then issuing from the stacks in a finely divided, very persistent, massive plume. One single plant, located west of Farmington, N.M., puts out from 10^{20} to 10^{22} submicron particles per day. These form a blanket of smog affecting four states. It is no exaggeration to say that the beauty of the Southwest and its parks and monuments, the heritage of all Americans, is being destroyed. Matters are rapidly to get worse, in spite of our efforts to add precipitators to the plants, for plans are afoot and abuilding to increase plant capacity by an order of magnitude. Thus far we have been absolutely unable to attract any national attention whatsoever to this problem.

I submit, therefore, that the choice before us right now is not: Can we stop further production of power? Rather, it is: How can we get the power for the least pollution? It is, I believe, inescapable that the best answer is to use nuclear fuels. Certainly there is a risk, but it is clearly foolish to reject a very small increase in our radioactive background and associated risk in favor of an increase in our toxic chemical background (and its risk) by many, many orders of magnitude. In addition the nuclear plant is smog-free, which the Southwest, alas, no longer is.

I hope physicists will undertake general support of nuclear power as our best *present* alternative to massive power-plant "smog" and chemical pollution. I further hope that someone, somewhere, somehow, knows how to alert the country as to what is happening to the Southwest. After four years of trying, I do not.

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At the present time it is becoming abundantly clear that, with careful handling of wastes, nuclear fuel *must* replace fossil fuels—and in the 20th century. The pollution lessons taught by the sprawling smog of our great cities are being retaught in our most remote and desolate areas.

It has been shown many times that high-power fast breeder reactors will satisfy our power requirements for the forseeable future. But, these systems require a very high capital investment, \$200 million or more, and produce a significant portion of the generating-system power. This clearly implies that uncertain performance and frequent or prolonged subsidy of noncompetitive choices can not be supported by industry. Another way to establish the quality of the energy source for long-term power production must be found. One such way is illustrated by the Southwest Experimental Fast Reactor Development Program, which has occupied the attention of a small group, at relatively small cost, from 1964 to the present. A second way should also be followed.

The National Laboratories were established to implement the will of Congress through research and development in the many fields of past and current interest, particularly the fields of nuclear energy. These laboratories use large amounts of energy, and have developed extensive facilities for research on nuclear physics, properties of materials, biological effects of radiation and many other aspects appropriate to and necessary for the development of commercial nuclear power and disposal of its waste.

Why are the National Laboratories being cut off from advanced-reactor development? Why are they not supplying their own power needs with nuclear reactors of types too new to be evaluated for long-term commercial-power production? Are not these places staffed with people who can anticipate fundamental difficulties, solve the new problems that will come with long-term nuclear-power production, optimize performance, and generally extend the frontiers of energy science? Are these not the most suitable and economical test beds for nuclear power?

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Case for in-house computers

As the educational marketing manager of Digital Equipment Corporation, I feel that the readers of your magazine have been given a very one-sided and inaccurate argument concerning the use of the commercial time-sharing utility versus the "in-house" small computer system. The argument presented by Hussein Elkholy (July, page 40) ignores very real economic considerations.

First, once a computer facility is installed in a department or on a campus, it becomes a fixture. And, as more of the faculty and student body become familiar with the computer, the demand for its use increases. Second, the task of applying the computer to physics courses, problems and experiments is easier than ever before. Digital Equipment Corp (and most other manufacturers) have developed easily learned, interactive languages for minicomputers that are used by physicists and physics students in all levels of education. This language can solve all types of problems including those typically found in high-school and college physics. Third, the absolute importance of adequately preparing physics students for industry and research is best accomplished by "hands-on" experience with a computer.

Then there is the argument: "The small computer doesn't have the power of the large computer:" Of course not!

letters

But the large computer is seldom needed for problem solving by the typical college physics department. In those instances where additional computational power is required, the total resources of the minicomputer system can be dedicated to a single problem. After the "tough" problem is solved, there are three or more off-line teletypewriters—depending on the system—immediately available for on-line applications. If the dedicated small computer is unable to run the program, then time can be rented from a commercial utility.

A far better alternative than purchasing time from a commercial time-sharing utility is to buy your own time-sharing system. It is very low-cost, and the system can be expanded as the need arises and financial resources are allocated. Hundreds of educational institutions throughout this country are starting off with smaller systems and gradually expanding them. For example, a single-user configuration costs approximately \$8500. This system is expandable to a four-user time-sharing configuration for less than an additional \$16 000. Alternatively, an initial investment of approximately \$13 000 permits the institution to expand its single-user system to a multilanguage 16-user configuration whenever the need arises or financial resources are allocated.

In comparison with a commercial time-sharing utility the costs of a four-user time-sharing system are about the same over a three-year period but more on-line terminals are available to students and faculty when a computer system is owned (four terminals instead of one). And the school owns a computer system at the end of the time period instead of having a pile of worthless rent receipts.

I might also add that if you don't have a physicist in your department with a computer background, don't worry. All computer systems come complete with instruction booklets, training courses, and sales experts.

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Solid-state biology?

Freeman Dyson seems to equate theoreticians and snobs in his stimulating article, "The Future of Physics" (September, page 23). With regard to molecular biophysics, at least, I prefer his phrase "scorn of snobs" to Bragg's "scorn of theoreticians." There is plenty of room for both theoreticians and experimentalists in this still relatively new field.

One important area not mentioned by Dyson in his admittedly brief survey, and of great current ignorance, is the solid-state physics of biological materials with high pi-electron densities. (The pi-electrons are those whose wave functions extend significantly out-of-plane in organic ring compounds.) Two examples of such materials are native DNA with its stacked bases, and the chlorophyll-protein complexes in photosynthetic lamellar structures. In fact, the pi-electron density along a single strand of stacked DNA is an order of magnitude greater than that in crystalline anthracene, a favorite object of study among organic solid-staters. Philip Rosen[1] has constructed a Kronig–Penney model for DNA from which he calculates single-electron bandwidths that are between one and two orders of magnitude greater than those for anthracene. Transport kinetics in anthracene is a matter of controversy concerning narrow-band conduction versus phonon-assisted hopping; what of DNA, with its much broader bands? The question is wide open. There is a whole new solid-state physics involving DNA alone.

While a true "solid-state biology," if it ever comes, is still far off, a band-theoretic approach to the properties of the macromolecular structures of biology may be just as important a complement to the currently hegemonic valence-bond approach as it has been to the properties of crystalline inorganic solids. Life, after all, is probably just as much a game for electrons as for molecules.

The physics of biological materials is also of interest in its own right, regardless of applications to biology *per se*. The reason is that study of these materials may lead to new, not-necessarily-biological, technologies. This point is not itself new, of course, most notably having been recognized by Bell Telephone Laboratories some years ago. Possibilities for DNA, with its variety of conformational states, range from highly compact and reliable information storage to room-temperature superconductivity.[2]

The great barrier to progress at present in this new branch of solid-state physics is the lack of significant and substantial confrontation of theory and experiment—theoreticians and experimentalists are still going their separate ways. The situation is rather like that in which metallic solid-state physicists found themselves before they came together on the Fermi-surface problem (Walter Harrison, October 1969, page 23). A certain amount of water is essential for the structural integrity of most functional biological materials, a fact which has thus far severely hindered experimentalists. Theoreticians have concentrated on calculating properties, such as dc conductivity, that have small hope of reliable experimental verification. Solid-state biophysics has not yet found