Like many a girl with a long-haired father, I refer to myself as a girl rather than as a woman, and I gravitate to places I suspect my father, dead fifteen years now, might haunt. My father was a left-handed professor of meteorology at the University of Oklahoma, an Israeli immigrant who never saw the interior of a mall, who remained suspicious of proposed ideologies of global warming, who lived nothing quite so much as a Sunday morning of watching political ’arguing shows’ and who regularly called my best friend in elementary school “the Hugene,” for no other reason, I think, than that her last name sounded vaguely French and he liked saying the word. His office answering machine promised to return calls “as soon as feasible.” So, naturally, when the Whitney Museum put on a Buckminster Fuller retrospective—one advertisement featured Fuller’s diagram for a weatherproof dome over forty blocks of Manhattan—I went.

A tour of middle schoolers was there, gathered around models of affordable homes built out of re-purposed grain silos. A peppy docent was Rika Galchen, the author of Atmospheric Primitives, a novel. This is her first article for Harper’s Magazine.

LIGHTFUL TECHNOLOGY, WE COULD CAPTURE JUSTLY USING RENEWABLE ENERGY, RECYCLED RESOURCES, AND, EVENTUALLY, COMPUTER PROGRAMS THAT WOULD RESOLVE SOCIOECONOMIC ISSUES AS EASILY AS THEY APPEARED.

A HOLISTIC VISION OF FULLER’S WORLD WERE WELL-DEPICTED, BEAUTIFUL, AND LUCID.

LUCIDNESS—that’s another word, along with “feasible,” that my father invoked in his stoic and stoic manner. He was a phoenix who rose from the ashes of an impoverished, doomed failure of a man who, following his daughter’s death from polio complications, had been near suicide.

My father either admired Buckminster Fuller tremendously or thought he was a tremendous fool, I can’t quite remember which, can’t remember only that the feeling was strong and probably expressed with the word “tremendous.” Alone that afternoon at the Whitney, among the mock-ups of all those new edenic geodesic domes. I recalled hearing tell from my father of a time not so long ago when the term “technological fix” didn’t sound dirty and delusion.

When my dad was young, Fuller and scientists like him were crusaders of the left, heroically engaged in subverting in an utter transformation of society. The humbly engineered new world order would be one of less waste, more justice, less suffering, domed town halls built out of Vener-ation blunders, and, just maybe, plastic living rooms that happier housewives could simply wash down with a hose. The technological aspirations of Fuller’s world were well-diagrammed, beautiful, and lucid.

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point of deciding whether or not to steal fire from the gods.

Intentionally modifying the weather—denatured as "natural" the doped-up Spaceship Earth's current veerings—might not be so doomed and ludicrous an idea after all. Trying to weaken a superhurricane would be treating the symptom rather than the cause, but seeing as most scientists agree that even if we didn't emit a single molecule more of CO₂ into the atmosphere we'd still see continued warming for decades, a grain or two of aspirin for the fever is at least tenable as part of a long-term treatment plan. Of course, familiar as we are with Frankenstein, that most beastly of our technology fables, we fear the bumbling creation of monsters even more hideous than those we've already got. Our Earth, captained by scientists! Even my kind and relatively levelheaded dad—or so I like to think of him—aren't his ice cream with a fork. When showering he never remembered to put the shower curtain inside the tub, and it was always my mom who would notice, and clean up, the resultant flood. Again and again.

My father wasn't a rainmaker, and he wasn't a hurricane guy. He didn't even study global warming, not much anyhow. I like to say he was a "meteorological epistemologist," exploring the limits of how and what we might ever possibly know about the weather of tomorrow, or even of today. (A term I love that appears often in his work is "nowcasting.") Since my ability to plumb the subtleties of his scientific writings is, however, on a par with my ability to follow the subtleties of a puppet show in Hungarian, my understanding of his work is, despite my reasonable scientific literacy, inevitably tinged with fantasy. Regardless, I can confidently say he was his own kind of eccentric. We had read Kurt Vonnegut together and he'd told me that Vonnegut's brother really had invented something like IceNine, which happens to be close-ly related to what was used in the first modern scientific attempt to intervene in hurricanes, a 1960s project called STORMPURGHT that was led by the meteorologist Dr. Joanne Simpson, whom my father admired tremendously. It was Simpson who told him in secret before the official announcement, just before he died unexpectedly in 1994 at the age of fifty-three, that he had been named a Fellow of the American Meteorological Society, which, silly as all honorary societies are, was the group any American weather writer wined to be part of.

I don't know why I started following ideas for modifying hurricanes rather than ideas for making rain or for cooling the planet. There are even relatively well-worked-out notions for relocating Earth to a new sun, should ours begin to die, and those ideas seem more up my proverbial alley. Maybe I followed hurricane ideas because I love Shakespeare's The Tempest. Or maybe because of New Orleans. I've been there only once, in 1991. My father was attending a conference of the American Meteorological Society, and my whole family tagged along. The trip was memorable for overlap-ping with the start of the first Iraq war, for the three hours my dad and I spent in the Ripley's Believe It or Not! museum, and for the beignet shop where I (fourteen years old) was twice mistaken for the girlfriend of my brother (twenty years old). A special time, a special city, where it was easier to imagine that the world might be something wildly other than what I'd thought it to be. My dad took me to the conference's keynote speech, which was given by a well-known senator from Tennessee who stood up on a chair to point out on his poster board just how high atmospheric CO₂ levels could soon enough be expected to reach. Shakespeare, New Orleans, death, my parents' unpredictable moods, the wildness of Midwest thunderstorms—something in that muddle in the back of my mind made my adult self pay attention to rummages that ideas for manipulating storms were out there.

Since the field of weather modification was relatively young (again), I knew I couldn't just read about it, that I'd have to speak to people in order to learn anything, but since speaking to
people scares me, I started out at the library, so as to delay contacting people who I suspected had known my father and whom I therefore really wanted to contact.

From the annals of old newspapers and journals, I pieced together a history of storm modification. In October of 1947, in conjunction with both the military and General Electric, the United States Weather Bureau dropped 180 pounds of crushed dry ice into the rainy band of Hurricane King, a hurricane that had already made landfall and moved out to sea. The hypothesis was that the dry ice would weaken the storm, and, at first, this appeared to prove true. A few hours later, though, the storm took an unexpected turn and hit Savannah, Georgia, making what insurance companies term an "act of God" into—at least plausibly—an act of man. OE subsequently pulled out of all weather-control projects, and federally financed field research for "hurricane-shirking Thor" basically vanished for several decades. American weather-modification efforts re-emerged during the height of the Cold War, when "weather war" technologies were a headline concern (and aspiration), especially since weather wars were thought to favor the U.S.; the predominant winds assured that a storm hatched west Europe would drift over to the U.S.S.R. and blizzard out on the steppe. In 1965, the United States Air Force secretly launched Operation POPEYE, an attempt, via silver iodide seeding of storms, to extend the monsoon in Vietnam and so keep the Ho Chi Minh Trail too muddy for passage.

Around the same time, American scientists on Project STORMPURR were openly attempting to manipulate storm systems as they conducted field experiments to reduce Atlantic hurricane strengths (or, according to Castro, attempted to use hurricanes as a countermeasures instrument of war. POPEYE and STORMPURR were both eventually shut down (Weathermen!) in response to international pressures remarkably strong considering that no weather-modification effort had ever proved more successful than drumbeating, prayer, or the costing overhead of a sacrificial saddle.

To supplement this history, I read Divine Wind, a textbook-like introduction to hurricanes by one of the field's foremost experts, the meteorologist Dr. Kerry Emanuel of MIT. I could hang with terms like "paleo-climatology"; I knew that the power dissipation of a storm increased as a cubed function of wind speed. I was approaching prepared. I'd finally finished a novel in which my dead father was mistakenly thought to be a heroic leader of a group (the Royal Academy of Meteorology, a mashup of the American and British meteorological honor societies) fighting to maintain the randomness of weather, and I'm doing so with a sudden thought that in a long, I started and highlighted passages in the Bulletin of the American Meteorological Society and the Journal of Geophysical Research and otherwise passed time. Finally, fully indeed, with written questions, I decided I was ready to
I finally backed up and placed a phone call. Hoffman works for Atmospheric and Environmental Research, Inc. (AER), a private firm at which the very polite Maria Pionte, the former vice president of the Commercial Division, informed me that no, nobody would speak to me about Hoffman's work.

I did the since-it's-old-every-public- and-in-newspapers-wouldn't-it-be-better-to-influence-the-ways-you-covered-it-in-the-press move, and was again flatly refused. But I could hear companies in Maria's voice. Which smacks too weird.

I tried the look-know-knowledgeable-able-already-sent-them-the-dark-sound-professional thing, the think-of-the-fancy-magazine-the-week-will-get-coverage-on thing, and still I got nowhere. "I actually came to my interest in meteorology through my father, the meteorologist Tris Gal-Chen," I said, finally. "I'm very sympathetic to the community," I said, whatever that meant.

"Yes," she said. "We are familiar with that name." A conspicuously long pause followed. "We suspected you might be related to Dr. Gal-Chen."

Surprised? I started sweating.

It suddenly returned to me how very much my father had liked those Sunday-morning营养 giveaways, and assorted in general, and how I'd taken childlike joy in recounting to me stories of publicly humiliating colleagues he thought were charlatans. Lots of people adored him. A fair number of people, though, probably really didn't like him at all.

I told Maria to give me a call if Hoffman had a change of heart. As if in revenge, I began to think of Hoffman as a 1940s sci-fi-scary evil scientist, conducting weapons research and rubbing his hands together as he cackled about world domination. I nourished my delusion with trivia I'd picked up from my reading, like the fact that the energy released by a single hurricane is comparable to that of five hydrogen bombs. I even called the relevant offices of the Air Force, the Navy, the Department of Defense, whoever I could think of, to try to figure out if they were funding Hoffman's work now that the NASA Institute for Advanced Concepts was kaput. But the bored conversationalists of the PR people made me think they weren't lying to me when they said they knew nothing about contemporary research into weather-war technologies or about using hurricanes as weapons. I uncovered no actual evidence of a heroic-scale secret or even of ennui. But I still found the thought more alarming than the competing hypothesis that Hoffman just didn't want to speak to the daughter of the meteorologist Tris Gal-Chen.

"We're not the first species to have dramatically altered the climate," Gerry Emanuel noted as we sat in his spacious MIT office overlooking the Charles River. Emanuel was talking me through the research linking superhurricanes to global warming, the ambiguities of distinguishing intentional and unintentional weather modification. "There were micro-organisms that changed the primate atmosphere from a largely hydrogen one into today's—annihilating themselves in the process." Emanuel has a talent for the long view yet remains remarkably grounded in the everyday. "He's come out publicly and strongly in favor of better hurricane preparedness—the unsexy and sensible approach—and actions to dramatically reduce CO₂ emissions.

I asked him if he thought we should, or would, eventually use scientific knowledge to mitigate superhurricanes. "I don't have a crystal ball, but if I did, I'd guess we'd be that this might happen after something really terrible, a Katrina times five, where people say, 'By God, we don't ever want this to have happened again.' At that point, if scientists have something technically feasible, with all the it's dotted and i's crossed, then there will be pressure to try it. Not weather modification as it's usually conceived, but disaster avoidance. "The hurdles are not really on the technical side," he continued. "The hurdles are on the social and political side." I said that to a leprous technical hurdles seemed pretty daunting, too. "It's helpful to know how hurricanes naturally die," he
said, as preface to explaining a bit about ideas for weakening hurricanes through human intervention. "Most of them die by coming over land or cold water. It's proposed fifty years ago to do that artificially by coating the surface of the ocean with a film of some kind. That didn't work in laboratory experiments, because strong winds break up the many films they tried." "Another way that storms die is by moving into an environment where the large-scale wind change is in height." Of the variety of ideas currently being explored—cooling the sea-surface temperature, altering evaporation at the base of a hurricane, affecting the heat and wind patterns either within a hurricane or within the area it moves through—Emmanuel said Hoffman's was the most promising, that I should do well to talk to him.

I said I hadn't had any luck getting to speak with Hoffman. Maybe for some reason he didn't want to talk about his work.

Emmanuel said he was very close with Hoffman, that Hoffman was a great guy. He said he would ask Hoffman, "I was not sensationalist press they get a lot of that. I guess and that he was almost certain he could convince Hoffman to speak with me.

Either good instincts or paranoia made me doubtful. But I didn't say anything, because I didn't want to seem like the easy person Hoffman seemed to "suspect" I was. Emanuel struck me as sincere, and I hoped his would prove infectious.

Toward the end of our meeting, Emanuel pulled from his bookshelf a microscale meteorology textbook co-authored by my father. Just to show me. I made some comment to the effect that my father was a troublemaker, wasn't he? "Your father was willing to push people's claims the field could use more smart people who like to stir things up a bit. I still miss him."

Maybe I would somehow get to talk to Hoffman after all. Maybe I'd send another email.

Meanwhile, Dr. Daniel Rosenfeld of Hebrew University was in New York as promised. Of course, I wore my dapper cream-colored suit, he seemed to be cut from the cloth of quintessential pragmatic scientists more than just a Fulper, maybe just slightly more conservative than someone like my dad.

Rosenfeld's idea for mitigating hurricanes followed logically from his larger body of work in a series of papers beginning around 2000, he, among others, demonstrated that clouds over pollution sources—over industrial areas in Israel, as well as over the areas of the Amazon rainforest affected by biomass burning—were unusually devoid of rain. In typical rain clouds, water droplets coalesce to form larger drops, which eventually become heavy enough to precipitate out. But the particulate matter of the pollutants seems to provide a nucleation site for the formation of stable drops so tiny that instead of raining out they remain suspended.

"I thought that the smoke-suppressing rain in the Amazon might point to a way to fix what was wrong in STORMFURY," he said. That project had seeded hurricanes with silver iodide in the hope that this would cause a storm's supercooled water—water that is below the freezing point but that has not yet become a solid—to freeze abruptly. This freezing was meant to embolden the hurricane. Meteorologists later learned they'd been wrong to assume the presence of supercooled water in a hurricane, so from the get-go the project was doomed to fail.

"Supercooled water holds on to its heat," Rosenfeld explained. "Whereas when rains are formed, a tremendous amount of latent heat is released in the process of condensation." Such heat fuels a cyclone. Rosenfeld's work imagines dispersing an aerosol at the base of a hurricane (possibly just salts) to

"Sort of. One of the unique 'wings' instead from the operational failure of STORMFURY was learning precisely this about hurricanes anyway—the surprising absence of supercooled water. Joanne Simpson, STORMFURY's project leader and the gamble, said he that she herself was never incorrect in actually changing the course of hurricanes. She viewed the project as a way to learn more about storms as they are."

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inhibit rain formation and consequently promote supercooling. More supercooled water would, theoretically, tamp the hurricane. A nice, tidy notion.

"I walked down the hall to my colleague Alex Khan and said, 'Let's simulate this process.' They expected to find a less hot, more humid, and slower hurricane, with a smaller eye. (The perimeter of the eye, termed the eyewall, tends to be the most destructive part of a hurricane.) The simulated hurricane was cooler. And more humid. And had a smaller eyewall. But even maximum wind speeds turned out to be basically the same, and wind speed was what mattered most, since it is what best correlates with a hurricane's destructiveness. 'We were surprised,' Rosenfeld said. The main way you move forward in science is by finding out you were wrong about what you thought you already knew—that was something my dad used to say.

Rosenfeld doesn't hope for a day when there are no hurricanes. He seems to be more acutely aware than even an ardent environmentalist that hurricanes, in some forms, are a part of nature residing in that magical state we call balance, that even very destructive hurricanes aren't necessarily symptoms of a mutated planet. But he does believe that the meteorology community would do well to make weather-modification research less taboo. "What's of fundamental importance is that we've learned something about how the humidity affects the buoyancy of the air. These simulations have helped us in prediction."

Still, for all his sophistication, or maybe because of his sophistication, a touch of unapologetic science, a la Puller, remained in Rosenfeld. Regarding his own work, he took pains to point out that even without decreased wind speed, a smaller eye might still mean a less calamitous storm, because the highest wind speeds would be covering a smaller area. The storm surge—raising seas caused by the wind and pressure changes of a hurricane—would be reduced, which certainly would have helped with Hurricane Katrina. "According to our calculations, we could have saved New Orleans. But still," and he said this with extra emphasis, as if to ensure that I wouldn't have to say it, "simulation and reality are far apart."

"What do you think of Dr. Hoffman's idea?" I asked.

"We've met," he said. "He's a very good scientist. We talked. But we didn't hear each other.

It wasn't looking like Hoffman and I were going to hear each other either. Emotions themselves sounded surprised when he left me a message saying he had spoken to Hoffman but that he was pretty firmly set against discussing his work with me. I felt like a knight who had failed his lady. Or like a disappointed samurai who was now expected to perform seppuku. Or maybe it was my master's fault and I was an innocent, random child? What can I say, my dad and I watched a lot of dumb television together, especially old movies on TNT. The particular failure stories that came to mind were all mixed up and outraged and saying, I knew, but that happened to me a lot. Usually it was just some old feeling trying to sneek back home in whatever costume was at hand.

I called Hoffman's firm again and I spoke to the oddly compassionate former vice president of the Commercial Division, Maria Paine, again. This was possibly our fourth conversation and my eighth or ninth phone call. After going through our regular rejection exchange and wondering once more at her unfeigned kindness (maybe I was imagining it), I found myself dropping the flimsy professional mask I'd been trying to wear and saying to Maria—"I may have even used her name in direct address—"I mean, I just kind of curious, well, do you have any guess you might be able to offer me as to why he doesn't want to talk to me? Did I do something wrong? Did I send too many emails?"

Forgive me, but her voice really did sound motherly to me.

"Well," she began. "You know," she began again. "I think it's that book you're writing. About the conspiracy of scientists controlling the weather. I think that really put him off."

"What? That's not—"

"That's what someone here was saying—"

"It's a novel. The narrator's kind of psychotic. The narrator's not me!"

The term "weather nut" was actually used in this conversation.

I mumbled various defenses/explanations of my righteousness and spoke about the irrelevancy of that project in this one. Eventually I got off the phone with little more than a halfhearted assurance from Maria that she thought I sounded very normal but that it wasn't for her to decide. The strangest part was that I actually did feel guilty, like I was lying to her, like I really was a crank and a fraud. Both. I don't know how to explain the feeling except to say that not very long ago I went to a cardiologist complaining of a heart murmur and when he took my patient history I was too embarrassed to admit that I had an M.D. myself, or even to use any of the terminology that might have revealed I knew something about medicine, and when the cardiologist asked me what I did for a living, I told the truth, which is that I'm a writer, and after he examined me hastily, he said: "You're fine. You just need to drink more red wine and maybe try to get something published." Then he laughed. It wasn't that I disagreed with his advice, but I felt so said realizing that there I was, in my thirties, still radiating the worst parts of adolescence with every gesture, every exchange.

Talking to oncomephragmites, people who I had no reason to suspect had known my father, was a happy relief. I spoke first with Dr. Alan Blumberg of the Center for Maritime Systems, whose passion for a hurricane's "Se" did more than just touch base theoretically with the techno-optimism of the past. "I had a colleague named Bob Abel," he explained, "one of the pioneers of trying to figure out how to take water from deep underground the ocean in order to generate electricity." He was referring to the gloriously failed
Ocean Thermal Energy Conversion (OTEC) project of the 1970s, a Department of Energy-funded venture that aimed to use the heat differential between the ocean's surfaces and depths as an inexhaustible source of clean energy. Conspiracy theories still circulate as to why the project closed down, and maybe it really was due to a nefarious petroleum lobby, but it happened at least in part because the whole thing proved wildly expensive. "One day I was talking with Bob Abel," Blumberg said, "and we sort of put our ideas together, his idea about how to bring cooler water to the surface and my idea of reducing the impacts of hurricanes." If sea-surface temperatures in hurricane-prone areas were reduced a couple of degrees, hurricanes might be less intense, less destructive.

The pumps Blumberg has proposed using to cool the ocean's surface are different from the OTEC pumps, though conceptually they're closely related. "You know how if you have a straw in your soda and you put your thumb on top of the straw and you lift the straw entirely out of the liquid, the liquid will not come out of the bottom? Imagine I have a pump that looks like a straw three thousand feet long, three feet in diameter. When a wave comes—and hurricanes make big waves—the straw goes up, and as the straw moves up, you close the bottom of the straw with a valve. I actually couldn't quite follow him, but at least I now had a picture in my mind: Permeate. Vacuums. Basic high school physics stuff. "So now the straw is up in the water, and when the wave goes by, the straw comes down. And as the straw comes down, you open the valve, and you force liquid into the bottom so that water from down deep starts to come up."

Blumberg himself pointed out one of the many reasons to be skeptical of such a plan. Cold water might sink back down, instead of mixing at the surface. Strong hurricane winds might destroy the pumps. While the pumps are in the ocean, they'll disrupt shipping lanes. And the relatively rapid bringing of nutrient-rich cold water to the surface might cause algal blooms or other disruptions of marine ecosystems. But even with these caveats, many people are exploring variants of the same basic idea. Microsoft founder Bill Gates recently co-funded five relevant U.S. patent applications. Oceanographer Lauren Ginis of the University of Rhode Island became sufficiently intrigued by the idea of using pumps to cool the ocean's surface that he explored aspects of the theory in detail. "A few years ago," Ginis told me, "I was approached at a conference by someone—the inventor Philip Kibbly—"who developed these wave-driven pumps." He pretty much ignored Kibbly's idea until, on sub-Saharan half a year later, his curiosity led him to do some calculations to see if the cold water brought up would be as cold as he suspected, sink right back down. He found that the water would sink, but "not back to the place where it was originally; not below thirty or forty meters." Since hurricanes interact with the entire upper layer of the ocean—not just the very top—he thought it might be worthwhile to conduct field experiments to confirm his mathematical modeling. Ginis told me he heard of an experiment in Hawaii that had set out to study the effects Kibbly pumps might have on sea-surface biology; the pumps

1. In an interesting environmental twist, algal blooms are what James Lovelock—industrial scientist and father of the Gaia hypothesis, which proposes that we think of Earth as a superorganism, our currently requiring "from parents" to produce algae, also pumping water to the sea's surface. The algae blooms would absorb CO2 and also release a beneficial, dimension wider, that is known to aid in the formation of silicons-refracting clouds. It would make for an increased sky and thus fewer ocean waves, but it would be compatible with human life as we know it, more or less. Lovelock's forecast for global warming is out of the most dire, which is likely why he supports such a radical experiment; he uses Griffiths' nuclear power to control our carbon emissions, and when asked about the complications of nuclear waste, he notes that the areas around Chernobyl are among the most biodiverse on the planet, because radiation causes the flora and fauna fewer problem than the incineration of nuclear waste.

2. Already a similar kind of pump is being used to help cool reefs, where delicate ecosystems have been severely unbalanced by rising surface temperatures.

promptly fails or sank irretrievably to the ocean floor. But perhaps future experiments will fare better. In January, Ginis, along with a team of colleagues that includes Rosenfeld and Khan, won substantial funding from the Department of Homeland Security for further hurricane-modification research.

It turned out that Ross Hoffman hadn't hated my dad, he wasn't developing storms for North Korea, and he hadn't even been convinced—not for too long, anyway—that I was a conspiracy kook. But he thought his highly theoretical work had been presented on a few pop science shows as farfetched in practice as it was, and that the resultant attention hadn't been wholly undeservedly welcoming, or welcomed. But he had changed his mind and was willing to speak with me.

(Truth be told, I hadn't even done my own work to get the interview with him; at least I don't think my previous efforts had changed his mind. Instead, my editor in les-jeunes, called and spoke with Maria Pirone. With my editor's non-western, guilt-ridden voice, I guess everything was cleared up. An interview was agreed to.)

The day I rode the train up to Boston to meet with Hoffman, the lead story on NPR was the Mississippi and Iowa river overflowing their banks. An NPR reporter insistently explained that we had overloaded in the floodplain, and now what were we going to do, move the University of Iowa? Hoffman had listened to the same broadcast, and he brought it up as we discussed whether his work generated anxieties about humans messing with the workings of nature. "My feeling is we've already messed with nature. Most of the problems we face as a species have to do with the fact that we have overrun the planet," Mild-mannered and dressed in khakis and a button-down shirt, he didn't look like he ever watched much Star Trek. He studied geology at Brown University because he liked rocks. "We wouldn't need to do things like trying to induce rainfall if there weren't so many people that
were thirty and living in mangroval lands. The same goes for cyclones in areas like the Bay of Bengal, where population pressure forces people to make their chances in places where they shouldn’t be living. Once we’ve gotten to this point, we really have to be engineers for Earth. I felt like I was sitting across from Fuller’s more emotionally manned grandpa.

In his hurricane-modification work, Hoffman turns to advantage the very aspect of hurricanes that might seem above all to make them difficult to control: their chaotic nature. Chaos is common, misunder-

stood as randomness, whereas what is characteristic of chaos is that very small changes in a chaotic system can lead to enormous changes in that system’s future. This is the stuff about the butterfly in Kansas City causing a typhoon in Taipei. But most flutters don’t matter much at all.

Considerable meteorological work has gone into trying to identify reliably which slight perturbations will likely affect large-scale changes, which proverbial butterflies matter. My dad did some work of this kind.

Using data from real storms of the past, Hoffman’s research explores what would likely happen if you changed a bit in the butterfly’s wings. A few days before, he decided to do it. The work I do really has to do with it: if you could modify the atmosphere—you know, jest it, cool it—what patterns would be best?

Hoffman showed me the models of the altered storms on his Macbook. Red indicated locations where small increases in temperature had been applied to models of actual past storms; blue represented small de-

creases. The computer then produced tiny movies of the thirty-hour alter-

nate-history histories of the hurricanes.

When Hoffman’s team was first able to change only the temperature of the central Pacific Hurricane Ini-

ki, the experimental intervention was moderately successful; Ini had tracked farther west than it had in its unaltered form, but not as far west as would have been ideal. (If Ini had traveled over the Atlantic, its eye would have bypassed the island of Kauai altogether and

pierced out at sea.) When the team assumed it could not only change temperature but also affect some winds, the storm deviated entirely clear of Kauai. In another simulation, done with the Atlantic Hurricane Andrew, Hoffman’s team wasn’t able, with minor temperature fluctuations, to turn the storm’s course away from Florida, but they did succeed in sig-

nificantly reducing the hurricane’s strength at landfall.

The model had a SunCity sexti-

ness to it; enormous blue and red swells menacing the Southeast Unit-

ed States with just a sorry and dan-

gering squall of mathematicians and meteorologists to save the day. I felt like I’d seen this dream somewhere, maybe on PBS, maybe on TNT.

Hoffman has given some thought to how small changes in the atmosphere might be engineered, though it’s not the focus of his work. One notion is to diode an aerosol of carbon black atop a hurricane system in just the right pattern for absorbing additional heat in just the right places, creating a mosaic of temperature alternations of one or two degrees in specific spots throughout the storm. In another topic, of dystopic future, an “array of Earth-orbiting solar power stations could eventually be used to supply sufficient energy” to bring about the patterns of interstorm tem-

perature modulations. We “might use giant mirrors to focus the sunlight into the solar cells and then have the collected energy down to microscopic re-

corders on the ground,” and this could serve as the energy source for financing a storm’s track. Such technology sounds, yes, pretty wild, and not yet developed, but it could make for a virtually endless job (as long as the life of the solar cell) source of clean energy, so is at least worth thinking through a bit. A “gentler” approach Hoffman men-
n tioned might be to encourage the proper small changes by making minor alterations to the weather-modifying activities we already engage in planes that leave behind contrails to increase cloud cover slightly, crop-irrigation practices that affect evaporation.

Offhand, of course, this all sounds, well, infeasible, but it’s worth recalling the 1893 speech of old Secretary of Agriculture Jeremias Ross that rainmaking should find its resting place “among the curiosities of so-called scientific investigation, in com-

pany with its own absurdity, the flying machine.” Like Emanuel and Eugene, Hoffman thinks the truly difficult issue to resolve is political and soci-

cal, not technical. “The more we dis-

cuss, the better,” Hoffman said. “The fact is, we’re changing the climate all the time through ‘large changes to land use, large changes to staff in the atmosphere. If there’s some way to manage what we do so that the chang-

es will be beneficial or at least neutral instead of negative, that usually makes sense to me.”

I was reminded of a characterization of Hoffman’s work that Emanuel had made: “You’re not creating some thing extraordinary, you’re creating something quite ordinary. A baby playing in the plans of Tibet a week earlier may have caused a dust devil that does the same thing but without anyone’s knowledge or control. We’re constantly doing this.”

Somehow, against my natural incli-
nations, on the train back to New York, I felt oddly comforted thinking of these harnessed-up meteorologists, Emanuel and Hoffman, with their various academic academies. They see Earth as a planet tremendously out of balance with human life as we know it, but still—I briefly felt like everything might end up okay, for Earth and for us humans too. If we could just be people like them, then ship the thing. Then rather than for, save. And then rather than nature as it is currently running, make. They could be the parents. I’d sleep better, dreaming of chaos reined, asteroids evaded; a backup moved to if necessary. I did in fact sleep sworn on that train.

E

manuel made the case with

strengths for what I’d decided was my own sensible, adult posture: all these hurricane-mitigation plans are little more than Ruth Goldberg corrections. Better predictions, better evacuation plans, and more hurricane-prepared coastal living would save lives—and at least property—more reliably and for a lower cost. A poor region like Bangladesh might provide the best evidence for such an argument. In 1970, when Bangladesh
was not yet its own country but, in
tead the poorest part of Pakistan, a
hurricane hit that killed as many as
500,000 people. (When the rest of
Pakistan neglected the devastated
area, Bangladesh sought and gained
their independence.) In 2007, when
Bangladesh suffered a hurricane as in-
tense as the 1970 one, fewer than
3,500 people died. A tragedy, but a
much smaller one. Nothing expensive
or spectacular was responsible for the
difference. Since the 1970 hurricane,
a whole suite of NGOs had come in
and built evacuation shelters: simple
concrete structures, numerous enough so
that few people have to walk more
than ten miles to reach one. The in-
tervention had worked.
But funding for far-reaching projects
can be justified for reasons other than the
practical, for reasons that are closer to
why it makes sense to fund, say, art. These
great weather-conditioned ideas,
chanted in mathematical detail, are
works of the scientific imagination. I
myself think of them as poems. They are
constrained not by meter or rhyme or
genre but by the stuff of our real
world. We’re used to thinking of con-
straints as a way to enhance the artis-
tic imagination; we’ve just not used to
these particular constraints, the laws of
our universe as we understand them.
Which is why we treat certain scientific
imaginations as pragmatic undertakings
rather than, as a kind of art, we end up
with bumblebee disasters, occasionally
profound evil, and now and again
something like a smallpox vaccine and
affordable clean-water resources for
millions of people. But as a way of
dreaming rigorously, these poems of
science might be like Shakespeare’s
Flours de mai, or Lewis Carroll’s "Jab-
berowk." Or like the work of the
Monagu de Sade. We don’t ask of these
creations that they fly as literally to
the moon, or light up the path to a
righteous future. Consider Backmin-
er Fuller. Maybe it isn’t wisdom and
hindsight that make him seem so silly
but rather the cattiness of age and the
collapses of experience.
Precisely because so much weather-
mobilization theory looks, smells,
sounds like, and easily could be trans-
formed into a nightmarescape technol-
ogy, we should be suspicious of these
pre-packaged outrage at such tangetters
inevitably the work out of the
public eye and out of public funding.
Letting some private company develop
technologies so the government can
keep its hands clean for now doesn’t
avoid any real problems. It’s easy to
image private industry designing an
Offshore Hurricane-Awayer (which,
like most commercial rainmaking to-
day, might or might not work, and
which might or might not cause disas-
trious side effects) for gated StayPut
Mansions communities. A wealthy
antitrust Attorney Wessex Aboogheous.l
lobbying group will keep government
regulations of such things to a mini-
 mum. Our fear of what we’ll do with
scientific knowledge should be sharpened
by the prospect of that knowledge being
being pursued outside the public’s mon-
ery, normalizing, sobering size.
Maybe the dominant technology
myth should no longer be that of the
Titan Prometheus (steal fire), or
Pandora’s box) but of Daedalus,
the suffering mortal, the engineer. King
Minos tells Daedalus he needs a
prison, and Daedalus builds him a
labyrinth. So ingeniously is his cre-
ation that when Daedalus himself
and his son Icarus are imprisoned in
it, even they can’t shake their way out.
So yes, Daedalus unmention-
ably fabricates his own dungeon. But,
ever resourceful, he builds wings for
himself and for Icarus, so they can
soar fly up above the labyrinth and
escape. As you know, only one of them
lives. Which, arguably, is better than
none.

Old stories don’t come back; it’s more like they were always there and sometimes they set down their cam-
ouflage. I said any father never went
to a mall. But I have reason to be-
lieve that he actually did go once. A
few weeks into college, when I was
already discovering my parents with
my announcement that I wanted to
major in Spanish literature—never
mind that there was no such major—
and not, say, physics or chemistry,
I received a package in the mail from
my dad. I was surprised to think that
he could feel and negotiate the post
office. Inside, there was a passed Hall-
mark card with a poem titled “Daughters,” two unattractive XXL
T-shirts of the kind that used to be
sold at bookstores—one a caricature
of Einstein, the other of Sherlock
Sparrow—and a copy of Din Quonot.
My father could always be relied
upon to give me money, and when
ever he traveled he brought me back
curious souvenirs, but he’d never in
the last gotten me a gift. Not for grad-
uation, not for birthdays, not for any-
thing—that just wasn’t a thing in my
family. My dad died ten days later.
I hadn’t read Do Quonot, but I had
corrected my dad’s pronunciation—key-
board—by using to say—though I later
learned that his way of saying it was the
correct one. That gift, it’s like it keeps
insisting it’s one of the little butterflies
that matter, though I still can’t clearly
discern its flutterings. Don’t waste your
mind beating gifts at the mall and
standing in line at the post office, the
inside of the package seemed to say,
even as the package’s actual arrival
spoke to the contrary. Life shouldn’t be
wasted on reality, that gift might have
meant. Waste it some other way. There
will be disasters regardless.

Ocearch Index Scores
1 Hitter's research/China Market Research
croup (Shanghai)/Appropriations Committee,
U.S. House of Representatives; 4 Hitter's
research/China Market Research Group (Shanghai)/Appropriations
Committee, U.S. House of Representatives;
5 Jon M. Huntsman Jr., China Studies
Center, Harvard Business School; 6 The Levin
Institute (NYC); 7.4 Katherine Paquette,
The Pennsylvania State University (State
college); 9 Caroline Sisombo, Comor Science
Group, Peking University (Beijing); 10.1
International Marine Science Association (South
Africa, Durban); 12 DoD Space Based
History (NYC); 13 U.S. National Oceanic and
Atmospheric Administration/14.5 U.S. Marine
Inselligence Unit (London); 15 Department of
Homeland Security; 16.1 Virginia Department of
Transportation (Richmond); 17 Cheddar
Department of Transportation (Washington); 18 Office of a
Congression Alan Cohen (Oklahoma, Okla.); 19.21 Centers
for Disease Control and Prevention (Washington); 22
James Kau, Villanova School of Business
(Philadelphia, Pa.); 23 John Lawrence, Iowa State
University (Ames); 24 8.1 U.S. Census Bureau;
25 26 Pew Research Center (Washington); 27 Levin
News Institute (NYC); 28 The Washington Post
Trends to Prevent Prem and Unplanned Pregnancy
(Washington); 30 Family Pro-Regency
(Berkeley, Calif.); 31 D. K. Daniel, Tacket,
Carson University (Oxford); 32 Illinois Digital Media
(Austin, Tex.); 33 Mr. Whiter (NYC); 34
Vern Pavas, Instrumental Computer Science
Institute (Berkeley, Calif.); 35 Pew Research Center
(Washington); 36 Hacienda (Perino Turo, Colombia);
37.38 U.S. Dog Enforcement Administration; 39.40 Pew
Research Center (Washington).