Letters

Punctuated Equilibrium

Roger Lewin's recent article "Punctuated equilibrium is now old hat" (Research News, 14 Feb., p. 672) sounds almost like a conciliatory gesture to population geneticists to offset the attention he has given in the past to the theory and its proponents Niles Eldredge and Stephen Jay Gould. Several models have already been published (*1–2*) that demonstrate how easy it is for a population genetic model to mimic punctuative change. One, in particular, uses Wrightian landscapes quite well to illustrate the expectation of alternations of slow and rapid change (*1*). The model of random deviation from an adaptive peak (*3*) is certainly a possible mechanism of sudden change, but only part of a spectrum of models. Indeed, the earlier work of Lande on reduction of digits (*4*) shows how Wright's original model of digit regulation mimics punctuation, simply because many traits are regulated by threshold effects. This model explains why so many characters show no phenotypic change, then a geologically instantaneous transition, in the face of continuous environmental change. In other words, the notion of sudden change alternating with stasis is so context-dependent, both in terms of trait determination and the selective regime, that the claims and counterclaims of the "punctuationists" about the presence of stasis fall safely within an effectively infinite range of possibilities.

What Lewin does not mention is that punctuated equilibrium is as much about species and speciation as it is about stasis. A major part of all of the objections have addressed the part concerning speciation. As the geophysicist George Kennedy used to say about other such theories, this concept "extrapolates into the face of known data!" It is disingenuous to trivialize the concerns about speciation by arguing that stasis is the real issue. There would have been no problem in the first place if the straw man of phyletic gradualism had not been invented. I dare say that Gould's earlier works on developmental constraints would have generated the same interest in stasis, without subjecting us all to a decade of hype. Let us just say that a maladaptive intermediate phase, the punctuated equilibrium theory, may have forestalled an adaptive phase in evolutionary biology.

The theory of punctuated equilibrium as first stated by Eldredge and Gould appears now to be as dead as a doornail. It has become an emblem for a confusing array of valid and invalid claims. In a defense of punctuated equilibrium (*5*), Gould has recently wondered how so many critics could think a theory to be so trivial or incorrect while passionately bashing it. By the same logic, I suppose one could think that scientific creationism and sociobiology—of which Gould has been a strident critic—are intellectually potent. Theories that are vague or untestable are usually far more difficult to criticize than elegant and simple theories. They become transmuted into catchy slogans and acquire a life of their own. Like sociobiology and (the oxymoron) scientific creationism, punctuated equilibrium has become so diffuse that it is impossible to refute or even discuss it without in effect perpetuating the slogan. Any advertising executive would be envious! As DeBeer (*6*) once wrote: "It is characteristic of a slogan that it tends to be accepted uncritically and die hard."

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The Future of U.S. Agriculture

In his article "U.S. farm dilemma: The global bad news is wrong" (25 Oct., p. 408), Dennis Avery presents a classically unrealistic solution to the problem of declining American agricultural exports. Avery appears to be arguing that, since food production is increasing in developing as well as industrial countries, U.S. farmers will have to continually implement "cost lowering" new technologies, and adopt free market agriculture at home and abroad, to remain competitive in world markets.

If one puts aside the complexities involved in the application of new technologies in agriculture, Avery's thesis on behalf of free trade in agricultural commodities is idealistic to the point of being irrelevant. Two important facts subvert Avery's position: We cannot compete "freely" in international agricultural markets when our major competitors subsidize their exports; and, in any case, new markets will soon be needed to absorb surplus commodities. While the greatest potential market for these commodities is Africa, governments there do not have the foreign exchange to import commodities at anything resembling a market rate.

Perhaps Avery avoids this issue precisely because of the dismal prospects for market development in Africa and other "fourth world" nations. Most poor (the poorest 50) nations depend on cash crop exports for foreign exchange. Unfortunately, these growers compete directly for markets with producers from both developing and developed countries. Faced with subsidized competition from developed nations in many export crops (sugar, cotton, beef, peanuts, and tobacco) or surpluses and elastic demand for others (cacao, rubber, coffee, and fruits), poorer nations are literally losing billions in foreign exchange earnings to American and European exporters (*1*). The balance of trade and foreign exchange earning capacity of most non–oil-producing African countries are declining, and the unfortunate fact is that debtor nations will never be able to import our agricultural products at prices that guarantee American farmers a profit in the absence of large U.S. government subsidies.

To make things worse, in 45 countries, most of them in Africa, food production is lagging far behind population growth rates with no realistic hope of catching up for the rest of the century. Per capita food production in Africa has fallen every year since 1970. While most of these nations will have to import foodstuffs, this will continue to take the form of subsidized exports, as is the case with the European Economic Community (EEC), where 40 percent of the total EEC budget ($5.8 billion in 1981) goes to export surplus commodities.

To guarantee future markets for U.S. agricultural commodities, it makes much more sense for the United States to allow and actively encourage developing nations (India, China, Indonesia, Thailand) to feed themselves, regardless of the theoretical comparative advantage that they may have in certain commodity exports. These countries will then use a well-fed population to develop a more diversified economy, which in the long run will import far more from American farmers and other industries than an economy that perpetually exports cash crops at the expense of domestic agriculture.

While domestic food distribution inequities persist, Brazil, Korea, and Taiwan illustrate this point; having developed their own agricultural capability, they now import more agricultural products from the United States than ever before. Unfortunately for the American farmer, this is precisely the result that is squelched when U.S. and European agricultural surpluses are continually dumped on poor countries, distorting their agricultural systems and rural economies.

In the short run, American agricultural exports will have to become cheaper to remain competitive. This will involve the selected application of new technologies in production, a devaluation of the dollar in international money markets, and the use of aid and subsidized export programs to compete with similar policies of the major commodity exporting nations.

In the long run new markets must be nurtured, which means the African continent must be allowed and encouraged to develop. The first step in this process is the development of an indigenous agricultural capacity. Some of this will occur through the application of technologies cited by Avery, some will be the result of domestic policies that discourage the import of grains while raising the price of domestically grown foods. While this may put a damper on the dumping of surplus commodities on poor nations, recent history shows this is the only way that international trade in agricultural goods will prosper.

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Avery's article concerning the future of agriculture in the United States and other countries carries a curious and disturbing message. It attempts to dispel the commonly held belief that global food production will fall short of the needs of a growing world population in the years ahead (the "good news"), and by the same token it predicts that the current overproduction in U.S. agriculture will continue and that our farmers will have to face surpluses in world markets (the "bad news").

There is, however, a serious oversight in Avery's otherwise excellent article. He makes little mention of the role that climate changes will play in the agricultural picture of the future. Avery states: "There is no solid evidence that a global climatic change is taking place." This reflects the conservative school of climatologists, who steadfastly refuse to believe both the theory and the evidence concerning the magnitude of the warming taking place due to the "greenhouse effect" of increasing atmospheric carbon dioxide from worldwide burning of fossil fuels. Furthermore, we must not forget the appreciable additional contribution to the warming from other infrared-absorbing trace gases whose concentrations are also rapidly increasing. Of even greater importance than the warming itself will be the inevitable, and probably significant, shifts of rainfall patterns, although we still cannot describe these regional shifts in adequate detail.

The latest and most authoritative statement concerning the climatic change that is taking place and that will undoubtedly continue to intensify comes from an international conference held in October 1985 in Villach, Austria, sponsored by the UN Environment Programme, the World Meteorological Organization, and the International Council of Scientific Unions. There seems little doubt that the predicted climate changes will indeed occur, and the conference dwelled on the policies that should be adopted to cope with it. The conference statement recommends:

> Support for the analysis of policy and economic options should be increased by governments and funding agencies. In these assessments the widest possible range of social responses aimed at preventing or adapting to climate change should be identified, analyzed and evaluated. These assessments should be initiated immediately and . . . should be undertaken in a regional context to link available knowledge with economic decision-making and to characterize regional vulnerability and adaptability to climate change. Candidate regions may include the Amazon Basin, the Indian subcontinent, Europe, the Arctic, the Zambezi Basin, and the North American Great Lakes.

If Avery's remarks can be taken to apply to the next decade or two, then the need to superimpose climate changes on the other factors involved in food production should have been acknowledged. In a passing reference to climate change he says: "High-technology agriculture could probably even take a significant degree of change in global climate in stride . . . with some countries being helped and others hurt."

I do not share Avery's optimism that the coming climate changes can be "taken in stride," especially when we realize that in the early part of the next century (perhaps even sooner) the world will probably be warmer than at any time in this interglacial period (*1*). The history of mankind tells us that climate changes of a relatively modest and gradual nature have led to vast readjustments of people and nations. On the time scale of human affairs the coming changes are expected to be unprecedented in magnitude, and any discussion of the future that does not take them into account as best it can will not be telling the whole story.

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Avery states that the global bad news about world food and resources is wrong. Yes, more humans are being fed in the world than ever before in history; however, at the same time we have about 1 billion humans who are malnourished, and the problem is growing rapidly in severity (*1*)—there are now the largest number of malnourished ever in history. Is this not bad news?

Increased food production is due in part, according to Avery, to "better pest control technology, such as new low-volume pesticides" and sprayers. I have not seen any data that document that pest losses in the less-developed countries (LDC's) have declined. In the United States, despite about a tenfold increase in insecticide use since 1945, losses of crops from insect pests have increased 7 percent to 13 percent (*2*); this is due to a complex of changes in agriculture. As a group, LDC's use only about one-fifth of the world's pesticides; thus it is highly doubtful that they have benefited as much as Avery suggests. Although the use of ultra-low-volume sprayers is helpful in aerial application, less than half of the applied pesticides reaches the target crop area (*3*). For both the aerial and ground application of insecticides, less than 0.1 percent of the insecticide applied actually reaches the target pests (*4*); most pollutes the environment.

Without data or documentation, Avery states that soil erosion has been less severe than many expected. The limited data available suggest just the opposite, and the problem is rapidly growing. In the Deccan black soil region of India, for example, soil erosion rates range from 40 to 100 tons per hectare per year (*5*). The cultivated rolling loess of the Yellow River basin in China erodes at a rate of 100 tons per hectare per year (*6*). Numerous other examples exist for LDC's, and the rates range from 20 to 200 tons per hectare per year. Although soil loss and depth are important, loss of water, nutrients, and organic matter associated with soil erosion has the greatest impact on agricultural productivity.

Avery suggests that the prices of oil and other energy resources for agricultural production are a minimal constraint for the LDC's. However, in just the 8 years after 1972 the cost of fuel imported by developing nations rose from $6 billion to $79 billion (*7*). This tremendous increase of energy import costs, including fertilizer, is having an immense impact on farmers and their quality of life in the LDC's (*8*).

Avery suggests that "the banning of the early persistent pesticides" has diminished the side-effects, "such as the buildup of insect resistance." Again, this suggestion is made without documentation. The literature (*9*) shows that pesticide resistance con-

tinued to grow after the banning of persistent pesticides and now pesticide resistance is the highest ever in history.

Although science and technology have helped world agricultural production and these accomplishments should be viewed as good news, at the same time we must recognize that cropland, water, and other resource shortages and serious environmental degradation exist in the world. This is bad news for agriculture in the short term, but especially in the long term (*10*).

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Response: I wholeheartedly agree with Wiles that encouraging agricultural and other types of economic growth in developing countries is the best way both to attack hunger and to further our own trade interests. I had not intended to present a "solution" to the problem of declining U.S. farm exports, but rather to warn that we are faced with a long-term problem. Since more farmers in more countries are becoming *able* to produce more farm products, how do we rationally resolve who *should*? As Wiles notes, more countries are resorting to export subsidies. There is also a strong recent trend toward increased national self-sufficiency—sometimes at high internal cost.

Obviously, climatology is Kellogg's field rather than mine. However, I have a general impression that the riskiest projection of all is the long-term straight-line projection from the current situation. Necessity has been the mother of so much invention that the history of efforts to reorganize society on the basis of perceived long-term emergencies looks like the history of crying "Wolf!" We may very well have a serious problem with the greenhouse effect and its implications—if nothing major in the equation changes over time. If so, it is proper and important to warn that changes are needed. It is probably not correct, however, to fault a sectoral analysis for not including a particular concept of emergency that is probably going to be headed off. For one thing, I wonder if the burning of fossil fuels that has lent the greenhouse effect most of its power may not be displaced by new technologies that will be even more efficient and have less impact on the environment? Might not the pace or even nature of the greenhouse effect be altered by new corrective techniques?

In the next decade or so, it does not seem likely that the greenhouse effect will push much of the world's agriculture beyond the current range of rainfall or temperature variability.

The Pimentels are correctly concerned about the long-term maintenance of our resources and food productivity. However, they appear to have missed the point of my article. I was attempting to show that the *process* of agricultural research is successfully dealing with a broad range of agricultural constraints in ways that the limits-to-growth projections did not foresee. Furthermore, we can count on the process to make further progress so long as we continue to seek new knowledge.

I made no claim that science has eliminated our insect problems. I doubt that permanent total victory over insects is possible. But science has given us more potent, less persistent insecticides, integrated pest management, evolved a fascinating technique that may work against tse-tse flies, and developed methods of propagating millions of insect predators. Soil erosion is still a serious problem, but U.S. use of minimum tillage has doubled in a decade, "no-till" agriculture has tripled, alley cropping is proving a stable long-term system for West Africa, and the use of higher yielding seeds is taking pressure off fragile lands by making it possible to raise more food on stable lands. The worst erosion problems are, and will be, in the "low-tech" agricultures.

Fertilizer use in the LDC's doubled in the last, high-cost decade because more powerful seeds and farming systems cut real fertilizer costs per ton of food. Now, oil prices have fallen nearly 50 percent, and fertilizer use in the LDC's may increase even more rapidly.

The Pimentels say the world has 1 billion malnourished people. Alternatively, the World Bank says the proportion of the world's population whose health is at risk because of lack of food has declined significantly, to 6 percent in 1980. Another 6 percent of the world's population may have lacked enough calories for an active working life, but that proportion has declined despite enormous increases in population. It should also be recognized that most "hunger" estimates are soft numbers. Thomas Poleman of Cornell University has carefully documented the tendency to underestimate LDC food production and to overestimate the calories needed by "small but healthy" people.

Data from the Food and Agricultural Organization shows that LDC's raised their farm output 4.4 percent annually from 1979 through 1984 compared with a 2.4 percent annual rate a decade earlier. Their per capita food production increased 1.6 percent annually from 1979 through 1984, compared with a decline of 0.6 percent annually in the previous decade.

Something has given agricultural productivity enormous speed and momentum in recent years. I contend it has been the agricultural research process embodied in the new international research centers. This process has contributed untold benefits to human health and well-being, lessening the effect of population growth rates that are still too high and raising millions from abject poverty.

There are still real problems. The Pimentels are right to be concerned about them. But too many people have relied on "what ifs" and scare tactics to get support for the efforts they believed were necessary for the future. I have even heard it said that it was all right if the report of the Global 2000 Task Force was too pessimistic, since that would simply stimulate more output.

These scare tactics have led us into enormous mistakes. Much of the current U.S. farm crisis was precipitated by unrealistic expectations about a world food shortage and the consequent bid-up of land values. The "land and buildings" segment of U.S. farm costs rose from 16 percent of all farm costs in 1960 to 41 percent in 1982. Now, when U.S. land values have dropped 50 percent and the world has a structural farm surplus equal to more than 100 million metric tons of grain a year, payment for bad advice is being extracted from U.S. farmers, their creditors, and the taxpayers. What does a limits-to-growth philosopher say to a farmers' meeting these days?

Realism is the best basis for public policy. The world has made major progress against hunger and is likely to make more—if it continues to invest in research.

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