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SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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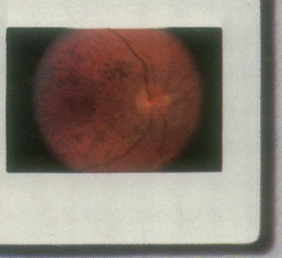
"The light from this particular galaxy took two million years to reach my camera. The exposure, patiently guided on chilled emulsion, took two hours. After all that, I'm not about to let my slide out of sight! I keep the original of the Spiral in Triangulum safe at home. Should a journal or a friend request a print, I simply use my master slide to make excellent quality Polaprinter color prints in 60 seconds." Ben Mayer, Chairman, Envel Corporation.



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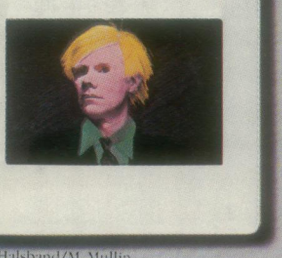

"A client may call to ask, 'What kind of Warhols do you have?' We find that, rather than send out for duplicate slides of the work, it's much faster and less expensive to make Polaprinter instant color prints from our original slides. How well the Polaprinter captures the detail and vibrancy is important—we sell quality work and want it well represented. I'm not used to raving about a product, but these images are *very* good." Tom Pelham, Leo Castelli Gallery, New York, N.Y.

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

COVER

Erosion from a 9-centimeter rain falling in 45 minutes in mid-May 1982 on a field in Woodbury County, Iowa. The area received as much as 23 centimeters of rain during the week. Erosion was estimated to be as much as 330 tons per hectare (2.5 centimeters). About 90,000 hectares of cropland were heavily damaged by the storm. See page 458. [Lynn Betts, Soil Conservation Service]

ontological data preclude any adequate analysis of species. This old dilemma did not arise with punctuated equilibrium; it forms the classic "species problem in paleontology" (*8*). Most paleontologists admit these limits in most cases but point to the number of favorable examples where geographic control and, particularly, the sympatric occurrence of forms with their ancestors or sister taxa provide as much evidence as neontologists generally obtain in designating species. As a related point, Schopf and Hoffman argue that systematic biases greatly overestimate the ranges of fossil species. While I disagree strongly and suspect that, if anything, the longevity of most fossil species may be underestimated by actual occurrences (*9*), I fail to see the relevance of this point to the validity of punctuated equilibrium. The issue is whether or not most species are stable after their origin, not how long they last. Indeed, shorter durations and more species would be favorable for the most important implication of punctuated equilibrium and another phenomenon denied by Schopf and Hoffman—species selection (since any Darwinian process of selection requires copious raw material, and species themselves are raw material at this hierarchical level).

As their third criticism, Schopf and Hoffman charge that punctuated equilibrium is untestable. Yet many tests have been made, for better or for worse [several good cases of gradualism have been documented, including, in my opinion, that of Raup and Crick on *Kosmoceros*, their own overcaution notwithstanding (*11*)]. Two forms of test have been fruitful. First, empirical studies of individual cases are now sufficiently voluminous to indicate general conclusions (see below). Ironically for Schopf and Hoffman, their three favorite cases of gradualism (foràms studied by Malmgren and Kennett, mammals of the Bighorn Basin, and hominids) have all been challenged and interpreted as punctuational by additional or different empirical data (*12*). Their professed disproof of punctuated equilibrium in hominids (*13*) is, in fact, an example of a priori bias for gradualism. Cronin *et al.* (*13*, p. 116) document a trend in brain size as four clusters of points clearly permitting no distinction between alternative hypotheses of a single connecting line (phyletic gradualism) or several stepped events of speciation (punctuated equilibrium). Yet they write: "Any impulse to draw a step diagram through the points should be resisted."

Second, as pioneered by Stanley (*10*), estimates of aggregated change may be calculated and compared with data on species number and duration for entire faunas to see whether transformation within lineages can account for observed change without invoking primary increments at rapid speciation events. Stanley concludes that phyletic evolution within lineages is too sluggish to account for much accumulated evolutionary change.

Punctuated equilibrium was proposed just a decade ago, but empirical case studies already point to general conclusions: high frequency of gradualism in single-celled planktonic organisms compared with high frequency of punctuated equilibrium in shallow-water marine invertebrates (*2*); higher frequency of gradualism in pelagic environments than in benthic environments (*14*). Punctuated equilibrium, particularly through its recognition of stasis as data, has greatly expanded the arena of evolutionary studies directly accessible to paleontologists. Eldredge and I are pleased that this theory about how speciation translates to patterns of geological time has generated so much fruitful empirical work.

STEPHEN JAY GOULD
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7. P. G. Williamson, *Nature (London)* **293**, 437 (1981).
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9. Average species durations of more than 5 million years were estimated, with attempts to correct for biases in the fossil record, by D. M. Raup [*Paleobiology* **4**, 1 (1978)] and S. M. Stanley (*10*). Empirical tabulations must err primarily in artificial shortness because imperfections of the record can only decrease duration by missing true earliest and latest occurrences, especially since species probably tend to be rare at their origin and near their demise. Schopf acknowledges this point but says it is swamped by the species of short duration that we miss altogether. I do not deny these total misses but point out that we can only work with what we have—and the empirical records of what we have are underestimates.
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4 February 1983, Volume 219, Number 4584 **SCIENCE**

Perspective on Agricultural Research

Recent commentators on the status of agricultural research have expressed concerns about long-range program priorities, resource allocations, and the capacity of the system to provide leadership in fundamental aspects of the agricultural sciences. The discussions have involved primarily the programs of the federally and state-supported research and education system. Some critics contend that the system is giving insufficient attention to basic research. Others argue that the system has demonstrated its capacity to adjust and accommodate to new scientific and technological developments. Finding a consensus is a priority concern of the Department of Agriculture's Science and Education agencies and our partners—the state-based institutions, the Agricultural Experiment Stations, and the Cooperative Extension Service.

Over the next 12 months, our agencies will be taking a new look at research priorities and directions. An assessment will be made of the long-term food, fiber, and forest products needs for the 21st century and the role of science and education in meeting those needs. A 5-year plan will then be prepared for research, higher education, and extension programs, including an examination of the roles of federal, state, and private agencies.

The Agricultural Research Service has already prepared a long-range strategic national research plan. Through its Office of Education, it is examining the supply-demand picture for agricultural expertise. The Forest Service, in cooperation with forestry schools, recently completed a 10-year national program of research on forests and associated rangelands. The Cooperative State Research Service is looking to new approaches for identifying research priorities. The Extension Service is completing a comprehensive study of its program designed to develop guidelines for its activities in the 1980's and beyond. A common denominator in all of these studies is a reevaluation of the role of research and development in relation to expanding opportunities for institutional-industry interactions that can strengthen our national research and education capacity in agriculture.

This is a time to intensify the use of the scientific and educational resources of the agricultural community and to find answers to critical questions. Will it be possible to reduce severe soil erosion and increase the water use efficiency of crops? Will new developments in molecular biology provide a much better understanding of genetic linkages to basic physiological functions? What new scientific developments can be employed to expand the use of agricultural products and develop new markets? Finally, what programs can be instituted to encourage more high-potential students to prepare for careers in the agricultural sciences? Already, new developments in plant and animal genetics and in the field of bioregulation promise to increase yields of major food and fiber crops and improve the efficiency of animal production. Nutrition research must address the special dietary problems of the more vulnerable segments of the population, including children and the elderly. Research must also be carried out on the effects new production practices might have on the composition of the food we eat. Other areas needing attention concern the impact of technology on the environment and the effects of changing social, political, and economic conditions on the quality of family life, especially in rural America.

Today's budgetary realities may slow adjustments, but we must prepare to seize promising scientific developments in the years ahead and apply them to our food and fiber production system. Scientists and institutions involved in agricultural science and education are not only receptive to new ideas, but anxious to adopt approaches that will bring stronger programs. The foundation for science and education is strong within the agricultural sciences and has demonstrated a capacity for change and progress. American agriculture is at a crossroads of significant proportions, and all those involved must reexamine ways of collaborating and marshalling resources for the future.—ORVILLE G. BENTLEY, *Assistant Secretary, Science and Education, Department of Agriculture, Washington, D.C. 20250.*

Announcing

A Special issue of *Science*, 11 February 1983 on Biotechnology

This issue will portray some of the many ways in which biochemistry, biology, and microbiology are being applied in medicine, pharmacology, agriculture, and the production of chemicals.

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announces the

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R & D, High Technology, and Economic Recovery

Trends and Topics

- R & D in the FY 1984 budget
- Congressional reactions
- Industry R & D funding
- International competition
- Human resources
- Research partnership

Current Data

Registrants will receive *R & D in the FY 1984 Budget: A Preliminary Analysis* in advance of the Colloquium and *AAAS Report VIII: Research and Development, FY 1984,* by Willis H. Shapley, Albert H. Teich, and Jill P. Weinberg (including Colloquium highlights), following the meeting. *Congressional Action on R & D in the FY 1984 Budget* will be sent in the fall.

Informed Debate

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- Federal R & D agencies
- Congress
- Industry
- Universities

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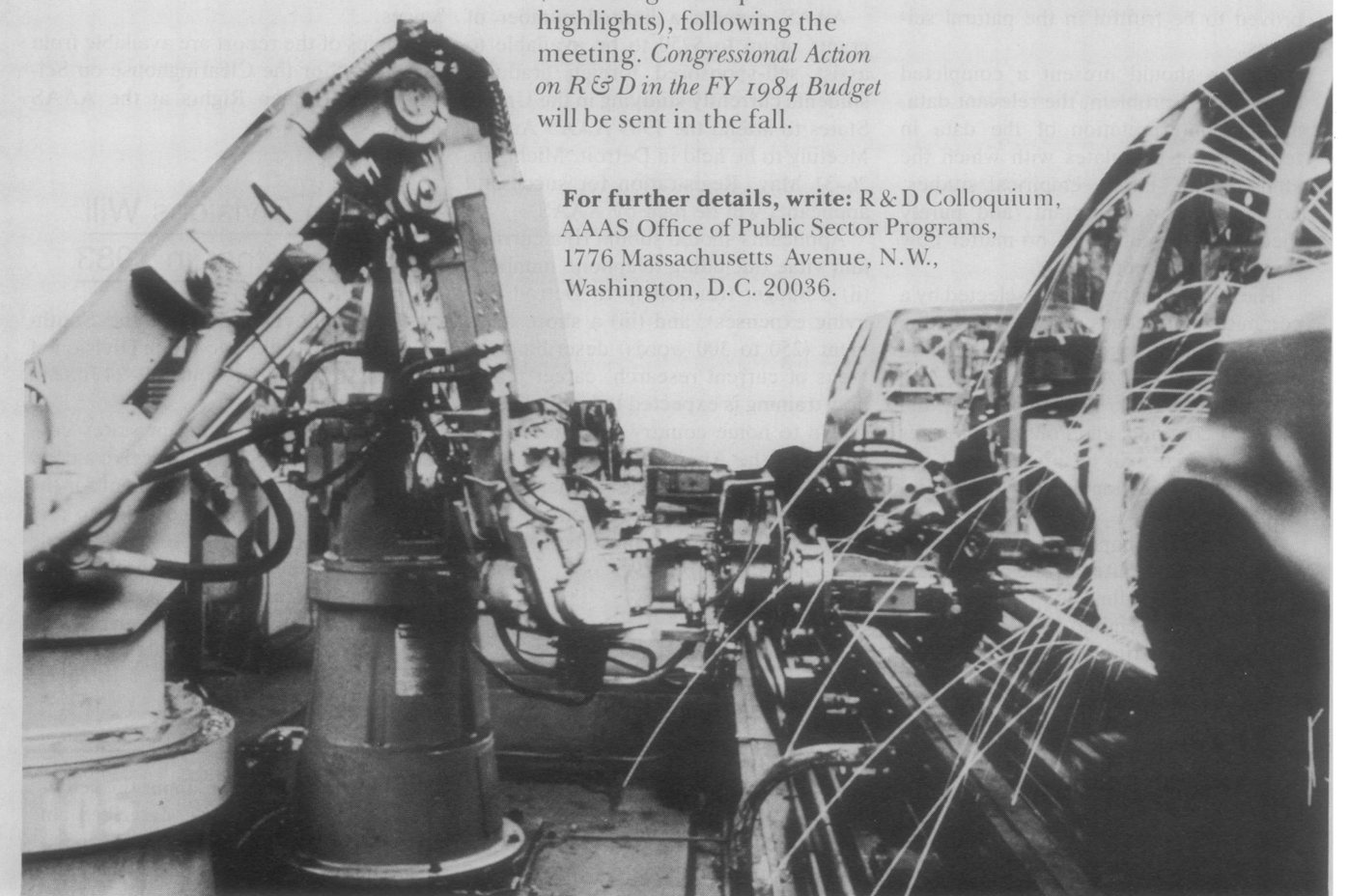

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8th AAAS R & D Colloquium
Washington, D.C.
24 & 25 March 1983

Advance Registration Form

Thursday & Friday, 24 & 25 March, at The Shoreham Hotel, 2500 Calvert St., N.W., Washington, D.C.

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Program, badge, meal tickets, and R&D in the FY 84 Budget: A Preliminary Analysis will be mailed 11 March. Registrations received after 11 March will be held at the AAAS Registration Desk at The Shoreham Hotel. AAAS Report VIII: Research & Development FY 1984 will be mailed in June and Congressional Action on R&D in FY 84 Budget will be mailed in the fall. (Highlights of the Colloquium will appear in Report VIII. Inquire for earlier reports and proceedings.)

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