LETTERS

Evolutionary Studies

In his interesting article about the creationist suit recently tried in California (News and Comment, 20 Mar., p. 1331), William J. Broad notes that this deliberately limited case could prove to be a mere prelude to a major series of legal battles over basic constitutional issues. As adumbrated by the creationist attorney Richard K. Turner, exposing the "religious" nature of evolutionary "beliefs" will be part of the fundamentalists' legal strategy.

Turner cites Popper's falsificationist theory of science, and the notorious deduction that the inability to make predictions denies scientific character to evolutionary theory. In 1980, Popper dissociated himself from this deduction which claims evolutionary studies to be "metaphysical" (*1*). In these circumstances, Popper's exact words should be quoted: "It appears as if some people would think that the historical sciences are untestable because they describe unique events. However, the description of unique events can very often be tested by deriving from them testable predictions or retrodictions." In short, Popper has now defended the scientific character of the theory of evolution and of paleontology.

Popper's own statement, made after critical reexamination of his views on the methodology of science, proves much broader than those of many experimentalists who claim his views as the basis of their scientific operations. A similarly narrowed view of Darwinism has dominated adaptational research with theories based on current and immediate optimality of all structures and processes. This restrictive research program has been criticized recently by Gould and Lewontin (*2*), who have set out a number of alternatives in an elegantly presented essay which supports Darwin's own pluralistic approach to evolutionary studies. Credible and successful scientific defense in future creationist trials could require that scientists avoid making narrowly restrictive and unnecessarily dogmatic statements about their scientific methodology.

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References

1. K. Popper, *New Sci.* **87**, 611 (1980).
2. S. J. Gould and R. C. Lewontin, *Proc. R. Soc. London Ser. B* **205**, 581 (1979).

Population Growth and Energy Use

In his editorial "It is people who use energy" (30 Jan., p. 439), Kingsley Davis proposes population growth as a major cause of the energy problem.

In the United States, even if population had remained constant from 1955 to 1978, total energy consumption would have increased by 51 percent. To compensate for the increase in per capita energy consumption, the 1955 population would have had to fall by 56.2 million people or 34 percent by 1978.

Davis says worldwide consumption of energy has been growing at a rate of 3.5 percent per year. By contrast, population has been growing at a rate of between 1.7 and 1.8 percent. Thus, while population growth may be a major cause of rising energy consumption, one cannot disregard per capita consumption.

Per capita energy consumption in industrialized countries in 1978 was about 44 times higher than in low-income countries. The estimated annual population growth rates for these two groups of countries were 0.7 percent and 2.2 percent, respectively. While low-income countries accounted for 30.5 percent of the 1978 world population, they consumed only about 2.4 percent of the energy resources. In comparison, industrialized countries accounted for only 15.7 percent of the world population but consumed about 54.4 percent of the energy resources (*1*). A decrease in worldwide population growth rates, without a decrease in per capita energy consumption in industrialized countries, cannot solve the global energy problem.

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References and Notes

1. Based on data included in tables 1, 7, and 17 of *World Development Report, 1980* (World Bank, Washington, D.C., 1980). This report classifies 125 countries in six groups: low-income, middle-income, industrialized, capital-surplus oil exporters, and centrally planned economies. Countries in these six groups accounted for 30.5, 20.6, 15.7, 1.4, and 31.8 percent of the 1978 world population but consumed about 2.4, 9.1, 54.4, 1.1, and 33.0 percent of the energy resources in 1978.

Davis infers that part of the energy problem in the United States is that we are letting in too many refugees. People use energy, true. However, I doubt that immigrants are the ones who are surrounded by electrical gadgets at every turn, keep comfortably warm or cool despite the weather, and drive their own cars (plural per family) rather than sup-

port public transportation. The relationship between numbers of people and energy use involves more than per capita use figures.

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With respect to Streng's letter, I can say only that immigrants are people, and, like other people, they use energy. They need heat in winter and air conditioning in summer, just as other people do. They eat food grown with fossil fuel, and they drive cars. In fact, the worldwide current of migration from less to more developed countries is exacerbating the drain on energy supplies, because the migrants use more energy after migrating than they did before.

Jain and I agree that a solution to the world's energy crisis requires conservation, particularly in the industrial countries. We disagree when he uses this view to obscure the necessity of population control and implies, as is often done in the Third World, that the energy problem would be solved if the industrial nations were less wasteful.

His own analysis, I think, shows the futility of conservation in face of population growth. If the less developed countries are consuming far less energy than the industrial countries, they are evidently *conserving* it. This enforced conservation, however, is not solving their energy problem; rather, their population increase is creating a demand for fossil fuels which they are too poor to meet, with the result that they are burning up their forests at a prodigious rate and using their land and human resources inefficiently.

In the 38 countries the World Bank singles out as low-income countries (25 of them in Africa and most in the tropics or subtropics), the average population density is two and one-fourth times that of the industrial nations; yet their population increase is three times as fast. Their external public debt and foreign debt service have been rising relative to the gross national product, and their food deficit, already monumental, is forcing them to rely for subsistence on the New World industrial nations. These nations, however, can export food on a grand scale only because their ratio of people to land resources is still reasonably low and because they use copious amounts of energy in agriculture. As the Steinharts, Pimentel, and others have shown, more calories are being used in American food production and distribution than the food itself yields at the table. In the process, we are losing top-

soil, poisoning rivers and lakes, and exhausting fossil water reserves. As the cost of energy soars, so will the cost of food exports. The unprecedented growth of population in the less developed countries is thus causing an acute energy crisis not only at home but in the world as a whole. Conservation in the industrial states, badly as it is needed and certainly as it is soon to come, cannot compensate for this relentlessly mounting pressure on diminishing resources.

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Innovation in Science Teaching

Was Frederick Mosteller aware that his important presidential address, "Innovation and evaluation" (27 Feb., p. 881), concluded with the beautiful but tragic example of his point? He suggested that the AAAS sponsor initiatives in science and engineering education. Perhaps he was thinking of a recent 211-page book (*1*) reporting the results of nine studies under contract to the National Science Foundation. Neither Mosteller nor the authors of that book mentioned teaching methods which have long since proved their value (*2*).

In 1960 in Roanoke, Virginia, an 8th grade class, using simple teaching machines and a previously untested program, covered all of 9th grade algebra *in one term*. Their grades met 9th grade norms, and measures of retention a year later were considerably better than normal. The educational establishment should have been delighted. Here was the way to teach algebra! But, 20 years later, the study is forgotten. Forgotten also are scores of equally dramatic experiments. Surely this is an example of a lag in the use of innovations to be added to those so delightfully described by Mosteller.

What is needed in education is not innovation but a change in the establishment that will permit efficient teaching methods to be used.

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References

1. *What are the Needs in Science, Mathematics, and Social Science Education? Views from the Field* (SE809, National Science Foundation, Washington, D.C., 1980).
2. E. W. Rushton, *The Roanoke Experiment* (Encyclopedia Britannica Press, Chicago, Ill., 1965).