Readers' perspectives highlight vagaries of progress in science

Charles Day's article "A reporter's look at the progress of science" (PHYSICS TODAY, December 2013, page 35) provided a fascinating look at how scientific research does or doesn't stand up over time. Some cutting-edge research thought to be a shoo-in for the next big thing ended up going nowhere, while other investigations that appeared interesting but impractical turned out to be extremely useful. Two of the points Day makes at the end of the article are worth repeating:

- The time scale for research to bear fruit is unpredictable and often long.
- Because of that uncertainty, basic research is best undertaken by university (and I might add, government) labs, because the returns are just too risky for industry.

My experience on shale gas is a case in point. Back in the 1980s, I was working as a geology contractor for the US Department of Energy on the Eastern Gas Shales Project, which was attempting to develop new, domestic sources of natural gas in response to an oil embargo against the US.[1] Many different gas shales were investigated, and a great deal of effort and money were expended to develop resource assessments and new hydraulic fracturing technology to recover economical amounts of gas. Despite a few successes, most attempts were failures,[2] and the program was officially shut down in the early 1990s. In a paper I published describing some laboratory studies on shale core samples,[3] I mentioned that at least one of those formations, the Marcellus, might have significantly higher gas potential than official estimates indicated. The results went largely unnoticed at the time because the economical extraction of shale gas was not yet possible.

Twenty-five years later, technological advances in horizontal drilling and staged hydraulic fracturing have made shale gas a significant contributor to domestic energy supplies in the US.[4] The project even got mentioned by President Obama in his 2012 State of the Union address, when he said, "It was public research dollars, over the course of 30 years, that helped develop the technologies to extract all this natural gas out of shale rock—reminding us that government support is critical in helping businesses get new energy ideas off the ground."

The president's statement reinforces another important point that Day makes in his article: The funding of short-term, targeted research at the expense of basic research could negatively affect the development of unforeseen and promising applications. How many basic research projects today, from astronomy and space to energy and the environment, are being shortchanged by politicians concerned only about budget cutting and reelection? When basic research is not funded, we don't even know what it is that we don't know.

References

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■ **The article by Charles Day** about the outcome of scientific developments 10 years later caught my attention. Having worked in optical storage from the 1990s until my retirement a few years ago, I could closely watch the rise and decline of that industry. I would offer a somewhat different perspective about three-dimensional storage than that presented in the article.

Ten years ago 3D optical storage still looked quite promising, in particular because it was assumed that magnetic storage would run into the so-called superparamagnetic limit. Several companies thought that with optical and magneto-optical storage, the magnetic hard disk could be overtaken in price and capacity, but most of the companies trying to develop the 3D technology went bankrupt after spending hundreds of millions of dollars. And Day's example, Call/Recall, never put a device on the market as far as I know.

My comments are not meant to disparage optical technology; developments in hard-disk storage capacity were just much faster than the optical-disk industry anticipated. At present, the storage density of hard disks is about 1 terabit per square inch (an ugly unit, but in common use), an order of magnitude higher than anticipated 10 years ago, and that density was achieved thanks to the application of clever physics. What we can learn from it: Not every good idea will make a fortune, particularly when one is fighting big companies like those in the hard-disk industry.

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Historical notes on the expanding universe

The article "Measuring the Hubble constant" by Mario Livio and Adam Riess (PHYSICS TODAY, October 2013, page 41) reviewed studies of the expanding universe from the 1920s to the present. Although the history of the subject underwent considerable compression to fit the length of a magazine article, we think it may leave a misleading impression of some of the key steps to our current understanding. We therefore offer the following clarifications.

Most significantly, papers by Arthur Eddington and by Willem de Sitter