FROM THE EDITORS' DESK

From the Editor's Desk: on the Nature of Scientific Progress

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In the twelfth century, John of Salisbury wrote "we are like dwarfs sitting on the shoulders of giants. We see more...not because our sight is superior or because we are taller…but because they raise us up." In 1676, Newton wrote, "If I have seen a little further it is by standing on the shoulders of giants." This prompts the question of whether scientific advancement is incremental, we progress by building on what previous scientists have done or whether it's revolutionary, we progress by remarkable inspiration. The latter is the romantic notion of the scientist, working alone in darkness until a sudden flash of insight yields profound understanding. From the outside, it can often appear that this is what happens. But, in reality, usually an aberration in existing theory prompts someone to look at the problem from a different angle or with new tools; they use their understanding of existing theory to advance knowledge. Sometimes, that advancement is dramatic and provides the foundation for subsequent generations of scientists. For example, Newton, as a mathematician and a physicist, was keen to explain physical phenomenon. Newton was well grounded in the works of Copernicus, Galileo, Descartes, and Keppler and was troubled by empiric observations that demonstrated that Keppler's rules for planetary motion yielded inaccurate results; by examining physical phenomena and applying his deep understanding of mathematics, Newton developed new physical principles, grounded in empirical observation that comprised his seminal work, Philosophiae Naturalis Principia Mathematica. The truth is not quite as good a story as an apple falling from the tree prompting Newton to ponder on the nature of gravity. In order to help understand his new laws of motion, Newton developed a new form of mathematics, calculus (an honor he shares with Leibniz who independently developed it at the same time), both men were aware of the work of earlier mathematicians (such as Descartes) who had discussed the concept of the derivative and Newton himself wrote that calculus was informed by Pierre de Fermat's "way of drawing tangents." While Newton's genius advanced both physics and mathematics considerably, his work was built, as he put it, "on the shoulders of giants."

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Einstein recognized that Newtonian mechanics did not adequately explain electromagnetic fields; there were conflicts between Maxwell's equations about the laws of electricity and magnetism and Newtonian mechanics. Newtonian mechanics also sometimes resulted in paradoxical results, particularly when applied to objects moved at very high speeds. His reconciliation of the two resulted in his first breakthrough, the theory of special relativity. While the concept of gravity was central to Newton's three laws of motion and Newton explained the empirical effect of gravity, he did not explain its cause. In Einstein's theory of general relativity, gravity was shown to be caused by a distortion in space-time continuum; this second theory also partially resulted from Einstein's dissatisfaction with the behavior of inertia in his own theory of special relativity. Like Newton, Einstein moved his field forward dramatically, but also like Newton, he was well grounded in the mathematics and physical models of the universe of the time. He spent the rest of his life trying to find theories to unify general relativity with quantum physics. No doubt, eventually another genius will recognize incongruities in the two, will examine the problem from a different perspective, and will develop a radical new way of explaining reality.

Watson and Cricks were aware of Todd's work showing that the DNA backbone contained deoxyribose sugar and phosphate; that Chargraff had already demonstrated the fixed ratios of adenine/guanine/cytosine and thymine; that Pauling had discovered that a single-stranded alpha helix was the structure of many proteins. They had copies of Rosalind Franklin's high-resolution X-ray images that suggested a helical shape, and shared an office with an American chemist, Jerry Donohue, who pointed out that their cardboard models for thymine and guanine, though based on textbooks of chemistry at the time, were incorrect. They took these varying pieces of the puzzle and developed a model for DNA, a model that has subsequently had a dramatic impact on medicine. While its importance cannot be overstated, the "discovery" was not a blinding flash of insight, but an example of building on existent knowledge.

History is replete with examples of individuals who made significant contributions to understanding and advanced science dramatically, for example, Marie Curie and Linus Pauling are the only two scientists who have received Nobel prizes in two different fields; careful examination of their body of work demonstrates that both stood on the shoulders of others and that their unique contribution was due to an ability to look at problems with fresh perspectives and a willingness to question and throw out established paradigms. The advancement they made was "incremental," just significantly larger than most "incremental" work.

It is disingenuous when grant writers suggest that they are looking to fund radical ideas rather than incremental work. "Radical" ideas spring from incremental work, from empirical work by scientists that focus on resolving aberrations, and looking at old problems using new approaches. Radical ideas can only spring from a solid foundation of incremental work; the way forward has to be grounded in the knowledge to that point in time. Sudden insights do occur, but they ocur in minds that have been primed by rigorous training and because they allow their minds to take them somewhere new. Genius occurs when someone pulls the pieces together in a new way that provides a better model of how reality works. For example, Jocelyn Bell discovered pulsars in 1967 as a graduate student working with Anthony Hewish, her mentor, while making radio observations of the universe. She was using a new tool to map the universe when she noticed that some of the radio sounds were "pulsing." Explaining what pulsars were and how they worked significantly advanced astrophysics.

At JGIM, if writers submit a manuscript that provides profound new understanding, we would love to publish it; we only hope that we will have the ability to recognize it for what it is and not reject it as heresy. It is in this spirit that JGIM welcomes work that is "incremental." Hopefully, a sufficiently robust description of a known phenomenon will yield insight, theory, and interventions that will push knowledge forward. We encourage young scientists to question dogma, to ask "what if" and to look at the big problems of the day with fresh perspectives and with new tools. As you advance scientific knowledge, you will do so, standing on the shoulders of giants.

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