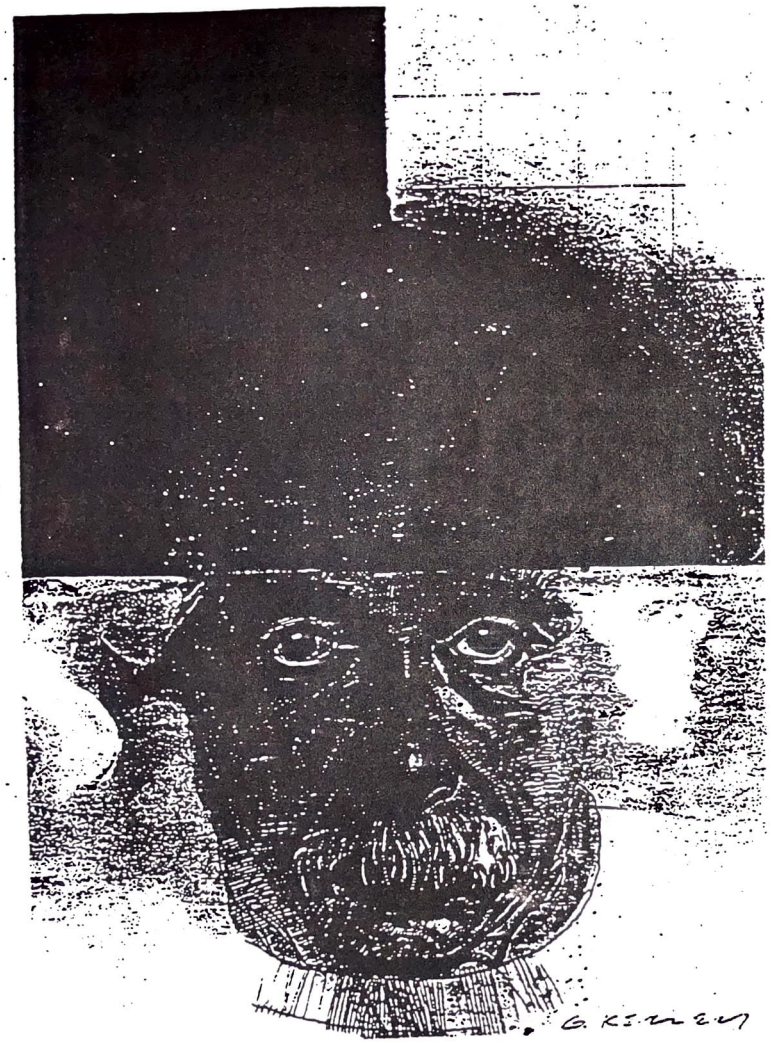
TOK- SCIENCE



K. C. COLE:

On Right and Wrong

Early last year, I was asked to speak to a group of junior high school children on the subject of "Science and Creativity." Thinking that nothing could be as creative as Einstein's theory of relativity (what could be more creative than refashioning our fundamental notions of matter, space, and time?), I decided to try that out on them. All went well until the end, when a girl in the back asked: "But what if Einstein was wrong?"

What indeed? It was a fair question, to be sure. Science seems littered with mostly forgotten remnants of "wrong" ideas. Heat is not a fluid; the earth is not flat; the planets do not revolve in perfect circles on fixed celestial spheres; and Mars is not covered with canals. No luminiferous ether pervades our space, undulating invisibly as a carrier of light. On the other hand, empty space is now—incredibly—described as curved, and even vacuums are said to come in several exotic varieties. It seems as if the outrageous ideas of yesterday are the scientific facts of today—and vice versa. So why shouldn't Einstein be wrong?

In truth, Einstein will almost certainly be proved wrong in the long run. Or, at least wrong in the sense that he himself proved Newton wrong. But "wrong" is obviously the wrong word for it. The girl's question reminded me of a conversation I once had with MIT cosmologist Philip Morrison about whether some current views of the universe were "right" or "wrong." Finally, Morrison said to me: "When I say the theory is not right, I don't mean that it's wrong. I mean something between right and wrong."

The territory between right and wrong, however, is uncomfortably unfamiliar to most of us—especially when it comes to science. "It's a scientific fact" is virtually synonymous with "It's absolutely true." Smearing social theories with shades of grey is one thing, but everyone knows that scientific knowledge is black and white. Or so goes the common misconception: "In the conventional model of scientific 'progress,' we begin in superstitious ignorance and move toward final truth by successive accumulation of facts," writes Stephen Jay Gould in *Ever Since Darwin*. "In this smug perspective, the history of science contains little more than anecdotal interest—for it can only chronicle past errors and credit the bricklayers for discerning glimpses of the final truth. It is as transparent as an old-fashioned melodrama: truth (as we perceive it today) is the only arbiter and the world of past scientists is divided into good guys who were right and bad guys who were wrong."

Nobody is more clearly a good guy today

than Einstein, at least in part because he was right about things that even the great Newton had wrong. Newton thought that time and space were invariable, and Einstein proved they were not. Yet Newton's "wrong" ideas still are used to chart the path of space shuttles and to place artificial satellites into near-perfect orbits. Apples still fall and the moon still orbits according to Newton's formulas. For that matter, Newton's theories work well for everything in our daily experience. They break down only at extreme velocities (approaching the speed of light), where relativity comes into play, or at extremely small dimensions, where quantum theory takes over, or in the presence of extremely massive objects such as black holes.

Einstein proved Newton wrong only in the sense that he stood on Newton's shoulders and saw things that Newton could not see—like what happens to time and space under extraordinary (to us) conditions. Mostly, Einstein proved Newton *right*, since his theories were built on Newton's foundations. Einstein took Newton's notions and stretched them into a new dimension, made them broader, bolder, more sophisticated. But if Newton's ground had not been firm to begin with, Einstein would have fallen flat on his face.

Right and wrong are surprisingly *unscientific* ways of describing things. "The notion of absolute truth is shown to be in poor correspondence with the actual development of science," writes physicist David Bohm. "Scientific truths are better regarded as relationships holding in some limited domain."

New ideas expand, modify, and limit the old ideas—but rarely do they throw them out the window. For centuries, people argued over whether the wave theory or the particle theory of light was correct. But light turned out to be both: part wave and part particle. Both theories were right, but limited. A correct theory requires aspects of both.

Unfortunately, categorizing ideas as cleanly right or wrong retains immense philosophical appeal. No one likes being left in an intellectual purgatory. No wonder the slow evolution of scientific theories is usually perceived as a series of revolutionary coups. "Scientific revolutions are not *made* by scientists," says physicist Hendrik Casimir. "They are *declared* post factum, often by philosophers and historians of science . . . The gradual evolution of new theories will be regarded as revolutions by those who, believing in the unrestricted validity of a physical theory, make it the backbone of a whole philosophy."

A science teacher I know found it impossible to argue effectively in favor of evolution because the creationists in his class kept insisting that the "proof" that evolution was wrong lies in the fact that even its own supporters argue among themselves. Yet modifying a theory in light of new insights or discoveries hardly destroys it.

Right ideas are seeds that tend to flower into righter ideas, whereas wrong ideas are sterile and do not bear fruit. Right ideas have deep roots that often make surprising connections between seemingly unconnected things, and have an uncanny knack for turning up the unexpected. Once Newton got the right idea about gravity, he explained a great deal more than falling apples. And once Maxwell got the right idea about light, Hertz knew where to look for radio waves. Even the ether was right enough to clear the way for future discoveries. At least, it posed the right questions.

Wrong ideas, on the other hand, are just plain wrong. We know for a fact that the earth is round and not flat. Or do we? When you think about it, the difference between a round earth and a flat one is really one of perspective. The earth certainly seems flat enough when you walk around town. You can only see the curvature when you look from a broader perspective—as Erastothenes and Columbus did. Indeed, space-time itself only begins to look curved when your measurements cover a large enough territory. In the same way, quantum mechanics and relativity offer a larger perspective on classical physics, taking it into new and uncharted realms.

Wrong, in other words, more nearly means limited. It implies that something has been missed, that some part of nature has kept itself hidden beneath the surface. It does not imply that the person who is wrong is misguided. People do not say Lord Rutherford was wrong because he discovered the atomic nucleus only to insist that anyone who saw anything practical in its application was "talking moonshine." They recognize that "right" does not mean clairvoyant.

So of course Einstein was wrong. He could not resolve every unanswered riddle, or foresee every possible consequence of his own conclusions. He could not—any more than could Newton—claim to be all-seeing or all-knowing. People who do claim to be completely right about the fundamental nature of things are not in the business of science. Right and wrong in that sense are not questions of science. They are only matters of dogma. ▣