be able to contribute something to that field as well. The split between small and big science is inevitably a source of tension. It is important that researchers in big collaborations working on very large projects and those on smaller-scale efforts support each other. In my department, it is not uncommon to find, for example, our high-energy lab lending some of its resources to research in condensed matter (including soft condensed matter), and to find condensed matter physicists providing advice on detectors and detection strategies. But the exchange could be better.

As for hiring, when we serve on search committees in others' subfields, we must often defer to colleagues, but I find that we usually have enough in common to exchange useful advice. A candidate search can be an opportunity to learn about what is interesting to our colleagues.

Nagel does not mention another field that has altered the physics landscape during the past decade. When I was a student, astrophysics was peripheral and cosmology disreputable. Today, many physicists, both theorists and experimentalists, from other subfields are spending much of their time on these subjects.

Cosmology and astrophysics highlight the issue of reductionism. The two fields are not exactly reductionist, but neither are they simply emergent. They are phenomenological in the most exciting sense. We are finding that the data fit into a fantastic picture. Cosmologists have used an impressive array of techniques from various fields to attack and apparently solve the classic problem of galaxy formation. Yet we don't yet know the physical laws that account for dark matter, dark energy, inflation, and the very origin and nature of the universe. The reductionists, both theorists and experimentalists, are attacking these questions vigorously.

In the end, Nagel's article gives me some hope for optimism. I, too, could list what I find to be the burning questions, and there would be a surprising amount of overlap. The question Nagel mentions of systems far from equilibrium arises frequently in particle physics and cosmology. Most recently it has been raised by the discovery—by astronomers, cosmologists, and astrophysicists—of a nonzero cosmological constant. Particle physicists and astrophysicists are proposing that these questions be studied further, using technologies developed in part by condensed matter physicists. So, while we face many challenges, ours remains a rich and exciting field.

Michael Dine
(dine@scipp.ucsc.edu)
University of California
Santa Cruz

Sidney Nagel claims that the goal of physics to find the basic underlying laws of nature has slowly been eroded—particularly in the US—since the demise of the Superconducting Super Collider.

The crash of a few commercial giants indeed depresses the stock market, but physics is not a stock market! Cancellation of the SSC cannot be used to define the vitality of the field. The edifices of particle physics still stand and are used by our cosmology colleagues with great benefit to our worldview. Inflationary theory of the Big Bang has its origins in the theories put forward by Peter Higgs about the sought-after Higgs particle. It is most likely that particle physicists will find dark matter, if indeed it exists in particle form. The symbiotic relationship between particle physicists and cosmologists is yielding a most active

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research domain nowadays.

Otherwise, I find Nagel's excellent analysis a very valuable admonition to all physicists that they keep in mind the unity of physics and not be distracted by petty interdisciplinary arguments.

Drasko Jovanovic
(draskoj@aol.com)
Fermi National Accelerator Laboratory
Batavia, Illinois

As a solid-state physicist, I suggest an alternative interpretation of the changes that Nagel portrays as the lost hegemony of high-energy particle physics. That hegemony was always at least partly in the imagination of the high-energy community, and the community's change in perception may reflect a loss of rose-colored glasses now that its funding situation is tight.

I recently spent a few years teaching in a small four-year college, and I can affirm the continued existence of common ground among physicists. The school combined all the natural sciences into one department, and it became reasonably clear that even a nuclear theorist and a solid-state experimentalist share some important views of science. That level of agreement is less common between life scientists, chemists, and geologists. The strong mathematical emphasis of a physics education promotes a quantitative, analytical approach to problem solving. Also, although Nagel is correct that the reductionist approach to science no longer goes unchallenged, it is still a strong enough feature of the physicists' worldview to provide some "family resemblance" among most physicists. In facing the fractures in the physics community, we would do well to remember that we do indeed have much in common.

Larry Merkle
(lamerkle@juno.com)
Army Research Laboratory
Adelphi, Maryland

Prominent research physicist Sid Nagel writes about the fragmentation of physics, but does not include the growing separation between physics and physics education.

Over the past 30 years, the American Association of Physics Teachers, once a society of physicists interested in teaching, has become largely a society of educators interested in physics. The number of AAPT members who are research physicists has declined while the number of physicists from high schools and two-year colleges has increased.

On past occasions, top physicists like Ed Purcell and I. I. Rabi could be seen at AAPT meetings. Now, noted research physicists rarely come to a meeting unless they are being honored and asked to give an invited talk. And the joint AAPT/American Physical Society meetings that brought research physicists and physics educators together are no more.

The 2002 conference of the International Research Group on Physics Teaching (GIREP) in Sweden, with a thoroughly international group of participants, had as a theme the flight from physics. Physics enrollments and degrees are down in most countries, and not one research physicist of note was among the 400 conference participants.

The undergraduate physics curriculum once united physicists. We bragged that, unlike the chemists, any physicist could teach any undergraduate physics course. The knowledge base provided by the undergraduate curriculum gave physicists in all research areas the ability to move from their frontier research position, take a few steps back toward that base, and find common ground with physicists in other specialties. That ability is no longer available. The chain of logic from a specialty back to a common base is too long. So we do not talk to each other—hence Nagel's crisis.

My introductory physics text of the 1950s, Sears and Zemansky (Addison-Wesley, 1955), is a black-and-white version of current physics textbooks. My introductory texts in chemistry and biology, however, bear no resemblance to current textbooks in those fields. Students are introduced to chemistry and biology in ways that represent the disciplines as they are today. Physicists, though, introduce students to their discipline as they did 50 years ago. Yet look at how physics has changed.

If we reform the structure and content of undergraduate physics to represent more accurately what contemporary research physicists do, we might establish a new knowledge base that would provide common ground for our discipline. Then, perhaps, we could talk to each other once again.

John S. Rigden
(jrigden@aip.org)
College Park, Maryland

Nagel replies: I am delighted to see such a varied response to my Opinion piece. My intention had been to start a productive discussion, and it seems that has now begun.

George Trilling and Michael Dine assert that particle physics is exciting and may be as productive now as in the past. Those are also the main points made by Joseph Lykken in his Opinion piece (PHYSICS TODAY, November 2002, page 56). Drasko Jovanovic points out the important symbiosis between particle physics and cosmology. I am happy to see such arguments made. I hope physicists from all different areas will become eloquent (yet avoid exaggeration) about their optimism for the future. We need to make clear *why* we find our fields exciting and why the achievement of our goals can open up new vistas for research. Particle physics is perhaps especially important in this regard simply because it may not appear to an outsider to have the same vibrancy it had during the development of the standard model. I commend Trilling, Dine, Jovanovic, and Lykken for starting the process of making the case for their field.

The executive committee of the American Physical Society's division of condensed matter physics, with input from its counterpart in the division of particles and fields, has organized a symposium entitled "Dreams for the Future of Physics: Where Are We? Where Are We Going?" This will be presented in a plenary session at the 2003 APS March Meeting in Austin, Texas, and I hope it becomes an ongoing tradition. The symposium's objective is to build a greater sense of continuity in physics by communicating the goals of a few major fields—condensed matter physics, nuclear and particle physics, cosmology and astrophysics, physics in biology, and string theory—and presenting some of the most pressing open questions in those fields. I hope that this symposium will not only be exciting but will also teach us how to convey the enthusiasm we feel for our own specialties to a more general public.

Trilling questions the existence of a widening gap between big and small science. Although increasing sophistication of apparatus occurs in condensed-matter as well as particle physics, so that one can correctly make the claim that both fields are simultaneously getting bigger, a different trend occurs that is not as often noticed. Many soft condensed matter experiments actually use extremely