# You Can't Fool Mother Nature

## *Schools should teach students the principles of scientific integrity.*

**By Richard Feynman**

During the Middle Ages, there were all kinds of crazy ideas, such as that a piece of rhinoceros horn would increase potency. Then, a method was discovered for separating the ideas − which was to try one to see if it worked, and if it didn't work, to eliminate it. This method became organized, of course, into science.

But even today, I meet lots of people who sooner or later get me into a conversation about UFOs, or astrology, or some form of mysticism, expanded consciousness, new types of awareness, ESP, and so forth. And I've concluded that it's *not* a scientific world.

Most people believe in so many weird and wonderful things that I decided to investigate why they did.

I looked into extrasensory perception, for example, and the latest craze there was Uri Geller, a man who is supposed to be able to bend keys by rubbing them with his finger. So I went to his hotel room, on his invitation, to see a demonstration of both mind-reading and bending keys.

He didn't do any mind-reading that succeeded; nobody can read my mind, I guess. And my boy held a key and Geller rubbed it, and nothing happened. So I was unable to investigate that phenomenon.

But then I began to think, what else is there that we believe. And I thought then about witch doctors, and how easy it would have been to check on them by noticing that nothing really worked.

So I found things that even more people believe, such as that we have some knowledge of how to educate. There are big schools of reading methods and mathematics methods, and so forth, but if you notice, you'll see the reading scores keep going down − or hardly going up − in spite of the fact that we continually use these same people to improve the methods. There's a witch doctor remedy that doesn't work!

In the South Seas, there is a group of people who saw airplanes land with lots of good materials during the last world war, and they want the same thing to happen now.

So they've made things like runways with fires along the sides, and a wooden hut for a man with two wooden pieces on his head like headphones and bars of bamboo sticking out like antennas. And they wait for the airplanes to land.

It looks exactly the way it looked before. But it doesn't work. No airplanes land. So I call these things cargo cult science, because they follow all the apparent precepts and forms of scientific investigation, but they're missing something essential, because the planes don't land.

There is one feature I notice that is generally missing in cargo cult science. That is the idea that we all hope you have learned in studying science in school. We never explicitly say what this *is,* but just hope that you catch on. It is interesting, therefore, to bring it out now and speak of it explicitly.

It's a kind of scientific integrity, a principle of scientific thought, that corresponds to a kind of utter honesty − a kind of leaning over backwards.

For example, if you're doing an experiment, you should report everything that you think might make it invalid − not only what you think is right about it. You must also report other causes that could possibly explain your results, and things you thought of that you've eliminated by some other experiment, and how they worked − to make sure the other fellow can tell they have been eliminated.

In summary, the idea is to try to give *all* of the information to help others to judge the value of your contribution: not just the information that leads to judgment in one particular direction. We've learned from experience that the truth will come out.

A fellow named Millikan measured the charge on an electron by an experiment with falling oil drops, and got an answer which we now know to be a little bit off, because he had the incorrect value for the viscosity of air. It's interesting to look at the history of measurement of the charge of the electron after Millikan.

If you plot them as a function of time, you find that one is a little bigger than Millikan's, and the next one's a little bit bigger than that, and the next one's a little bit bigger than that, until finally they settle down to a number which is higher.

It's a thing that scientists are ashamed of because it's apparent that when someone got a number that was too high above Millikan's, he thought something must be wrong and he would look for and find a reason why something might be wrong.

When he got a number closer to Millikan's value, he didn't look so hard. And so he eliminated the numbers that were too far off and did other things like that. We've learned these tricks nowadays, and now we don't have that kind of a disease.

The basic principle is that you must not fool yourself − and you are the easiest person to fool. After you've not fooled yourself, it's much easier not to fool other scientists. You just have to be honest in a conventional way after that.

But this long history of learning how to not fool ourselves − of having utter scientific integrity − is, I'm sorry to say, something that we haven't specifically included in any particular course that I know of. We just hope you've caught on by osmosis.

***(Adapted from Surely You're Joking, Mr. Feynman! With permission of the publisher, W.W. Norton & Company, Inc. Dr. Feynman was a Nobel prize-winning physicist and the scientist who figured out why the Challenger rocket blew up.)***