher on tests of learning, memory, language and self-control than patients who spoke only one language. The findings, published in the April issue of the journal *Neurobiology of Aging*, add to two decades of work suggesting that bilingualism protects against dementia and cognitive decline in older people. —Jaya Padmanabhan (2023), "Bilingualism May Stave Off Dementia, Study Suggests," *The New York Times*
What They Said	"As I imagine it," Carl Sagan once said, "there will be a multilayered message. First there is a beacon, an announcement signal, something that says, *Pay attention. This is not some natural astronomical phenomenon. This is a signal from intelligent beings* . . . Then, the next layer is one that says, *This message is directed specifically to you guys on Earth. It isn't directed to anybody else.* And the third part of the message is the real content, which is a very complex set of data in a new language, which is also explained." He was describing his novel, *Contact*, a 370-or-so-page answer, literally or in spirit, to every question we can ask about how finding alien intelligence might go. Yes, there's conflict and strife—acts of terrorism, government obstruction, frustration and loss and death—but at its core the story promises an inviting cosmos. A door opening to a galactic community. We're not only not alone but also welcomed. This hope is central to the idealistic origins of the search for extraterrestrial intelligence (SETI), to Sagan's motivations as a scientist and communicator. It also makes it especially weird that the novel ends with its heroine finding proof that God is real, but we'll get to that. —Jaime Green (2023), "Why Does *Contact* Say So Much About God?," *The Atlantic*
Scene-Drop	The giant new spaceship was all fueled up and ready to go. Its stainless-steel exterior gleamed in the South Texas sun. Everyone gathered at the launch site was elated to witness the first uncrewed test flight of Starship, the futuristic spacecraft that Elon Musk wants to someday use to take people to Mars. The crowd erupted in cheers as the 33-engine rocket booster below the spacecraft ignited its engines and rose from the launchpad, generating twice the thrust of the Saturn V rocket that propelled Apollo astronauts to the moon more than 50 years ago. But as Starship climbed higher, toward the edge of space and the next move in the sequence, something went wrong. The spaceship and the rocket booster failed to separate as intended, and started tumbling. Four minutes after a beautiful liftoff, Starship exploded over the Gulf of Mexico. —Marina Koren (2023), "Elon Musk's Explosive Day," *The Atlantic*
Then-and-Now	Alex Wiltschko began collecting perfumes as a teenager. His first bottle was Azzaro Pour Homme, a timeless cologne he spotted on the shelf at a T.J. Maxx department store. He recognized the name from *Perfumes: The Guide*, a book whose poetic descriptions of aroma had kick-started his obsession. Enchanted, he saved up his allowance to add to his collection. "I ended up going absolutely down the rabbit hole," he said. More recently, as an olfactory neuroscientist for Google Research's Brain Team, Wiltschko used machine learning to dissect our most ancient and least understood sense. Sometimes he looked almost longingly at his colleagues studying the other senses. "They have these beautiful intellectual structures, these cathedrals of knowledge," he said, that explain the visual and auditory world, shaming what we know about olfaction. —Allison Parshall (2022), "Machine Learning Highlights a Hidden Order in Scents," *Quanta Magazine*

Moves That Make a Claim: Science

Move	Mini-Mentor Text
The Big Idea	Though we can't see them, X-rays are widespread in outer space. —Carlyn Kranking (2024), "See 25 Stunning Images of the Cosmos From the Chandra X-Ray Observatory as It Celebrates 25 Years in Space," *Smithsonian Magazine*
Outline It	And once the real MOMA gets to Mars, approximately in 2030, Brinckerhoff and his colleagues will use the prototype—as well as a pristine copy kept in a Mars-like environment at NASA—to test tweaks to experimental protocols, troubleshoot issues that come up during the mission and facilitate interpretation of Mars data. —Carmen Drahl (2023), "The Mission That Could Transform Our Understanding of Mars," *Smithsonian Magazine*
This-and-That	The measurements of mutation rates could be critically useful in calibrating the gene-based molecular clocks that biologists use to determine when species diverged, and they offer useful tests of several theories about how evolution works. —Yasemin Saplakoglu (2023), "Animal Mutation Rates Reveal Traits That Speed Evolution," *Quanta Magazine*
Not-This-But-That	Biodiversity might hinge on what species have in common, not their particular niches. —Veronique Greenwood (2023b), "A New Explanation for One of Ecology's Most Debated Ideas," *The Atlantic*
Synthesize It	COVID-19 has disrupted everyday life worldwide. It is the first disease event since the 1918–20 H1N1 Spanish influenza (flu) pandemic to demand an urgent global healthcare response, propagated by the speed and likelihood of potential transmission. —Grace E. Patterson, K. Marie McIntyre, Helen E. Clough, and Jonathan Rushton (2021), "Societal Impacts of Pandemics: Comparing COVID-19 With History to Focus Our Response," *Frontiers in Public Health*

Moves That Define: Science

Move	Mini-Mentor Text
It Is What It Is	Cosmologists' reigning model of the universe identifies dark energy as the energy of space itself and pegs it at 70% of the universe's contents. —Liz Kruesi (2024), "Fresh X-Rays Reveal a Universe as Clumpy as Cosmology Predicts," *Quanta Magazine*
Say My Name	The powerhouse organelles called mitochondria are dutifully churning out energy. —Veronique Greenwood (2024a), "Cellular Self-Destruction May Be Ancient. But Why?," *Quanta Magazine*
Keep It Appositive	All of the characteristics of the odd ants—the wings, the social behaviors and the reproductive traits—were caused by what geneticists call a supergene, a collection of genes that are inherited as a unit and are highly resistant to being broken up. —Viviane Callier (2023), "A Mutation Turned Ants Into a Parasite in One Generation," *Quanta Magazine*
Gimme an Example	Venus has more than volcanic outbursts; the planet also sinks in places, like the chest of a recumbent giant exhaling. This process is called subduction, a phenomenon that also occurs on Earth, albeit by a different mechanism. —Shi En Kim (2024), "The Six Most Amazing Discoveries We've Made by Exploring Venus," *Smithsonian Magazine*
Engage With Etymology	The word "apocalypse" is derived from the Latin for "revelation," and our current predicament draws out the irony of that double meaning, as we mistake obsessing about the "end of the world" for acting on it. —Amanda Hess (2022), "Apocalypse When? Global Warming's Endless Scroll," *The New York Times*

Moves That Describe: Science

Move	Mini-Mentor Text
Describing Lists	More than four decades ago, field ecologists set out to quantify the diversity of trees on a forested plot on Barro Colorado Island in Panama, one of the most intensively studied tracts of forest on the planet. They began counting every tree with a trunk wider than a centimeter. They identified the species, measured the trunks and calculated the biomass of each individual. They put ladders up the trees, examined saplings and recorded it all in sprawling spreadsheets. —Veronique Greenwood (2023a), "The Key to Species Diversity May Be in Their Similarities," *Quanta Magazine*
Say It Again, But Make It Specific	Research indicates that these chemicals can be dangerous. Exposure to PFAS is linked to cancers, weakened immune systems among children, weight gain, and a wide range of other health problems. —Benji Jones (2023b), "You Probably Have 'Forever Chemicals' in Your Body. Here's What That Means," *Vox*
Dash That Describes	Of the 100 trillion neutrinos that pass through you every second, most come from the sun or Earth's atmosphere. But a smattering of the particles—those moving much faster than the rest—traveled here from powerful sources farther away. —Thomas Lewton (2023), "A New Map of the Universe, Painted With Cosmic Neutrinos," *Quanta Magazine*
Let's Imagine . . .	Bjånes likens the setup of their brain-machine interface to a football game. Imagine that your brain is the football stadium, and each of the neurons is a person in that stadium. The electrodes are the microphones you lower into the stadium to listen in. "We hope that we place those near the coach, or maybe an announcer, or near some person in the audience that really knows what's going on," he explains. "And then we're trying to understand what's happening on the field. When we hear a roar of the crowd, is that a touchdown? Was that a pass play? Was that the quarterback getting sacked? We're trying to understand the rules of the game, and the more information we can get, the better our device will be." —Marla Broadfoot (2023), "The Brain-Computer Interfaces That Could Give Locked-In Patients a Voice," *Smithsonian Magazine*
Figurative Language Comparison	We make an analogy to an orchestra. The musicians need to play in synchrony for the music to work. When you lose the cellos and the woodwinds, the remaining musicians can't deliver the piece as effectively as when all players are present. Similarly, when brain tumors hijack the areas surrounding it, the brain is less able to effectively function. —Saritha Krishna and Shawn Hervey-Jumper (2023), "Brain Tumors Are Cognitive Parasites—How Brain Cancer Hijacks Neural Circuits and Causes Cognitive Decline," *The Conversation*

Moves That Provide Evidence: Science

Move	Mini-Mentor Text
Hyperlink Layers	The age of dinosaurs was probably longer than you think. *T. rex* lived at the end of the Cretaceous period, just before the dinosaur-killing asteroid strike 66 million years ago. *Stegosaurus*, and other popular Jurassic dinosaurs such as *Diplodocus*, lived around 150 million years ago. —Abi Crane (2024), "Five Things You Probably Have Wrong About the *T. rex*," *JSTOR Daily*
Reference a Visual	A normal *Arabidopsis* seedling (right) bends toward light incoming from the right, while a mutant with water-flooded air channels (left) grows straight upward. Cross sections of the stems show why: Normal air channels create a gradient from brightness to darkness across the plant's cells (shown here using fluorescent methods) that indicates the light's direction. Mutant seedlings with water-flooded channels have no light gradient, and therefore can't sense in which direction to grow. [*The image shows two elongated plant structures, likely young seedlings or stems, positioned side by side against a black background. Each plant is associated with a magnified circular inset, displaying a close-up of the cellular structure.* • *Center: The two plant structures are bent differently. The one on the left is relatively straight with a slight curvature at the base, while the one on the right is curved more significantly towards the left side of the image.* • *Inserts: The circular insets on either side of the plants reveal a green honeycomb-like cellular pattern, suggesting that the cells are being viewed under a microscope, possibly using fluorescence imaging. The left inset shows the structure from the straight plant, and the right one corresponds to the more curved plant.* • *Label: There is a label on the right side of the image indicating the "Direction of light," with an arrow pointing leftward. This suggests that the curvature in the plant on the right is likely due to phototropism, where plants grow towards a light source.*] —Asher Elbein (2024), "Plants Find Light Using Gaps Between Their Cells," *Quanta Magazine*
The Fold In	A unique feature of hydrothermal vents is that they form structures composed of billions of minuscule microchambers, each contained and exposed to different conditions and reactants. They constitute a "vast array of simultaneously running semi-independent experiments," Brunk and Marshall described. —Ross Pomeroy (2024), "The Ocean Vents Where Life on Earth Likely Began," *JSTOR Daily*
Paraphrase It	**Quote from the book *The Science of Oriental Medicine, Diet and Hygiene* by Li Wing (1902):** When the Chinese commenced to study medicine they went at once to the root of different questions involved by practicing vivisection. Thousands of condemned criminals were taken and cut to pieces for the benefit of the living. In this way the functions of the vital organs, such as the kidneys, the liver, the stomach, the spleen and the heart were studied in the living person. The intensely important questions involved in the digestion of foods were determined as well as the effects of different drugs. These investigations, made while the man was still alive, were a thousand times more thorough and reliable than the guesswork which civilized physicians have practiced for many years by cutting up the bodies of dead men, when heat, motion and life are gone, and death has destroyed every function. (p. 10) **Mentor text:** A 1902 book by Los Angeles Chinese pharmacist Li Wing, *The Science of Oriental Medicine, Diet and Hygiene*, played on white Americans' beliefs about Asian barbarity. It claimed that Chinese doctors understood the human body better than American ones because they practiced vivisection on condemned criminals. —Livia Gershon (2022), "The Allure of Chinese Medicine," *JSTOR Daily*

Move	Mini-Mentor Text
End With Analysis	Programmed cell death appeared to create usable resources from dead parts. However, this process could only benefit relatives of the dead algae, he found. "It was actually harmful to those of a different species," Durand said. In 2022, another research group confirmed the finding in another algae. The results possibly explain how cell death can evolve in single-celled creatures. If an organism is surrounded by kin, then its death can provide nutrition and therefore further its relatives' survival. That creates an opening for natural selection to select for the tools for self-induced death. —Veronique Greenwood (2024a), "Cellular Self-Destruction May Be Ancient. But Why?," *Quanta Magazine*

Moves That Summarize: Science

Move	Mini-Mentor Text
Define and Detail	The telescope, named for James Webb, the NASA administrator during the buildup to the Apollo moon landings, is a joint project of NASA, the European Space Agency and the Canadian Space Agency. It was launched on Christmas one year ago—after two trouble-plagued decades and $10 billion—on a mission to observe the universe in wavelengths no human eye can see. —Dennis Overbye (2022), "The Webb Telescope Is Just Getting Started," *The New York Times*
Pivot Synopsis	Time seems linear to us: We remember the past, experience the present and predict the future, moving consecutively from one moment to the next. But why is it that way, and could time ultimately be a kind of illusion? In this episode, the Nobel Prize-winning physicist Frank Wilczek speaks with host Steven Strogatz about the many "arrows" of time and why most of them seem irreversible, the essence of what a clock is, how Einstein changed our definition of time, and the unexpected connection between time and our notions of what dark matter might be. —Steven Strogatz (2024), "What Is the Nature of Time?," *Quanta Magazine*
The Devil in the Details	For a pathogen to make us sick, it must overcome a lot. First it has to enter the body, bypassing natural barriers such as skin, mucus, cilia and stomach acid. Then it needs to reproduce; some bacteria and parasites can do this virtually anywhere in the body, while viruses and some other pathogens can only do so from within a cell. And all the while, it must parry attacks from the body's immune system. So while we are constantly inundated by microbes, the number of microbes that enter our bodies is usually too low to get past our defenses. (A tiny enough dose may even serve to remind our immune system of a pathogen's existence, boosting our antibody response to keep us protected against it.) —Tara C. Smith (2023), "How Many Microbes Does It Take to Make You Sick?," *Quanta Magazine*
Cause and Effect Sandwich	CRISPR provides a relatively easy way to release a gene drive. First, researchers insert a CRISPR-powered gene drive into an organism. When the organism mates, its CRISPR-equipped chromosome cleaves the matching chromosome coming from the other parent. The offspring's genetic machinery then attempts to sew up this cut. When it does, it copies over the relevant section of DNA from the first parent—the section that contains the CRISPR gene drive. In this way, the gene drive duplicates itself so that it ends up on both chromosomes, and this will occur with nearly every one of the original organism's offspring. —Brooke Borel (2016), "Genetic Engineering to Clash With Evolution," *Quanta Magazine*
Quote It to Me	Bothe found that the electric current needed to reach the voltage threshold and trigger a snake's body motor neuron was "way lower than for the rattle motor neurons," he said. "You need to put way more current into the [rattle] neuron for it to fire." And compared to rattle motor neurons, body motor neurons reacted more sluggishly. —Elise Cutts (2024), "Tiny Tweaks to Neurons Can Rewire Animal Motion," *Quanta Magazine*

Moves That Contextualize: Science

Move	Mini-Mentor Text
Let's Compare	Drawing parallels with successful policies like the "sugar tax" on soft drinks in the United Kingdom, meat taxes could incentivize a reduction in meat production by driving industry reformulation instead of relying on consumer behavior. —Aissa Dearing (2024), "Grilling the Globe," *JSTOR Daily*
Double Date	These studies and the keystone idea came to prominence at the same moment that America's environmental conscience was emerging. In 1973, Congress passed the Endangered Species Act, which took a species-focused approach to conserving wildlife. The idea that restoring the population of a single species—a keystone, perhaps—could ensure the biodiversity of an ecological community aligned with this new legal framework. —Lesley Evans Ogden (2024), "Ecologists Struggle to Get a Grip on 'Keystone Species,'" *Quanta Magazine*
Show Me the Data	Studies have found that some 50% to 70% of patients with major depressive disorder see their symptoms improve after a course of ECT. In comparison, medications aimed at altering brain chemistry help only 10% to 40% of depression patients. —Elizabeth Landau (2024), "Brain's 'Background Noise' May Explain Value of Shock Therapy," *Quanta Magazine*
Educated Inference	So it's easy to see why masting trees synchronize their seed production. Understanding how they do it, however, is more complicated. Plants usually synchronize their reproduction by timing it to the same weather signals. And warming temperatures and heavy rainfall correlate well with coordinated masting, suggesting that the trees synchronize to weather cues. —Meghan Willcoxon (2024), "Across a Continent, Trees Sync Their Fruiting to the Sun," *Quanta Magazine*
Past and Present Connection	Over 2,500 years ago, Greek philosophers debated whether the nature of reality was impermanence or constant change. Heraclitus was the champion of change, pointing to the march of the seasons and the ebb and flow of the tides. In contrast, Parmenides, a near-contemporary of Heraclitus, claimed that change was illusory and constancy was the rule. Modern physics has found subatomic examples that support both ways of thinking. For example, the electrons found in your atoms have been unchanged since the Universe began, supporting the constancy conjecture. However, in a clear example of constant change, another form of subatomic particles called neutrinos are in continuous flux, literally changing their identity over and over again. —Don Lincoln (2024), "IceCube Detector Confirms Deep-Space 'Ghost Particle' Phenomenon," *JSTOR Daily*

Moves That Add Voice: Science

Move	Mini-Mentor Text
Say It Slang 	Its unique hard covering, which may remind you of Taco Tuesday, most likely helped propel it through water, at times upside-down. —Rebecca Dzombak (2024), "Secrets Emerge From a Fossil's Taco Shell-Like Cover," *The New York Times*
Ask a Question 	Over the next century, eclipse expeditions helped settle one of the biggest mysteries in science: Was Mercury's odd orbit due to an undiscovered sun-hugging planet (which would presumably become visible during an eclipse)? Or, as turned out to be the case, was there some problem with Newton's understanding of gravity? —Joshua Sokol (2024), "How the Ancient Art of Eclipse Prediction Became an Exact Science," *Quanta Magazine*
Put It in Parentheses 	To me, a program isn't static code, it's the embodiment of a living creature that follows my instructions to a (hopefully) successful conclusion. I know computers don't physically work this way, but that doesn't stop my metaphorical machine. —Lance Fortnow (2024), "Computation Is All Around Us, and You Can See It If You Try," *Quanta Magazine*
Connect Personally 	As a geologist, I have had the extraordinary opportunity to work on both the Curiosity and Perseverance rover missions. Yet as much as scientists are learning from them, it will take another robotic mission to figure out if Mars has ever hosted life. That mission will bring Martian rocks back to Earth for analysis. Then—hopefully—we will have an answer. While so much remains mysterious about Mars, there is one thing I am confident about. Amid the thousands of pictures both rovers are taking, I'm quite sure no alien bears or meerkats will show up in any of them. Most scientists doubt the surface of Mars, or its near-surface, could currently sustain even single-celled organisms, much less complex forms of life. —Amy J. Williams (2024), "NASA's Search for Life on Mars," *JSTOR Daily*
Make It Metaphorical 	Previously, all known ribosome-disrupting hibernation factors worked passively: They waited for a ribosome to finish building a protein and then prevented it from starting a new one. Balon, however, pulls the emergency brake. It stuffs itself into every ribosome in the cell, even interrupting active ribosomes in the middle of their work. —Dan Samorodnitsky (2024), "Most Life on Earth Is Dormant, After Pulling an 'Emergency Brake,'" *Quanta Magazine*

Moves That Conclude: Science

Move	Mini-Mentor Text
What We Don't Know and What We Do	Even if we learn all the answers to what's happening to the body in a heat wave, Shandas said we still don't understand "a lot of the human face of heat," as in, how people actually cope. What scientists do understand is that this is just the beginning of these consequences playing out on a global scale. It's only going to get hotter from here. —Rebecca Leber (2023), "The Invisible Consequences of Heat on the Body and Mind," *Vox*
What's Next?	Our research group and other scientists are using computer simulations and numerical "larvae" to investigate how temperature, salinity and other factors may affect transport of marine organisms. With better understanding of these surf-zone conveyor belts, we aim to help keep swimmers safe and assess how rip currents affect aquatic ecosystems near the shore. —Emma Shie Nuss, Audrey Casper, Christine M. Baker, Melissa Moulton, and Walter Torres (2023), "Rip Currents Are Dangerous for Swimmers but Also Ecologically Important—Here's How Scientists Are Working to Understand These 'Rivers of the Sea,'" *The Conversation*
Share the Last Word	But LTT 9779 b may just be the benchmark for such ultrahot Neptunes. The more the team learns, the more they realize how rare it really is. "It's a super important world," Dr. Jenkins said, adding that the diversity of planets in the cosmos stretches far beyond those found in our own solar system. "Hopefully, we'll stumble across another." —Katrina Miller (2023), "Titanium Clouds Engulf This Ultrahot Neptune-Like Planet," *The New York Times*
The Bottom Line	Most of all, remember that having sharks around is a rare victory for conservation and—as we learn to live with them—human communities. These animals help sustain the ecosystems that support us all. —Benji Jones (2023a), "New York's Shark-Infested Waters Are a Good Thing. Yes, Really," *Vox*
Solve the Problem	There is no doubt that managing retail returns is a difficult task. To make the process more sustainable, retailers need to help customers make choices that limit the need for a return or that minimize the impact of a return on the environment and, of course, the retailer's bottom line. —Christopher Faires and Robert Overstreet (2023), "Just in Time for Back-to-School Shopping: How Retailers Can Alter Customer Behavior to Encourage More Sustainable Returns," *The Conversation*

Moves That Organize: Science

Move	Mini-Mentor Text
Topic Sentence Transition 	Turing machines perform computations by reading and writing 0s and 1s on an infinite tape divided into square cells, using a "head" that operates on one cell at a time. Every machine has a unique set of rules that governs its behavior. Each of these rules specifies what the head should do when it moves into a new cell, depending on whether it encounters a 0 or a 1 already there. —Ben Brubaker (2024), "With Fifth Busy Beaver, Researchers Approach Computation's Limits," *Quanta Magazine*
Hinge Transition 	These competitions were marked by baby steps, and the researchers had little reason to think that 2020 would be any different. They were wrong about that. That week, a relative newcomer to the protein science community named John Jumper had presented a new artificial intelligence tool, AlphaFold2, which had emerged from the offices of Google DeepMind, the tech company's artificial intelligence arm in London. —Yasemin Saplakoglu (2024), "How AI Revolutionized Protein Science, but Didn't End It," *Quanta Magazine*
List It 	In addition to the high ocean heat content, research has shown other environmental factors need to typically align for rapid intensification to occur. These include: • *Low vertical wind shear, where the winds steering the hurricane do not change much in strength or direction over the depth of the storm. Strong wind shear makes it difficult for a storm to stay organized and maintain its strength.* • *A moist atmosphere surrounding the storm, with heavy precipitation encircling the developing eye.* —Brian Tang (2024), "Hurricane Beryl's Rapid Intensification, Category 5 Winds So Early in a Season Were Alarming: Here's Why More Tropical Storms Are Exploding in Strength," *The Conversation*
Add Subheadings 	Subheadings: • *A Frozen Paradox* • *Life in Thick Water* • *A Cell's Perspective* —Veronique Greenwood (2024b), "The Physics of Cold Water May Have Jump-Started Complex Life," *Quanta Magazine*
Visual Anchoring 	The current bleaching event in the wider Caribbean region is longer and more severe than any previous bleaching episode recorded since the first global one in 1998. I study large-scale climate and ocean dynamics and am analyzing how biological connections between coral reefs—sometimes extending over great distances—may help reefs recover from heat stress. [*YouTube video clip of a news segment showing coral bleaching*] —Annalisa Bracco (2024), "The World's Fourth Mass Coral Bleaching Is Underway, but Well-Connected Reefs May Have a Better Chance to Recover," *The Conversation*