In Defense of Orthodoxy

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It is commonly believed that devotion to orthodoxy is a hindrance to scientific progress. Great scientific discoveries or breakthroughs are often attributed to mavericks and scientific outsiders who were willing to dispense with conventional wisdom and look at old problems in new ways. Although this "maverick theory" of scientific progress can account for some important scientific breakthroughs, most notably the discovery of continental drift by Alfred Wegener, it is by no means universally valid. Indeed, many great breakthroughs in science occurred not because scientists sought to overturn established principles but because they remained devoted to an orthodox theory despite considerable evidence against it.

"New Age" philosophers and proponents of pseudoscientific theories often invoke the "maverick theory" to defend or even justify their offbeat ideas. They dismiss critics of their exotic theories as close-minded pedants unwilling to entertain new and radical ideas. They love to remind us that great scientists such as Copernicus, Wegener, Galileo and Mendel were also ridiculed by the intellectual establishment. And they try to convince us that merely being criticized by established scientists somehow validates their ideas. Although the fallacy of such arguments is obvious, they all too often seem to achieve their aim. One way of countering this tactic is by citing examples of important discoveries that occurred within the scientific mainstream, discoveries that were not produced by mavericks.

Quantum mechanics is widely considered the most revolutionary breakthrough in the history of physics, even more important than Einstein's theories of relativity. In the popular imagination, quantum physics has become an exemplar of revolutionary science and of nature at its most mysterious and incomprehensible. Quantum physics is well known for its numerous mercurial concepts such as the Heisenberg Uncertainty Principle – the impossibility of measuring both the position and the momentum of a subatomic particle – as well as Bohr's Principle of Complementarity and the dual nature of light. Indeed, the term "quantum leap" has become so well entrenched in the modern lexicon that it even served as the title of a popular television show. But despite its reputation, quantum physics was not the product of maverick scientists or of outsiders bent on overthrowing classical physics. Rather, it emerged from a carefully designed research program undertaken at the turn of the century by Max Planck, a classically trained physicist, who, because of the unexpected results of his experiments, actually considered his research program to be a failure. More to the point, the most important discoveries underlying quantum physics were made because Planck remained slavishly devoted to classical physics and refused to abandon it despite the evidence arising from his own research.

Planck's work centered on an obscure phenomenon that only a physicist could love: "black-body radiation" – the electromagnetic radiation emitted by a non-luminescent source. The electromagnetic energy spectrum is a continuum of radiation characterized by different wavelengths: gamma rays and X-rays have short wavelengths and radio waves have long wavelengths. Visible light, bounded on the short wavelength side by ultraviolet radiation and on the long wavelength side by infrared radiation, falls within a very narrow range somewhere in the middle of the spectrum. Because the electromagnetic spectrum is continuous, everyone in 1900, including Max Planck, assumed that infinitesimally small changes in wavelength would yield proportionately small changes in energy output, with no lower limit. Yet instead of producing proportional changes in energy output, Planck's experiments showed that the energy generated by gradual changes in black-body radiation occurred in a step-wise fashion as discrete units or quanta. To Planck, these findings were entirely unacceptable because they contradicted everything he knew, or thought he knew, about electromagnetism. He refused to let the facts speak for themselves. Accordingly, he decided that his experiments must be flawed and he worked diligently to improve his instruments and methods hoping to discover what went wrong.

Max Planck may have been the most reluctant revolutionary in the history of science. Although he eventually published his results, Planck remained convinced for several years that his data were erroneous. When he finally came to believe his own experiments, Planck became genuinely distressed by the fact that classical physics, which he admired if not loved, had been overthrown by his own research. It took Planck years to come to grips emotionally with his great discovery. Conventional wisdom tells us that the young are the most open-minded and the old the most conservative. But for Planck, it was the other way around. As a young man, Planck devotion to classical physics was practically religious. It was a much older Max Planck who would remark that new ideas succeed not because of their own value but because the older generation of scientists dies off.

What lessons can we learn from this story? First, Planck never doubted that the classical theory of electromagnetism was correct. Accordingly, when his experimental results clashed with theory, he assumed that his experiments were flawed and he therefore strove to improve his methods and techniques. He never would have undertaken these improvements had he not been convinced that the theory was right and his results wrong. (Incidentally, the same thing happened to Edward Michelson whose experiments demonstrating the constancy of the speed of light became the empirical foundation of Einstein's Special Theory of Relativity. Michelson could never bring himself to believe his results and therefore spent the second half of his life trying to "fix" his apparatus.)

Second, it was because Planck was loath to abandon the orthodox theory that the scientific community stood up and took notice when he finally published his results. Had Planck been tagged as a maverick, or as one who jumped on scientific bandwagons, other scientists may have simply ignored his work. In short, Planck was able to become a revolutionary because he was so cautious and conservative. Indeed, even after the scientific community had acclaimed his discovery, Planck himself never fully believed it. He was one of the last of his generation to accept the reality of the quantum. Instead, he continued to search for "what went wrong" with his experiments. This only served to heighten his credibility and further convince his peers of the validity of his discoveries.

Quantum physics has come to symbolize everything that is revolutionary in science. It is therefore ironic that quantum physics originated because a classical physicist investigating an obscure problem refused to believe the results of his own experiments. Although psuedoscientists and New Age philosophers have appropriated it, quantum physics was the brainchild not of a radical maverick but of a mainstream conservative.