

Stories matter, and in a nation where belief in alien abductions is on the rise while belief in evolution is on the decline, the best way to defend science is to tell your friends a good story.

Tell Me a Story



Normally, if you're a science reporter at NPR or ABC, a trip to Caltech means that you call ahead, and you ask for a few precious moments with the world-class intellectual whatever. And you're ushered in, and you furiously take notes, all the time thinking, "Do I have any idea what this person is saying?" I'm sure you know the feeling.

So when I got my invitation asking *me* to give *you* guys a lecture, I thought, come on—what could I tell *you*? But I thought of something. And it's something that's going to happen to you, you sitting here with the black hats, in the next hour or two.

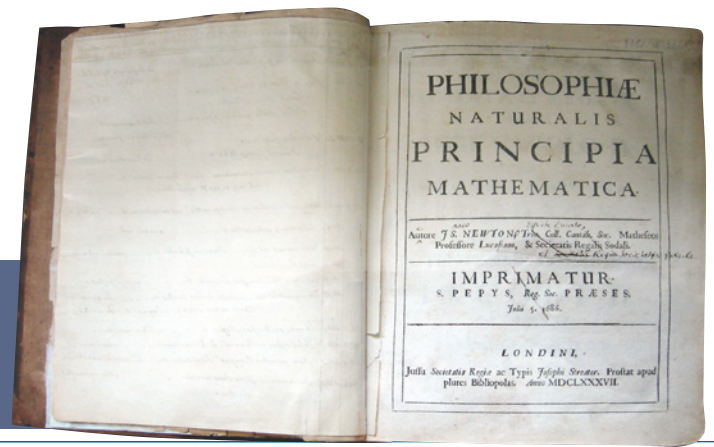
There you'll be, in your cap and gown surrounded by your family, and by friends, and by friends of friends, and somebody—maybe an uncle, a buddy, somebody—is going to turn to you and say, "So what have you been doing at Caltech? What were you working on?"

Not that they really want to know—but after all, you've been here for four years, or a different number, if you're a grad student, and you must have been doing *something* here, so it's only polite to ask.

And I know that a lot of you come from scientifically literate families. But let's assume that this relative, we'll make it a "he," is not a scientist. He's not an engineer. And the last time he had a thought, a complex thought about biology or math, was back in 11th grade . . . when he got a C- in both subjects and vowed never, ever to think about biology or math ever again.

But because this is *your* day, and because this person loves you, or because he

Science journalist Robert Krulwich, who is seen on ABC and heard on NPR, was the featured speaker at Caltech's 114th commencement exercises on Friday, June 13.



By Robert Krulwich

can't think of anything to say after "hi," he asks about your work.

And to make it still more interesting, let's assume that if you explain to this person what you've been working on, you might have to use certain words like "protein" or "quark" or "differential" or maybe "hypotenuse." And if you do, he is going to listen to you very, very politely, but upstairs, those words are going to mean not a whole lot. Because science is not his thing. He can lip-synch every word to 'NSYNC's "Bye Bye Bye," but "hypotenuse" is hard.

So . . . here's my question: When you are asked, "What are you working on?" should you think, "There's no way I can talk about my science with this guy, because I don't have the talent, or the words, or the patience to do it—it's too hard, and anyway, what's the point?"

Which, by the way, is not an unusual position. No less than Isaac Newton, and I mean *Sir* Isaac Newton, that one, was asked why he had made the *Principia Mathematica*, his earthshaking book about gravity and the laws of motion, so impossibly hard to read. He replied that he'd considered writing a popular version that people might understand, but—and I am quoting Newton here—"to avoid being baited by *little smatterers in mathematics*," that was his phrase, "little smatterers," he intentionally wrote the book in dense, scholarly Latin with lots of math so that only scholars could follow it.

In other words, Isaac Newton didn't care to be understood by average folks.

But here's the argument I want to make to

you guys this morning, and you're not going to hear this advice often. You may never hear it again: *Do not do what Newton did*. No, no, no.

When a cousin or an uncle or a buddy comes up and asks you, "So, what are you working on?" even if it's hard to explain, even if you know they don't really want to hear it, not really, I urge you to give it a try. Because talking about science, telling science stories to regular folks, is important. In a way, it's crucial.

Scientists need to tell stories to nonscientists, because science stories—and you know this—have to compete with other stories about how the universe works, and how it came to be. And some of those other stories—Bible stories, movie stories, myths—can be very beautiful and very compelling. But to *protect* science and scientists—and this is not a gentle competition—you've got to get in there and tell your version of how things are, and why things came to be.

We all know about creation-science movements in America. But what you may not know is that such movements are spreading all over the world. In Turkey, there's a group led by a man named Adnan Oktar, a Moslem creationist. And his group produced a picture-packed 768-page "biology" textbook that's priced very, very cheaply, so schools can have it for next to nothing. And that textbook is now in schools all over Turkey. It's written in clear and simple language, using fabulous pictures, and the pictures are designed to "prove" that fossils show no evidence of evolution.

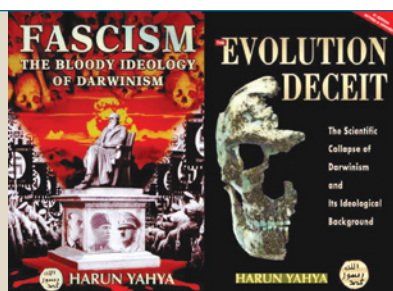
And this group's books, and their CD-ROMs, and their grocery-store magazines—they have grocery-store magazines!—are so inexpensive and so provocative, with titles like *The Bloody Ideology of Darwinism* or *The Evolution Deceit*, and their websites are so widespread, that in Turkey's high schools—which are not religious schools; they have a long secular tradition there—evolution and Darwin are getting less and less attention in the curriculum.

In 2006, when Turks were polled and asked whether it's true or false that human beings as we know them developed from an earlier species of animals, only 25 percent of the Turkish public said yes. That's a very low number. In Japan, 78 percent say humans evolved from a predecessor species. In the U.S., it's 40 percent. But that's above Turkey.

There was a debate, of course. And there's still one, sort of, except Mr. Oktar sued the people who opposed his views for slander, and managed to shut down their blogs. His followers attacked biology professors as "Maoists"—Maoists?!—for teaching evolution, which they called "nothing but a deception imposed on us by the dominators of the world system." High-school teachers in Istanbul were challenged because they taught evolution and not creation science.

And while Mr. Oktar was recently arrested for his role in a sex-ring operation, so he may be taking a break, creation science is now taught all over Turkey. And while Turkey may seem an ocean or more away, *it is not*. There are always Mr. Oktars who aim their

Two of the anti-evolution bestsellers that are changing the face of science education in Turkey. Harun Yaha is a pen name of Adnan Oktar.



In a typical episode, Ross is going on about opposable thumbs. He says, “Without evolution, how do you explain opposable thumbs?”

Replies Phoebe, “Maybe the overlords needed them to steer their spacecrafts.”

stories right at *you*, right at the heart of a place like this, at the values that Caltech has always honored from the beginning.

I know you spent long nights cramming and sweating under the weight of too many assignments and too many tests and too many papers from too many professors who didn't realize that there were *other* professors who were making you do the same tests, but somewhere in that nightmare of work, you may have noticed that your teachers were giving you more than tension headaches; they were giving you values. A deep respect for curiosity. For doubt. Always doubt. For open-mindedness, for going wherever the data leads, no matter how uncomfortable. For honesty. For discipline. And most of all, the belief that anybody, no matter where you are from, no matter what your language, religion, politics, age, or temperament—I mean, this place has seen *monstrous* egos, and bongo players and people who dress in Viking hats—but if you can learn to how to sit down in a laboratory and think in an orderly way, and if you have the patience to stare and stare and stare and stare looking for a pattern in nature, you are welcome here. It may be boring. It may be sometimes very exhausting. But there's a freedom, a *freedom*, in this way of looking that is precious in the world. And that

freedom can be attacked, or defended, with stories.

Stories matter.

After all, what is a science experiment? You make up a story that may or may not be true, and then you test that story in the real world to see what happens.

So, for example, let's say you're in Pisa around 1590, and a guy named Galileo comes up to you and says, “Hello there.” (He actually probably wouldn't say it that way, but still.) “You see I have a cannonball in my right hand, and in my left hand I have a musket ball, which is much lighter. Now, sir, if I told you that these two balls, if dropped from the same high place at the same time, would hit the ground simultaneously in spite of their five- or tenfold difference in weight, would you like to see me try?”

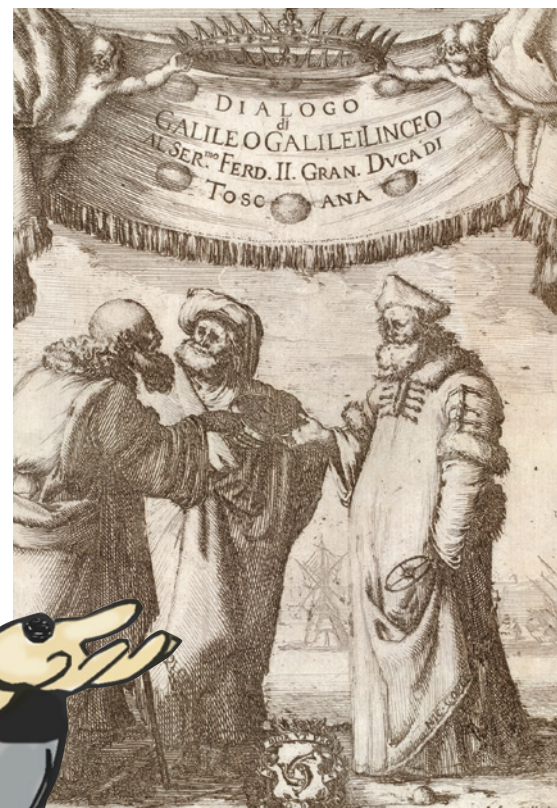
Whether Galileo actually did this or not—if he proposed this to you, wouldn't you stick around? Just to see how it comes out?

Galileo, for my purposes, is the great Un-Newton. Unlike Newton, he had a flair for narrative, a storyteller's sense. Unlike Newton, he wanted to tell people what was on his mind. Unlike Newton, he thought the people could understand

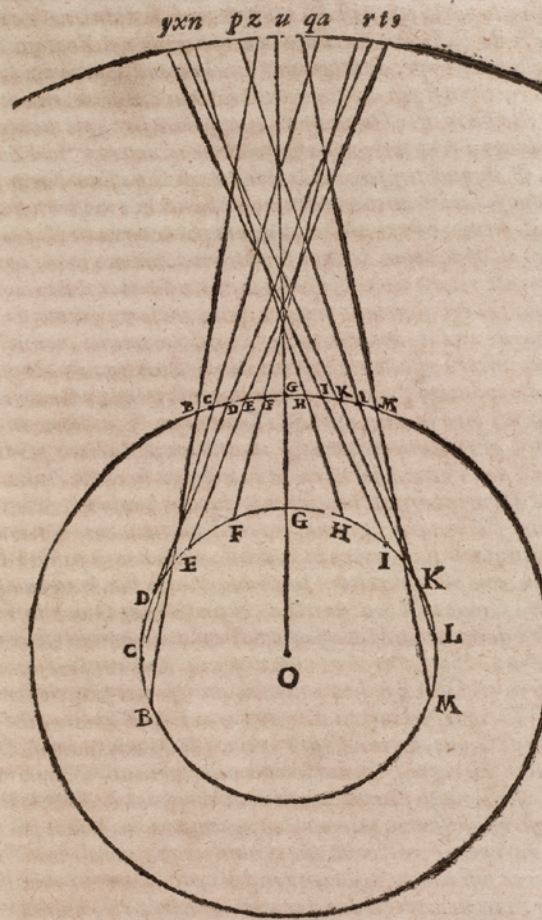
him. That's why he got in so much trouble.

His famous book, the *Dialogue*, about the sun being the center of the solar system, wasn't written in Latin. He wrote it in Italian, for a mass audience. And the writing was gorgeous. It was poetic, it was combative, it was funny. It's a running conversation between three good friends who spend four days together, arguing, eating, and boating through Venice in gondolas—the argument being, is the earth the center of the solar system, or might it be the sun? The book has pictures, little line drawings that he made; and he put in marginal headings to break up the text, so you wouldn't have a big sheet of writing. And while there are numbers, he doesn't get to them until two-thirds through the book, and if you skip the numbers you don't miss that much.

So because Galileo's book was so easy to read, and such a page-turner, it so threatened the established order that Galileo, as



In this page from the *Dialogue*, Galileo explains Jupiter's retrograde motion—in which it appears to slow, reverse course, and then move forward again against the background stars—as a consequence of both Earth and Jupiter orbiting the sun, with a faster-moving Earth on the inside track.



Supponendo hora, che quando la terra è in B. Giove sia in b. ci apparirà a noi nel Zodiaco essere in p. tirando la linea retta Bbp. Intendasi hora la terra mossà da B. in c. e Giove da b. in c. nel'istesso tempo; ci apparirà Giove esser venuto nel Zodiaco

you know, was put under house arrest. And it wasn't just his *science* that was alarming. I think it was the power of his storytelling. That's what made him extra dangerous, because stories have this power.

People *like* them.

E. O. Wilson, a great scientist and a great storyteller, wrote that "science, like the rest of culture, is based on the manufacture of narrative. . . . We all live by narrative." He doesn't know the half of it.

I work in radio and television. I can go on prime-time TV (and I have) and do an hour on string theory, and talk about multiple dimensions, and space-time curvature, and supersymmetries. This is very odd, very hard stuff, and yet a whole lot of people, a few million people, will sit there and watch the whole time, apparently—I like to assume—quite fascinated.

But the program ends, and then you have a bunch of ads—maybe seven commercials and one network I.D.—and three-and-a-half to five minutes pass, and the next program comes on, on the very same channel. This one is about extraterrestrials landing in anti-gravity machines to examine the breasts of innocent cocktail waitresses, and the same people who were watching the previous hour sit there with same sense of awe and fascination, and they kind of believe this one, too!

People are not discriminating about stories. Truth? Fiction? Eh . . . whatever. It's like the endless back-and-forth between Ross and Phoebe on the TV show *Friends*. Ross is a paleontologist. He studies dinosaurs.

Phoebe is his masseuse friend. She doesn't study anything, but she knows everything. And in a typical episode, Ross is going on about opposable thumbs.

He says, "Without evolution, how do you explain opposable thumbs?"

Replies Phoebe, "Maybe the overlords needed them to steer their spacecrafts."

So people can slip very easily from reason to fantasy, and they believe both. They don't feel a need to be consistent. They just want to be absorbed, swept away. So when you tell stories to Americans, really to anybody in the world, you have to remember there are

lots of Phoebes. Stories with gripping visuals and good punch lines, stories that make intuitive sense, that make sensual sense—to your eyes, to your ears, to your touch—can convince. They have power. You may not believe that two balls, one heavy, one light, dropped from the same high place will land together, but if you see it with your own eyes, *that* you remember.

As science gets harder, metaphor becomes more useful, and even necessary. More and more of what science teaches about the world is not intuitive. It makes no sensual sense.

Far left: Boy, have I got an experiment for you!
 Left: On the title page of his *Dialogue On the Two Chief World Systems*, Galileo pays homage to, from left, Aristotle and Ptolemy, whose views he demolishes, and Copernicus, who comes out the winner.

The Grand Canyon bears witness to the magnificent violence hidden in a torrent of old raindrops.



This starts early, in high school. If I slap my hand on a hard surface, like this lectern, the outer electrons in my hand and the ones in the wood repel one another. This is the electromagnetic force, as you know. Electrons just don't like being around other electrons, so the reason my hand doesn't go through the surface is that two platoons of electrons on a line of scrimmage got in each other's faces.

rinth." But having honored math, Galileo was very happy to create beautiful metaphors, to invent marvelous characters, to draw pictures; he knew how to light that labyrinth so the rest of us could see inside. Because the more abstract and mathematical science gets, the more we need to imagine something concrete. As the physicist and author Alan Lightman [PhD '74] has said, "we are blind people inventing what we don't see."

ters from Werner Heisenberg and Erwin Schrödinger, two of the 20th century's great physicists. Schrödinger liked to think in pictures, his most famous one being the image of a cat in a box who paradoxically is both alive and dead at the same time—don't ask. The point is, Schrödinger loved pictures. And Heisenberg, he loved numbers.

When Schrödinger read Heisenberg's papers, they were so mathematical that he wrote he was "*repelled*"—his word—"by the methods of transcendental algebra . . . [that so lack] visualizability."

And Heisenberg answered back, oh yeah? Well, he probably didn't say it that way, but he did say that the more he reflected on Schrödinger's work, "the more *disgusting* I find it." And "disgusting" is a quote. It's Heisenberg's word.

So there is a tension among scientists between two kinds of truth: math and narrative.

But the job we face is to put more stories out there about nature that are true and complex—not dumbed down—and that still have the power to enthrall, to excite, and to remind people that there's a deep beauty, a many-leveled beauty in the world. What scientists say is hard-won information, carefully hewn from the world. It's not the offhand opinions of a tribe of privileged intellectuals who look down on everybody.

It's my sense that if more scientists wanted to, they could learn how to tell their stories with words and pictures and metaphors, and people would hear and remember those stories and not be as willing to accept the other folks' stories. Or at least there'll be

So Mary Schweitzer gets the bone fragment in the mail, and although Bob the Dinosaur was about 70 million years old, almost immediately when she looked at it, she said, "This is not a Bob. This dinosaur is a girl, and she's pregnant."

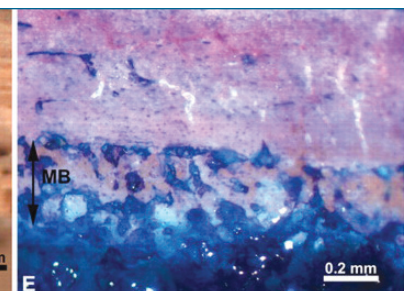
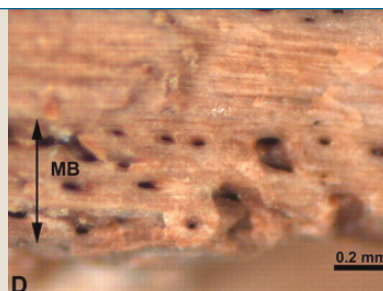
That's harder, though—to add faces, and motives, and football analogies to electrons. There are some of you, probably on the faculty, who will say, "You can't talk about nature that way. It distorts what's true. What's true is what you see in equations, in the math, that points to these laws."

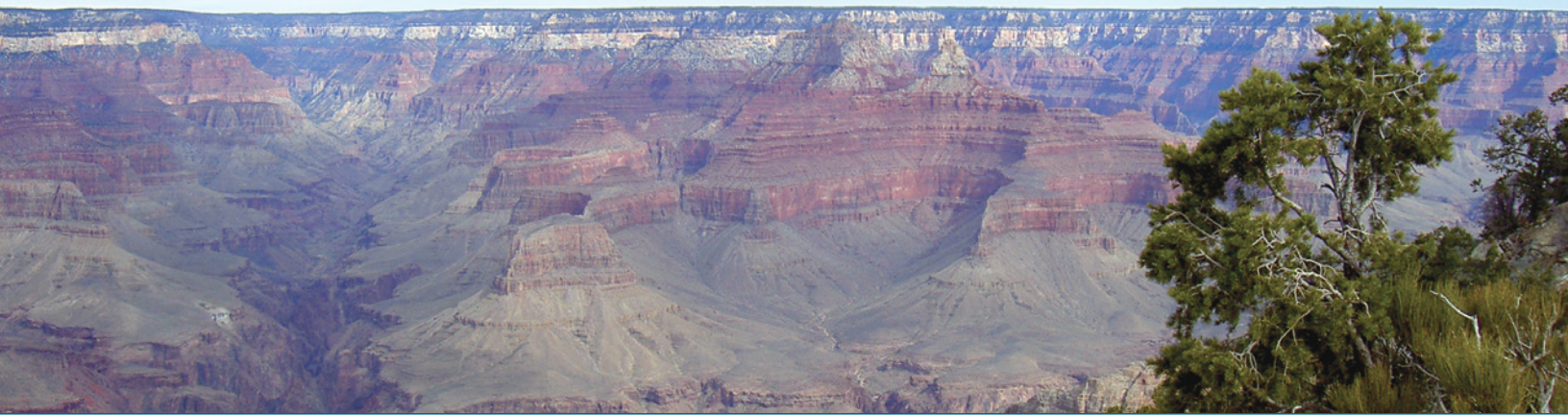
But I go back to my man Galileo, who was maybe the first, in Western tradition anyway, to honor mathematics as the primal force of knowledge. The logic of the universe, he said in his book *The Assayer*, is "written in the language of mathematics . . . without which . . . one is wandering around in a dark laby-

And yet many scientists remain wary of metaphors, of adjectives, and even of the active voice—"It was observed that . . ." sounds much nicer to these people, for some reason, than "I saw." And I can tell you from personal experience that they do *not* like talking to reporters because they think, "Whatever I say, this 'journalist' person is going to turn it into something stupid, and cartoony, and wrong." Yeah, you're applauding. And maybe it's true. But I was happy to learn that scientists are just as nasty about each other.

My favorite example is a pair of let-

Right: The photo labeled D is a micrograph of Bob's femur, and the one labeled E is an emu tibia. "MB" stands for "medullary bone," which is the calcium-storage tissue. Opposite page: Mary Schweitzer and Bob's smaller cousin, an albertosaur.





a tug of war, and I think that the science stories will, surprisingly, very often win.

I remember standing on the rim of the Grand Canyon looking down on that enormous hole created by running water, endlessly running water, fed by a distant Colorado rain, and thinking, "How did this beautiful thing happen?" And in my head I heard a line written by Loren Eiseley, a great, great scientist and writer, a line I had read in college, which described "the magnificent violence hidden in a raindrop."

And when I looked back at the canyon, and at the roaring river there, that's what I saw: magnificent violence hidden in a torrent of old raindrops.

Now we can't all be *that* good, and even when we try, we don't always win. Again, I'm thinking of Ross, poor Ross, and the show *Friends*. He tells Phoebe that he's seen

fossils from all over the world, and "you can literally see them evolving through time."

And Phoebe says, "Really? You can actually see it?"

And Ross says, "You bet. In the U.S., China, Africa, all over."

And Phoebe says, "See, I didn't know that."

And Ross says, "Well, there you go."

And Phoebe says, "Huh. So now, the *real* question is: Who put those fossils there, and why?"

So yes, science stories don't always win, but at the very least it should be a tug of war. And if you tell them right, they have the power to change minds.

On my way here, I read a story in *Smithsonian* magazine that's a good example of what I'm talking about. Imagine that you're sitting on your porch with a friend, a non-science friend, and as you sit there, a robin, an ordinary robin, wanders onto the lawn and you say to your friend, "You see that robin? Did you know that robins, in fact all birds, are directly descended from dinosaurs? And in a way, that robin is a small, feathery, modern dinosaur? Huh?"

And if your friend is like my friends, she'd say, "What? What are you. . . Go away!" But don't go away. Instead, you could tell her this story, which is how I'm going to conclude.

Eight years ago, Bob Harmon, who works for the Museum of the Rockies, was having lunch in a canyon somewhere in Montana and he looked up at a big rock face and he saw a bone sticking out of the wall,

just a bit. That bone turned out to be part of a *Tyrannosaurus rex*, one of the best-preserved examples of a *T. rex* ever found anywhere. And after three years of carefully, carefully, carefully chipping away, they got a 2,000-pound skeleton out of the wall. The dinosaur was named "Bob," in honor of Mr. Harmon, and on the way out, for various logistical reasons, they had to break a leg bone. Some of the fragments were sent to scientists around the world, including one at North Carolina State University named Mary Schweitzer.

So Mary Schweitzer gets the bone fragment in the mail, and although Bob the Dinosaur was about 70 million years old, almost immediately when she looked at it, she said, "This is not a Bob. This dinosaur is a girl, and she's pregnant."

When women get pregnant, they use the calcium from their bones to build the skeletons of their developing fetuses. And if the mother is a *bird*, she also needs calcium to build eggshells.

Mary had studied birds, and she knew that in the cavities within their bones, pregnant birds grow a special kind of spongy bone that acts as a calcium reservoir. It gets drawn down as the eggs are laid, so that the bones themselves don't get weakened. And when Mary looked at the dinosaur-bone fragment, she saw just what pregnant birds have.

The most primitive birds today are the emu and the ostrich, so just to be sure, she called a bunch of ostrich breeders in North Carolina and said, "Anybody have a dead



She'll glance at a little bird pecking for worms on the lawn, and she'll travel 70 million years back to a time and a place that creationists say did not exist, but now, because of your story, your friend has a pregnant tyrannosaurus in her head with the unfortunate name of Bob.

female? I need a leg bone here." And a few months passed, and the phone rang, and it was a farmer saying, "Ya'll still need that lady ostrich?"

So Mary and her two assistants collected the dead ostrich, which was in the farmer's backhoe bucket, and drove it back to Raleigh, and what do you know? The former ostrich had been a pregnant former ostrich, and the bones looked pretty similar. The next year, Mary published a paper in *Science* with the dinosaur bone right next to an emu bone, which looks even more like Bob's.

And since then, another *T. rex*, this one in Argentina, was found to have the same calcium structure—more evidence that when you look deep inside dinosaurs and deep inside birds, what you see is very, very similar. Which gives us yet another reason to think that the robin in your front yard *is* an itty, bitty dinosaur.

If your nonscience friend listens to that story, and leans in a little, and hears how scientists work with bones and dead birds in buckets, patiently looking for patterns, you have just placed a sword in her hand. The next time somebody tells her that scientists are know-it-alls who toss off opinions, that science is an elitist plot, she would think, "welllll, but I *did* hear this story . . ." and the scientific method gets a little more defense, a little protection.

But better than that, the next time your friend sees a robin, she'll see, I hope, more than a robin. She'll glance at a little bird pecking for worms on the lawn, and she'll travel 70 million years back to a time and

a place that creationists say did not exist, but now, because of your story, your friend has a pregnant tyrannosaurus in her head with the unfortunate name of Bob. Which makes robins and sparrows and chickadees and crows and all birds just a little more amazing, and a little more delightful to look at. Which means, *you win*. The creationists can't beat delight. You have smote them with your story.

So ladies and gentlemen of the class of 2008, mindful of the fact that this place, this institution, with its culture of intellectual freedom, and respect for truth, and love of inquiry, not to mention illegal bonfires on city streets and basketball teams that lose 207 games in a row—but not the women's team; I heard about their astonishing two-game, back-to-back winning streak, yes, yes!—*you* know, *you know*, that when you receive your degree today, you are part of, and you are celebrating, something very rare, and very precious, and very fragile in our world. This place celebrates freedom, and because you are now free men and women, you have to protect what you've been given by helping others who haven't been here and who never are coming here to understand the value of what you do. And what your teachers do, and what their predecessors have done. Which is why, an hour or so from now, when your brother, or your aunt, or your mom asks you, "So what have you been up to while you've been here?" take a chance. Find the words, find the metaphor, share the beauty, and tell them what's on your mind.

Tell them a story. **e&s**

Robert Krulwich regularly appears on ABC's World News, Nightline, Prime Time Live, and Good Morning America. He is also a regular on National Public Radio's Morning Edition and All Things Considered, and cohosts Radio Lab, a science show for people who don't listen to science shows. His beats include science, technology, and economics; he once created an opera (in Italian!), Ratto Interesso, to explain how the Federal Reserve regulates interest rates.

Krulwich joined NPR in 1978, and served as economics reporter until 1985, when he joined CBS News. Since 1994, he has been an ABC News correspondent. He is also a regular correspondent on the PBS investigative series Frontline.

His Frontline coverage of campaign finance in the 1992 presidential elections earned him an Alfred I DuPont—Columbia University Award, and his investigation of privacy on the Internet, "High Stakes in Cyberspace," won an Emmy, as did his ABC special on the cultural history of the Barbie doll.

Other honors include the George Polk Award from Long Island University, the Eleanor Nealon Extraordinary Communicator's Award from the National Cancer Institute, and the American Association for the Advancement of Science's Science Journalism Award.

This article was edited by Douglas L. Smith.