Discordant Observations

Eliot Marshall's discussion of controversy in science (News & Comment, 6 July, p. 14) will, I expect, stimulate a lively response. So let me make my position clear. Theoretical interpretation should be an open, progressive activity able to make small or big changes in response to observations. The only theoretical verity we can be really certain of in astronomy right now, however, is that there exists strong evidence that contradicts the fundamental assumption in the field. A small number of influential astronomers, for a variety of reasons, have denied the validity of this evidence. They simply state that the "ideas" are not proved or they are "harebrained" or "screwy." They certainly have not tested the evidence; for example, a NASA committee did not allow even a few thousanths of a part of the U.S. time on the x-ray telescope for elucidation of the connection between the quasar Markarian 205 and the low redshift galaxy NGC 4319.

Nevertheless, I would estimate that a majority of my colleagues believe there is "something" in the discordant observations that should be followed up. At the same time many would not welcome any direct competition with their own programs. Hence my suggestion that 10% of public resources be set aside for testing evidence in new directions (or 5% or even 1%, on a trial basis). The problem is to persuade the strong personalities in the field who feel it necessary that *they* decide what is right and wrong for everyone else. This is where the pressure must come from outside the field. There must be enough people of general education and conscience to say it is neither wise nor legally nor morally permissable to censor opinion or research in any human activity.

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Ph.D. Supply and Demand

In his AAAS presidential address "Supply and demand for scientists and engineers: A national crisis in the making" (27 Apr., p. 425), Richard Atkinson analyzes a number of projections, almost all of which appear dire. The major hopes, he believes, are (i) to encourage high school students who are qualified, but are not choosing science, to do so and (ii) to cut back on the numbers of students who drop out of science and engineering majors in college. These are worthy recommendations and should be vigorously pursued.

However, as someone who has spent more than a decade as an undergraduate adviser to talented freshmen students, I can attest to the onerousness of the task of trying to interest nonscience students in the field, or of convincing those who have discovered the joys of the Gothic novel or 19th-century philosophy that they should not shift out of their science concentrations. The former use their considerable intellects to devise excuses for why they should be allowed to substitute "soft" science for a "hard" science requirement. The latter, rightfully, explain that they had never encountered sophisticated thinking in literature or philosophy in high school, where the science teaching had been first rate. They were simply enlarging their horizons. The many "physics-for-poets" and now the largely nonscientific environmental courses that have sprung up in recent years have allowed many students to satisfy their science requirements, but rarely convert them.

The most promising opportunity to alleviate the predicted shortage is not mentioned by Atkinson, namely, the Immigration and Naturalization Service. Were every foreign science and engineering student in the United States, whether in a baccalaureate, masters, or Ph.D. program, awarded a green card at graduation, the immediate problem would be solved. At present, the rules and regulations are so complicated, and the procedures for granting resident status so confusing, that prospective employers attempt to avoid becoming enmeshed in the red tape and often negative results. This solution would provide the country with some of the best scientific talent in the world.

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Atkinson rightly identifies the indifference of research universities toward secondary education as a factor in the declining number of high school graduates who seek scientific careers. This will change. Research universities and colleges with strong bacculaureate programs in science will increasingly be called upon to structure curricula for those seeking careers in secondary education, as states drop school of education requirements for teacher certification. Those who would become science teachers must major in science, not education.

Science policy-makers must heed Atkinson's warnings about the looming crisis in science and engineering and take the remedial courses he recommends. Research universities must do all they can to see that those who would teach science will displace mediocrity with excellence through caring, competence, and creativity.

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Atkinson decries the fact that "few research professors pay much attention to teacher training programs at their university. . . ." Little wonder, considering that most research universities have established a reward structure that severely penalizes the few idiosyncratic professors who work to improve undergraduate education. The problems delineated by Atkinson might be diminished in the long-term if universities would instead heed the recommendations of the AAAS Project 2061 (*1*): (i) Presidents should "establish scientific literacy as an institution-wide priority" and ensure that all graduates, including K–12 teachers, "leave with an understanding of science, mathematics, and technology that surpasses what this report recommends for all high school graduates"; (ii) departments should design courses "for future elementary teachers and high school science teachers that go beyond, but are in the spirit of, the recommendations of this report, and create "in-service workshops and institutes tailored to the needs of teachers who wish to attain the standard of excellence implicit . . . in this report."

In addition, as suggested 16 years ago by F. Reif (*2*) to an evidently uncomprehending audience, universities "must be willing to face the challenge, worthy of the role of a university, of devoting to education the kind of searching thought commonly bestowed on scientific and engineering fields, and of promoting the translation of new ideas into practice." There now appears to be hope (*3*) that a much needed increase in federal funding for such research and development will soon be made available, especially if Congress is wise enough to reallocate some of the \$307-billion military budget request (*4*) for fiscal year 1991 to programs of more crucial national interest.

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1. Project 2061, *Science for All Americans* (American Association for the Advancement of Science, Washington, DC, 1989), p. 165.

2. F. Reif, *Science* **184**, 537 (1974).
3. M. Crawford, *ibid.* **247**, 405 (1990).
4. S. A. Cain, *Bull. Atom. Sci.* **46** (3), 7 (1990).

Atkinson and Robert Pool (News & Comment, 27 Apr., p. 433) present some projections of Ph.D. supply and demand for the coming decade and beyond. Both authors focus on the production of new Ph.D.'s, basing their projections on demographic predictions. No mention is made of some other groups who may be expected to fill academic and industrial vacancies as these become available—Ph.D.'s who hold marginal positions or are not currently employed in academics or industry, people with some science training who may enter Ph.D. programs if job prospects improve, and students who may finish their training early.

Possible recruits to science positions are people older than average graduate students. If job prospects are good, and funding is available, it may become economically sensible for a 40-year-old to enter a 5-year training program and work for 20 years before retirement.

Students and junior scientists who are prolonging their Ph.D. programs and postdoctoral appointments until job prospects improve may be moving into the workforce sooner than expected. There seems to be an inverse relationship between the job prospects in a specialty area and the length of time required to complete a Ph.D. in that area.

Many questions remain regarding these groups, but better information on their size and composition would allow more accurate predictions of future supply and demand for scientists and engineers.

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Endangered Species Biology

"Endangered species are in trouble mainly because their numbers are declining, right?" (Briefings, 6 July, p. 20) *Right!* Unfortunately, the contrary assertion offered in the briefing, that "the greatest threat to many endangered species is posed by genetic homogeneity," is one of the overly simplistic views of endangerment that can lead to distracting debates among conservation biologists and a poor track record in endangered species recovery. Genetic homogeneity through inbreeding *can* imperil a species, but such inbreeding occurs as a consequence of population decline and fragmentation. It is just one of several interacting factors that come into play when a population becomes so small that its fate is determined more by randomness than by fitness.

In most cases of species endangerment, the initial decline in numbers and geographic range is due to factors external to the biology of the species, and generally these are consequences of human activity. The prime factor, of course, is habitat destruction, but other factors include the introduction of competitors or predators and overharvesting by humans. Small and fragmented populations are the result, particularly for large vertebrates such as tigers, which have naturally extensive home ranges. Once populations are reduced in size and isolated, deleterious genetic and demographic processes ensue that serve to weaken further the survival potential of the species. The smaller populations also become progressively more vulnerable to environmental catastrophes. Even with amelioration of environmental circumstances, for example, provision of security in protected areas or zoological parks, a species may go too far down the so-called "extinction vortex" of multiple causes to be recoverable.

Zoos have had to face small population biology problems head on in trying to manage the long-term survival of species in captivity. The population viability analysis techniques developed for these situations are now being applied to similar problems in wild populations of species in the United States, Puerto Rico, Brazil, Indonesia, and Australia. Whether captive breeding or propagation is needed relates to the severity of the problem, but the policy of the World Conservation Union (IUCN), recommended by its Captive Breeding Specialist Group, states that such management intervention is best pursued while the wild population still numbers in the thousands. In other words, give the rescue workers a chance before a species is in the critical ward.

Prospectively, as intimated in the briefings, some techniques developed for the critical cases, such as in vitro fertilization in captive cats, may be valuable in the management of the genetic and demographic health of small, isolated wild populations. For example, needed genetic variability could be introduced by in vitro fertilization of a wild female tiger without the disruption that a new male tiger could produce in the local population.

The need for more support for the science and application of conservation biology has become very obvious, thanks to the media. We hope that *Science* will continue to publish articles about this need, but with the correct information, as it can have a great effect on decision-makers and on the general public.

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AI: Thousands of Ants?

The features of artificial intelligence by swarms of miniature robots described in M. Mitchell Waldrop's article "Fast, cheap, and out of control" (Research News, 25 May, p. 959) reminded me of the following passage from *The Lives of a Cell* by Lewis Thomas (Viking, New York, 1974).

> A solitary ant, afield, cannot be considered to have much of anything on his mind; indeed, with only a few neurons strung together by fibers, he can't be imagined to have a mind at all, much less a thought. He is more like a ganglion on legs. Four ants together, or ten, encircling a dead moth on a path, begin to look more like an idea. They fumble and shove, gradually moving the food toward the Hill, but as though by blind chance. It is only when you watch the dense mass of thousands of ants, crowded together around the Hill, blackening the ground, that you begin to see the whole beast, and now you observe it thinking, planning, calculating. It is an intelligence, a kind of live computer, with crawling bits for its wits.

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"Shoehorning" Men into Studies?

Regarding the controversy about including women in National Institutes of Health–funded studies (News & Comment, 29 June, p. 1601), I can certainly understand the position of a researcher such as Charles H. Hennekens. Since he had chosen physicians as his study population, and there weren't enough female physicians for his group to draw sound conclusions, it made sense to leave them out.

The real problem seems to lie in the unconscious assumption that the average, typical human being is male. Females are seen as a variation on this norm. How would male researchers react to the statement that "shoehorning *men* into studies for political rather than scientific reasons would be disastrous"?

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