and Peter D. Blair ignore a critical factor in the energy equation: the US population. Energy impact equals total population times energy impact per person. In a nine-page article there is not a single sentence that even mentions exponential population growth (currently 1% a year in the US and nearly 2% a year worldwide). In California, for example, the population doubling time is only 30 years. At such a pace, by the end of the 21st century California's population will equal the present population of the entire US. In the face of such growth, even the most enlightened energy policies will fail.

To requote the ancient Chinese saying quoted by Gibbons and Blair: "If you do not change your direction, you are very likely to end up where you are heading."

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Has Psychokinesis Met Science's Measure?

Philip Anderson (October 1991, page 146) says, "[W]ithin my competence as a theorist . . . physics as it is practiced, and specifically precise mensuration, is not compatible with [Robert G.] Jahn's claims" (that is, claims of the existence of psychokinesis). Anderson's idea is, no doubt, that if mind affected matter, this would disturb the results of laboratory experiments. An equivalent argument applied to chemistry would lead to the following: "Chemistry as it is practiced rests on the principle of the invariance of atoms, and so is incompatible with the idea that elements can be transmuted." The latter conclusion is not, I suspect, one whose truth Anderson would be as eager to assert in the columns of PHYSICS TODAY as the one quoted above.

Equally suspect is Anderson's second argument designed to persuade his readers to disregard Jahn's results, that is, Anderson's reference to the use of Bayesian statistical methods. I am willing to accept his claim that the use of such methods would make Jahn's numbers less favorable. But unfortunately the argument stops short at that point; Anderson does not inform us what the result would be if Bayesian methods were applied, and especially does not tell us the answer to the crucial question, Do Jahn's results remain significant if this analysis is done, or not? Why this reticence?

For Anderson and for other skeptics, belief in the paranormal is irrational. But very often skeptics, in their uncritical attempts to persuade others of their point of view, fall back on inadequate arguments themselves. Those examined above provide clear illustrations.

What, then, about irrationality? Is it irrational to assert that under special conditions psychokinesis can occur, although most of the time it does not? No more irrational, I think, than to assert that while for most people walking on a tightrope across a ravine is an impossible task, it may nevertheless be possible under sufficiently favorable conditions (for example, with suitable dedication, training and concentration); again, I suggest, no more irrational than to assert that while an amount of uranium of mass on the order of a kilogram generates spontaneously an amount of heat requiring sensitive instruments to detect at all, a suitably larger amount can generate enough energy to provide power for a large city. (Further, as one of my collaborators, social anthropologist and parapsychologist Marilyn Schlitz, of the Mind Science Foundation, San Antonio, Texas, has noted, there exist analogies that may be more directly relevant in the field of social systems, an example being the way under special conditions in a society particular ideas that individuals have may spread widely, although in the vast majority of cases the effects of individuals' ideas remain localized close to their sources.) Finally, is it really irrational or unscientific, as some skeptics seem to think, to suggest that a relationship may exist between John Bell's nonlocal connections and telepathy? In this regard, I wish to draw attention to the publication in a reputable physics journal of a paper[1] that gives a rational account of how the two could be related and of why the latter kind of coupling should be possible in biosystems but not under the conditions of the normal physics experiment.

I hope that some readers may by now have picked up a message that skeptics might prefer they did not pick up: that psychic phenomena may be both consistent with physics and conceivable in rational terms; and, as a corollary, that many of the experiments on the paranormal may be measuring genuine phenomena that it should be the goal of science to try to understand.

Finally, I should like to recommend to readers not wanting to be caught in a paradigm that may be outliving its relevance to our understanding of the natural world that they read David Bohm's elegant discussion of his concept "soma-significance."[2]

References

1. B. D. Josephson, F. Pallikari-Viras, Found. Phys. **21**, 197 (1991).
2. D. Bohm, in *The Search for Meaning*, P. Pylkkänen, ed., Crucible, Wellingborough, Northants, England (1989), p. 43.

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ANDERSON REPLIES: The non sequitur in Brian's first paragraph gives us an object lesson in the scientific method. Artificial transmutation of elements was accepted almost instantly after the first observation, as the history of science goes, because the effects were reliably predictable and totally reproducible. I am not aware of any psychokinetic effects that have been reliably predicted in advance as to nature, sign and magnitude.

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How Tiny Bubbles Can Cause Big Booms

I read with interest the news story "Light Comes from Ultrasonic Cavitation in Picosecond Pulses," by Barbara Goss Levi (November 1991, page 17), which describes, among other things, the generation of high temperatures during the collapse of cavitation bubbles and how these high temperatures have been thought to produce metallic glass when iron pentacarbonyl is irradiated with ultrasound. One area of considerable practical interest not mentioned in the story or in the references is the sensitization of explosives by microscopic bubbles.[1] Over two decades ago, Frank Philip Bowden and I showed, using high-speed photography, that when a microscopic bubble is rapidly compressed onto an explosive crystal, it can cause the initiation of an explosion in less than a microsecond.[2] The crystal acts as a fast-response thermometer: As soon as its temperature is high enough, an explosion results. Some scientists working in the field of explosives have argued, however, that not enough heat transfer can occur from the compressed gas to an adjacent surface in such a short time.[3] In view of the formation of metallic glass by cavitation, the work mentioned above and some other work on the sensitivity of explosives,[4] it appears quite clear that the heat

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transfer from the collapsing bubble occurs very rapidly and with high efficiency.

References

1. M. M. Chaudhri, L.-A. Almgren, A. Persson, in *Proc. Fifteenth Int. Congress on High-Speed Photography and Photonics*, SPIE Proc. 348, L. L. Endelman, ed., SPIE, Bellingham, Wash. (1983), p. 388.
2. F. P. Bowden, M. M. Chaudhri, Nature **220**, 690 (1968).
3. A. W. Campbell, W. C. Davis, J. R. Travis, Phys. Fluids **4**, 498 (1961).
4. M. M. Chaudhri, in *Proc. Ninth Symp. (Int.) on Detonation*, Office of the Chief of Naval Research, Arlington, Va. (1989), p. 857.

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I Get No Thick from Champagne

The paper by Neil E. Shafer and Richard N. Zare (October 1991, page 48) was a pleasure for somebody like me, who has used for years examples from everyday life such as the formation of bubbles in beer to teach transport phenomena to engineering students. However, my pedagogical form of the problem is slightly different from the issues addressed by Shafer and Zare.

The question I ask my students to consider is the following: Why is the foam formed in a beer glass so stable that one may actually cut it with a knife, while the bubbles that form in a champagne glass result in a quickly subsiding foam? Champagne (one hopes) has a slightly higher alcohol content, but the strongest beers one may buy in Europe are right up there with the lightest champagnes. Thus the difference in alcohol content, though possibly significant for explaining the widespread preference for champagne over beer, cannot be invoked as the basic reason for the different foam behavior. Shafer and Zare's initial argument about the equilibrium between the gaseous CO_2 under the cap and the liquid being upset when a beer bottle is opened also doesn't furnish any clue. Granted, a champagne bottle gets flamboyantly uncorked rather than absent-mindedly opened, but the physical effect is just the same: Pressure is suddenly relieved, as the fizz accompanying the beer bottle opening and the pop accompanying the champagne bottle uncorking reveal. The pop, of course, is much more spectacular than the fizz—but the difference in foam behavior is still left unexplained.

So wherein lies the difference? I use this problem to illustrate the fact that phenomena dominated by interfacial forces are tricky. The difference in foam behavior is related to the stability of the thin films between the bubbles in foam; unstable films collapse, the bubbles coalesce, and the foam subsides. Film stability is influenced by the Marangoni effect:[1] When mass transfer is taking place (in this case, when CO_2 is being desorbed to the gas phase), the thin films are or are not stable depending on the *sign* of the derivative of surface tension with respect to concentration. The thinnest regions of the films between adjacent bubbles are the ones with the lowest CO_2 concentration; hence if the derivative is positive, the surface tension is locally the lowest, resulting in an unstable film, and vice versa.

The sign of the derivative may well be influenced by the presence of trace components (for instance, proteins coming from the malted barley in beer, or even, God forbid, surfactants added to second-rate beers to increase head retention). Such trace components, to the general satisfaction of champagne drinkers and to the partial justification of the ethics of champagne manufacturers in establishing the prices of their wares, may indeed be as important to foam behavior as they are to taste.

Reference

1. C. Marangoni, Nuovo Cimento, Ser. 2 **5/6**, 239 (1872).

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Textbook Authors, Rewrite Old Wrongs

Your special issue on pre-college education (September 1991) discusses many new programs for improving physics teaching but doesn't make much evaluation of the existing programs and how they can be improved within existing frameworks—for example, books distributed by major publishers.

The involvement of professional physicists and astronomers has led to great advances in junior high school science texts in recent years. As an astrophysicist, for example, I became involved a dozen years ago with *Scott, Foresman Physical Science* and *Scott, Foresman Earth Science* (the latter includes much astronomy). Though we professional scientists don't have free rein in determining the content of junior high texts, and overlapping state requirements must be met, we were able to make our books much more accurate, up to date and interesting than previous junior high texts in wide use. It was shocking how inaccurate and how badly explained much of the existing material I looked at was; the content of junior high books just shouldn't be left to junior high and high school teachers and to editors alone, since they apparently don't understand the material well enough to explain it clearly. The junior high books led to the elementary school series *Discover Science*, which is also much more interesting and accurate than previous texts on that level.

One mustn't ignore the mainstream just because some much smaller project may be flashier. I have done what I can to add clear explanations of interesting material to junior high texts, and I hope that many other scientists can join the good fight. Further, if we all pressured local and state school boards to make accuracy (instead of merely readability) a requirement, the next generation of texts would be helped.

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Let *PRL* Readers Review the Referees

Richard Greene (January, page 96) complains that the "uneven, subjective nature of the referee process" makes publication of a paper in *Physical Review Letters* an unreliable indicator of research quality. Since promotions and grants often depend on publication success in *PRL*, many authors feel cheated when their work is rejected by that journal while similar (or possibly inferior) work is accepted. Greene therefore proposes abolishing *PRL*, while the journal's editors respond that it serves its purpose. We believe both he and the editors have missed an obvious solution: Let the readers referee the referees!

A simple reader response page inserted into each issue would encourage feedback to the editors, referees and authors. Readers could rapidly check off "Yes" or "No" to three easy questions on each article: "Did you read this Letter?" "Was it of sufficient importance and quality to warrant rapid dissemination in *PRL*?"