

Turner replies: The history of ideas is rarely just about equations and error bars; people and their interactions are equally important. Additional perspectives add to the picture, and I thank my colleagues for taking time to write. I add this to their insights.

In recounting the standard lore that the steady-state theory motivated the seminal 1957 paper by Geoffrey Burbidge, Margaret Burbidge, William Fowler, and Fred Hoyle (BBFH), which I learned from Helge Kragh's *Cosmology and Controversy* (Princeton University Press, 1999), I did not mean to imply that Hoyle came to nucleosynthesis through cosmology. The origin of the elements was the problem du jour in the 1940s, and many of the leading nuclear and astrotheorists worked on it, including Hoyle. However, BBFH has 995 citations versus 91 for his 1946 paper for a reason: The theory is laid out in full detail in BBFH, while Hoyle's initial foray covers one small aspect of it.

There is no doubt that nucleosynthesis motivated George Gamow's thinking about cosmology; however, a similar case is hard to make for the steady state. A re-read of the papers in David Arnett and George Wallerstein's reference 5 shows that the driving ideas are the perfect cosmological principle and continuous creation of matter, with no mention of the problem of the origin of the elements (or Hoyle's 1946 paper).

I regret not having the space to discuss the missed opportunity for Ralph Alpher and Robert Herman to benefit from the insightful criticism they received and to get Big Bang nucleosynthesis right. In their last paper on the subject, they set up the correct equations for the neutron abundance and were one step away from predicting the large amount of helium-4 produced in the Big Bang, but they didn't;¹ they stuck with their neutron-capture model to the end.

Finally, other than the fact that the steady state helped to stir early interest in cosmology, I find little to connect it with precision cosmology. True, it is a strong theory in the sense of Karl Popper—it is easy to falsify. For that reason it was falsified quickly, and interest in cosmology died down again until the discovery of the cosmic microwave background.

Reference

1. R. A. Alpher, J. W. Follin Jr, R. C. Herman, *Phys. Rev.* **92**, 1347 (1953).

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Calming the waters around Santa Barbara

As a member of the American Geophysical Union, I receive *PHYSICS TODAY*. The March 2009 issue (page 52) contains James Fleming's review of *The Great Warming: Climate Change and the Rise and Fall of Civilizations* by Brian Fagan. I have not had an opportunity to read the book, but the review was quite interesting.

Wearing my other hat as water commissioner of the City of Santa Barbara, I must question the review's second-to-last paragraph, which cites the "water authority in [Fagan's] home city of Santa Barbara as it pursues a diversified plan of stockpiling, looting, recycling, and desalinating its own liquid gold—seawater." In the past we have been accused of acts such as dyeing our lawns green and being equivalent to "Nazi Germany," but this is the first I have heard of our being looters.

Although what Fleming wrote may be true of much of California, it is *not* applicable to the City of Santa Barbara, where we have worked hard for years and with good success to establish water resources within our local control. The city's water supply is sustainable and, in fact, only uses imported water at a contractually required minimum level.

The city is undergoing a state environmental review of long-term planning, in which our water supply and its dependability are being scrutinized, so having that kind of term appear in print, in any publication, concerns me. If we could get "unaccused" of "looting," I would be very appreciative.

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Fleming replies: The term "looting" was used by Brian Fagan on page 238 of his book. He wrote: "Many of us live off looted [water] supplies, brought by aqueduct from the Owens watershed, culled from the Colorado River, and taken from artesian wells, aquifers that will one day run dry."

In my review I connected Fagan's reflections on modern-day drought to his own residence in Santa Barbara. I noted from the webpage of the County of Santa Barbara Public Works water supply overview that "the County's residents obtain their potable water from several sources: groundwater withdrawal, storm runoff collected in reser-

voir systems, the State Water Project, recycled water and desalination."

I am sure Barry Keller runs a tight ship and he and his colleagues are doing everything possible to hydrate an area with less-than-sufficient rainfall. However, since the city draws part of its water from Lake Oroville Reservoir, hundreds of miles north and not part of the Santa Barbara watershed, I applied Fagan's term to the city to highlight several points:

► The "silent elephant" of drought Fagan refers to stalks the author's hometown, and has for the past two years.

► The large-scale situation in Santa Barbara and much of the American West is not sustainable.

► Well-to-do cities with more resources may be able to stave off drought longer than poorer areas.

I applaud the city for its water efficiency improvement efforts, yet much more needs to be done.

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Parallel issues in nanotech, climate science

The feature article on ethical, legal, and social issues (ELSI) in nanotechnology (*PHYSICS TODAY*, October 2008, page 38) struck me as extremely enlightening. I liked the balanced tone of Cyrus Mody's text, including the application of the term "folk theory" to all sides. Other fields of science, and science policymakers, would probably do well to learn from the example of ELSI nanotechnology research.

In my own field, climate research, something keeps astonishing me. Many people I talk to still believe that there is a debate about the existence of the greenhouse effect due to carbon dioxide. But I remember seeing the effect demonstrated on TV, notably by Pieter Tans, a leading researcher from the Earth System Research Laboratory of the National Oceanic and Atmospheric Administration. Mody's article made me realize that the lack of belief in fundamental physics laws might not have to do with a lack of understanding or education. Disbelief might rather be the result of distrust—the same distrust Mody mentions toward genetically modified organisms and nanotechnology. In the case of the greenhouse effect, people are wary of the complicated cli-

mate models that only a few experts understand.

The contribution of climate science to society is not through development of mitigation technologies such as renewable energy, but through development of tools that allow better anticipation of what the future might bring (see how I avoid the term "prediction"). Climate science by itself will not lead to fewer greenhouse gases in the atmosphere. The mitigation of climate change is a job that policymakers and the general public need to put into action. However, given this limited but distinctive role of climate research, it is all the more important that the public have faith in the scientists who use those predictive tools. A prophet nobody will listen to is useless. But these are just my own observations; Mody's article convinced me that it is possible to do systematic and objective research that will pinpoint the misunderstandings and gaps in perception between scientists and the public.

What ultimately persuaded me that there is a parallel case between nanotechnology and climate science was when Mody mentioned Michael Crichton's anti-nanotech novel *Prey* (Harper, 2008) and reminded me of the contro-

versy surrounding his *State of Fear* (Avon, 2005).

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Conferences are avenue for getting published

The difficulty in getting papers accepted by journal editors is noted in Howard Greyber's letter (PHYSICS TODAY, July 2008, page 8). But that is the reason we have conferences and symposia. A conference paper can present opinions based on observations and analysis; it can challenge conventional wisdom and suggest new ideas and directions.

My last paper before I retired was presented at an international conference. I reported my analysis of observations with a suggestion as to the cause of the results. The meeting room was packed, and I received several compliments. That paper would never have been accepted by a journal editor. I would have been told that my results

were speculative and that I needed to do more research—that phrase, which disregards the reality of funding, seems to be a favorite phrase of editors. The paper was published in the conference proceedings.

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Knives determine ages of humans

I would like to correct one small but common error in the article by Graham Fleming and Mark Ratner (PHYSICS TODAY, July 2008, page 28). The terms "Stone Age," "Bronze Age," and "Iron Age" do not "refer to humans' increasing mastery over those materials." They have a specific meaning: the material most commonly used for making knives during the period in question. Today we are still firmly in the Stainless Steel Age, but there is evidence that we may be moving toward the Plastic Age—especially in airports.

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