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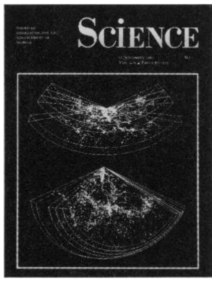

COVER Two views of the distribution of 3962 galaxies in three-dimensional redshift space. The white points display the distribution of galaxies in the right ascension range 8^h to 17^h and declination range 26.5° to 44.5°; the orange in the declination range 8.5° to 14.5°. "The Great Wall" crosses the survey nearly parallel to the outer boundary. See pages 885 and 897. [Graphics by M. J. Geller, J. P. Huchra, E. Falco, and R. K. McMahan]

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Support for Plant Biology

Fundamental research in plant biology should have a higher priority than it presently receives. The level of support has been small in comparison with other fields. Yet few of them can potentially contribute cost effectively so much to international competitiveness, future energy supplies, human health, the environment, and intellectual excitement.

The once great U.S. superiority in global agriculture has atrophied. Technology pioneered here has been adopted elsewhere on land that is as fertile as ours but less expensive. Costs of labor in other countries are usually lower. Our one hope to compete in the long term is better use of our brains, but even there prospects are only fair. Others are active and highly competent in plant research.

Society will ultimately find it necessary to depend heavily on renewable resources for energy and chemical needs. More immediate are concerns about health effects of pesticides. At present, the major focus is on commercial chemicals. However, as Bruce Ames has pointed out, we ingest about 10,000 times more by weight of natural pesticides than synthetic ones. The natural pesticides are present in all plants and commonly make up 5 to 10% of a plant's dry weight. A sizable proportion of the plant pesticides are carcinogenic, and many others are mutagens.

Natural pesticides are part of plant defense mechanisms against insects and other herbivores. Plants have complex biochemical equipment that enables them to respond in many ways to attacks by predators or pathogens.* For example, when an insect or fungus seeks to feed on a plant, it must first penetrate the outer covering of, for example, a leaf. In the process, small molecules are released that elicit responses in the plant. One response is to induce production of proteinase inhibitors in addition to those already present. A function of these inhibitors is to block the protein-digesting enzymes of the predator and thus render the plant protein indigestible. Another defense that plants have is an enzyme capable of hydrolyzing the chitin integument of insects. Another response of the plant is to produce potent chemicals that ordinarily are not present in it. These phytoalexins are powerful antibiotics. Current research is revealing more about the mechanisms while raising further questions to be studied.

Recombinant DNA technology has opened a plethora of possibilities for improving plant defenses. Already foreign genes have been incorporated within the plant genomes that confer improved resistance to pathogens. An example is introduction of a gene coding for a viral protein. The resultant plants showed enhanced resistance to the virus in field tests.

A gene from cowpeas for a proteinase inhibitor was used to transform tobacco plants. The gene was expressed in leaves, and the plants exhibited a relatively high level of resistance to the tobacco bud worm. Ultimately it may be possible to decrease the levels of natural carcinogens in plant seeds and tubers while maintaining resistance to plant pathogens. At the same time, the role of commercial pesticides would be attenuated.

In the foregoing, discussion has been focused on only one aspect of plant biology. The powerful techniques of molecular biology and superb instrumentation make accessible many areas. However, the realities of funding sharply limit the rate of progress.

The USDA has been slow to use the expertise of the broad scientific community. At the USDA, only 6% of R&D support is distributed by competitive grants. At the National Institutes of Health 83% and at the National Science Foundation 90% of funds are furnished in such grants. NIH supplied $6.4 billion in 1988, whereas USDA provided only $40 million in competitive grants. The average annual grant size from USDA is $50,000, in contrast with $71,300 from NSF and $154,900 from NIH. USDA grants have an average duration of 2 years, those of NSF and NIH, 3 years or more.

The Board on Agriculture of the National Research Council has issued an extensive report proposing that $500 million a year in competitive grants be furnished by USDA.† Those funds would be in addition to the current budget. Given the present situation in Washington, such a large addition is unlikely. However, even modest increases would have highly beneficial effects.—PHILIP H. ABELSON

*See C. A. Ryan, *Bioessays* **10**, 20 (1989). †National Research Council, "Investing in research: A proposal to strengthen the agricultural, food, and environmental system" (National Academy Press, Washington, DC, 1989).