adding authors. For example, the author list might include a friend or colleague of the lead scientist, an indirect financial supporter, or a contractor's technical representative. No author would ever discuss this matter publicly.

Many problems of irrelevant authorship arise with the journals themselves. Although all journals provide manuscript preparation guidelines that include some type of warning against "double publishing"—that is, repeating significant portions in another paper—only a few ask the contact author to confirm that the listed authors all contributed to the paper. Both *Science* and *Cell*, for example, do ask that all authors of an accepted paper "state their contribution to the paper," but they do not list any criteria for actual authorship, nor whether specific types of contributors should be relegated to an acknowledgement section.

A friend of mine, a former Bell Labs physicist, defended the inclusion of his name to the end of the author queue of each paper published by his students though many of the ideas were entirely his. His reasoning was that "the graduate student should always have top billing so that his career can be advanced." Each author's personal list of "first author" publications was certainly increased by my friend's unselfish generosity. It remained up to the reader to figure out whose ideas were actually being presented.

Whereas in former days, a PhD candidate during graduate school would prepare only a single paper based entirely on his or her work, the trend today is to leave graduate school with a raft of publications, considered essential for a job or postdoctoral appointment. Unfortunately, the time spent getting published often seems to be at the expense of obtaining the greater in-depth knowledge of the science itself. In the hundreds of interviews and CV reviews I have conducted over the past 25 years, I have found the presence of the basic building blocks of the science decreasing with each passing year. When a recent PhD in a physical science said that helium formed diatomic molecules, I knew we were in trouble!

The patent data shown in the table are of particular interest. The percentages for two or three inventors per invention for the most recently issued patents do not vary greatly from the percentages for 46 years earlier. Here's why: If a listed inventor, or "innovator," did not actually contribute to the invention, the issued patent will be void if such deception is ever discovered. The patents most easily challenged in court may well be those with extraordinary numbers of inventors.

Here's a final Fermi-inspired question: How many of today's tenured faculty members or research directors have never written a single-author paper?

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Letters

Radioactive toothpaste and reversed helicity

Maurice Goldhaber, who died in May 2011, shortly after his 100th birthday (PHYSICS TODAY, May 2011, page 40, and October 2011, page 65), was not only a great nuclear and particle physicist but also a witty and engaging speaker. Many years ago, when someone asked him if he was yet retired from Brookhaven National Laboratory, he said, "How can I be re-tired; I am not even tired yet."

On the occasion of the 50th anniversary of his mentor James Chadwick's 1932 discovery of the neutron, Goldhaber gave talks about the early days of nuclear physics. When he spoke at the University of Michigan, someone drew his attention to a radioactive toothpaste, named Doramad, that was produced in Germany from the 1920s to the 1940s. At a later talk I attended at Duke University, he showed a poster advertising Doramad. I told him that the toothpaste had been manufactured as a byproduct by the industrial firm Auergesellschaft near Berlin; my father, an organic chemist, worked there until our emigration from Nazi Germany in 1935. During my entire childhood I brushed my teeth with Doramad!

Naturally occurring thorium has a half-life of 14 billion years and emits 4-MeV alpha particles—a very mild activity. It was extracted by my father's company from monazite sand, imported from India primarily as a source of rare-earth elements. Those rare-earth materials were used by the company's founder, Austrian scientist Carl Auer von Welsbach, to impregnate the mantles in gas lanterns, so they would shine brightly, and for a number of other products, including tinted sunglasses

and dyes. As one of the companies involved in the production of nuclear fuel for potential German weapons, the Auergesellschaft also figured in the report of the Alsos Mission, led by Goldhaber's colleague Samuel Goudsmit. After the war, the company was taken over by Degussa.

The health benefits of Doramad were touted on the toothpaste tube: "Its radioactive radiation increases the defenses of teeth and gums. The cells are loaded with new life energy, the bacteria are hindered in their destroying effect. This explains the excellent prophylaxis and healing process with gingival diseases. It gently polishes the dental enamel so it turns white and shiny. Prevents dental calculus."[1]

Maurice Goldhaber never forgot that I grew up using radioactive toothpaste.

Reference

1. http://www.orau.org/ptp/collection/quackcures/toothpaste.htm.

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■ **Alfred Goldhaber and Maurice Goldhaber** presented a convincing case for not trying to observe helicity reversal in relativistic neutrinos (PHYSICS TODAY, May 2011, page 40). However, I was disappointed that they did not discuss the nonrelativistic Big Bang relic neutrinos. Their low energy precludes detecting them today, but their natural abundance and the existence of clever people make me suspect observation is possible in the near future. Helicity reversal effects may provide a key for this elusive search.

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■ **Goldhaber replies to Esterling:** As Bob Esterling implies, the challenge here is not producing reversed helicity but *observing* it: Reaction rates are tiny because of low neutrino density and small cross sections. Absent an independent calibration of neutrino density, there would be no characteristic signal of helicity reversal for Dirac neutrinos. If production of relic Majorana neutrinos were associated mostly with matter rather than antimatter, neutrino helicity equipartition still could lead to nearly equal production of electrons and positrons—a striking signal *if* it could be seen.

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Preserving quantum nondemolition

A a new concept appeared in the literature of quantum physics in the 1980s, under the name of "quantum nondemolition [QND] measurements."[1] The idea quickly became very popular, and it is now used in many contexts, with a wide agreement about its meaning and usefulness.[2–4]

However, Christopher Monroe argued in a letter to PHYSICS TODAY (January 2011, page 8) that QND measurements are a useless concept because they are just standard quantum measurements, as defined, for example, by John von Neumann at the dawn of quantum mechanics. Here I argue that this view is too schematic, to say the least.

Measuring the polarization of a photon—a representative quantum measurement—typically destroys the photon. The simple but crucial question addressed by QND measurements is the following: Is it possible to perform a quantum measurement in such a way that the system will continue to exist even though its state may be altered by the measurement that has been performed? The answer is yes, but one has then to use an indirect measurement rather than a direct one, and that is exactly where QND measurements come into play[1,2]—in quite a useful way.

For such a measurement to work, the trick is to use an auxiliary quantum system, usually called the "meter," and to devise the system–meter interaction in such a way that entanglement is created between the two. Then a direct measurement performed *on the meter* will result in a projective measurement on the system. Therefore, the system will evolve into a post-measurement state as expected, but it will not be demolished; hence the name quantum nondemolition.

The crucial role of the meter was already pointed out by von Neumann in the 1930s, but QND gives conditions for the measurement chain—entanglement, direct meter measurement, projecting the system onto the final state—to work properly.[1] For instance, the interaction Hamiltonian between the system and the meter should commute with the system observable to be measured. In addition, various QND criteria have been introduced to characterize the quality of such measurements.[2] Those criteria are useful tools to quantify the success of a real QND measurement; they are actually quite flexible and may be adapted to any given experimental situation, with continuous[2] or discrete[3,4] observables.