conduct experimental research on the farm. The appreciation of technology as a variable is leading to the development of alternative technologies adapted to different socionatural situations. As these emerging orientations become elaborated, they enhance the contributions which behavioral scientists can make to agricultural development.

References and Notes

1. For example, see S. Wortman, *Sci. Am.* **235** (No. 3), 30 (1976); and W. D. Hopper, *ibid.*, p. 196.
2. Organizational and institutional factors refer to input and product markets; research, credit, and extension programs; land tenure; and irrigation arrangements (*3, 4*).
3. R. S. Loomis, *Sci. Am.* **235** (No. 3), 98 (1976).
4. P. R. Crosson, *Science* **188**, 519 (1975).
5. Behavioral science is used in the sense of research dealing with social, cultural, and psychological factors in agricultural development. Although from a disciplinary perspective the fields involved are sociology, anthropology, and social psychology, the point of view expressed here is essentially sociological.
6. E. M. Rogers, *Diffusion of Innovations* (Free Press, New York, 1962). More than 2600 publications on diffusion of innovation are currently reported by Rogers, in "Where we are in understanding innovation," East-West Communication Institute Conference on Communications and Change: Ten Years After (1975), unpublished. Anthropology and social psychology have also made important contributions although they have been somewhat less influential. For example, on anthropology see G. M. Foster [*Traditional Cultures: and the Impact of Technological Change* (Harper, New York, 1962)] and E. H. Spicer, Ed. [*Human Problems in Technological Change* (Russell Sage Foundation, New York, 1952)]. On social psychology, see E. E. Hagen [*On the Theory of Social Change* (Dorsey, Homewood, Ill., 1962)] and D. C. McClelland and D. G. Winter [*Motivating Economic Achievement* (Free Press, New York, 1969)].
7. For example, see B. Ryan and N. Gross, *Rural Sociol.* **8**, 15 (1943). An early summary of diffusion research is provided in G. M. Beal and J. M. Bohlen, *The Diffusion Process* (Special Report 18, Iowa State Cooperative Extension Services, Ames, 1962).
8. Elaborated by E. M. Rogers with L. Svenning, in *Modernization Among Peasants: The Impact of Communication* (Holt, Rinehart & Winston, New York, 1969).
9. In addition to Rogers (*8*), see F. C. Fliegel, P. Roy, L. K. Sen, J. K. Kivlin, *Agricultural Innovations in Indian Villages* (National Institute of Community Development, Hyderabad, 1968). On extension, see J. P. Leagans, "Extension education and modernization," in *Behavioral Change in Agriculture,* J. P. Leagans and C. P. Loomis, Eds. (Cornell Univ. Press, Ithaca, N.Y., 1971), p. 101.
10. This theme is fully explored by K. Griffin, in *The Political Economy of Agrarian Change* (Harvard Univ. Press, Cambridge, Mass., 1974).
11. In partial exception, Lionberger viewed the individual as a member of an informal social group defined by communication links [H. Lionberger, *Rural Sociol.* **19**, 233 (1954)].
12. As policies based on these assumptions are implemented, the outcome is likely to be increased inequality. For fuller critiques of diffusionism, see D. E. W. Holden [*Rural Sociol.* **37**, 463 (1972)] and N. Rolling, J. Asheroft, and F. Wa Chege [*Commun. Res.* **3**, 155 (1976)]. For an earlier expression of concern with the diffusionist approach, see C. P. Loomis and Z. K. Loomis [in *The Uses of Sociology*, P. F. Lazarfeld, Ed. (Basic Books, New York, 1967)].
13. A study conducted by the International Rice Research Institute (IRRI) has identified irrigation, pest control, soil fertility, credit, price policy, farm size, and land tenure as the principal limiting factors. IRRI, *Changes in Rice Farming in Selected Areas of Asia* (IRRI, Los Banos, Philippines, 1975).
14. This tendency has been documented by D. K. Freebairn [*Land Econ.* **45** (No. 1), 31 (1969)] and A. Pearse ["Social and Economic Implications of the Large Scale Introduction of High Yielding Varieties of Foodgrains," Report 74–United Nations Institute for Social Development (UNRISD, Geneva, 1974), 55 pp.]
15. See L. R. Brown, *Futurist* **10** (No. 6), 307 (December, 1976).
16. A useful discussion of this issue appears in C. P. Timmer, J. W. Thomas, L. T. Wells, D. Morawetz, *The Choice of Technology in Developing Countries* (Harvard Studies in International Affairs No. 32, Center for International Affairs, Harvard University, Cambridge, 1975).
17. See C. H. Gotsch, *Am. J. Agric. Econ.* **54**, 326 (1972).
18. Systems theory was originally developed in response to the increasing complexity of modern technology [L. von Bertalanffy, *General Systems Theory* (Braziller, New York, 1968)].
19. I. W. Buddenhagen, personal communication; Dr. Winkelmann, "Comparative cases of farmer adoption of HYV technology," speech at Cornell University, March, 1977. CIMMYT's consideration of ecological variation is based on the research findings of R. Perrin and D. Winkelmann [*Am. J. Agric. Econ.* **58**, 888 (1976)].
20. Formal recognition of the importance of integrating agricultural development concerns within the behavioral sciences is also occurring at the professional level. Both the Rural Sociological Society and the American Anthropological Association have recently organized sections which deal specifically with the study of agriculture.
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22. International Center for the Improvement of Maize and Wheat, *CIMMYT Annual Report 1972* (CIMMYT, Mexico, D.F., 1973), p. 140.
23. W. F. Whyte, "Toward a new strategy for research and development in agriculture," paper presented at the Summer Institute on Science, Technology, and Development. Cornell University, 1976.
24. N. Roling, *Rural Afri.* **27**, 113 (1975).
25. P. E. Hildebrand, "A multi-disciplinary methodology for generating new technology for small, traditional farmers," paper presented at the conference on Developing Economies in Agrarian Regions: A Search for Methodology (Rockefeller Foundation Conference Center, Bellagio, Italy, 1976).
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27. See R. K. Merton, *Social Theory and Social Structure*, R. K. Merton, Ed. (Free Press, New York, 1949), p. 317.
28. See J. K. Boyce and R. E. Evenson, *Agricultural Research and Extension Programs* (Agricultural Development Council, New York, 1975).
29. An exception is the work of Boserup which illustrates the innovativeness of indigenous technology development [E. Boserup, *Woman's Role in Economic Development* (Allen and Unwin, London, 1970).
30. Two examples of recent work in which typologies are used are C. H. Gotsch (*17*) and J. M. Page [*Agrarian Revolution* (Free Press, New York, 1975)].

31. We thank A. Cavazzani, J. Cohen, J. Gilles, V. Gracen, B. Stavis, W. F. Whyte, and L. Zuidema for comments and suggestions.

NEWS AND COMMENT

Arthur Canfield Upton: New Director of the NCI

After an interregnum of nearly a year, the National Cancer Institute (NCI) has a director again—Arthur Canfield Upton, 54, a radiation biologist and former dean of the School of Basic Health Sciences at the State University of New York at Stony Brook. He knows a lot about cancer, can tolerate a certain amount of contradiction in life, and says he thinks he knows what he's getting into as he assumes command of the largest and most controversial of the National Institutes of Health (NIH).

Upton does not believe that vitamin C can prevent or cure cancer—or even the common cold for that matter—but he takes 500 to 1000 milligrams a day "on general principles."

He believes that Laetrile is a fraud but is nonetheless willing to authorize human trials if ethical questions about giving it to cancer patients can be answered.

Upton thinks it is foolish to make the "dogmatic statement that 90 percent of human cancer is caused by environmental factors," but he is certain there is a connection between cancer in people and carcinogens in the environment.

He maintains that anyone who believes there is such a thing as a "single human cancer virus" is "woefully naive," but he is "not a vociferous critic of viral oncology."

In a wide-ranging interview with *Science* on what was theoretically his first full day (28 July) on the job, Upton talked about the national cancer program, basic research, and the highly political arena he has entered. He introduced himself by cheerfully volunteering that he felt "a little strange" about being interviewed. "You see," he said, "I *think* I'm the director of NCI. Here I am anyway. But my appointment has not been made official yet and I really haven't any idea why." The NCI directorship is a Presidential appointment, and Upton had not heard a word from the President. It was not until the next day that Upton learned unceremoniously through a press aide that his papers finally had made it to Jimmy Carter's desk and that the White House officially announced his nomination.

As is often the case when power changes hands, NCI-watchers are attaching to Upton's ascension all kinds of symbolic meaning that may or may not bear any resemblance to reality. The most frequently heard theme is that Upton's arrival marks the downfall of the cancer kingpins who launched the much maligned "war on cancer," and signals the beginning of a new order. No longer, it is said, will the cancer program be run by financier Benno Schmidt or philanthropist Mary Lasker or the officers of the American Cancer Society. It is probably pointless to speculate about how Upton will operate with the many admittedly influential individuals and groups that want a say in how NCI is run. However, it is true that the manner in which he was selected and his own professional background are enough to justify the conclusion that Upton is something of an independent.

How the President "Chose" Upton

The business of selecting a new NCI director began last fall when Frank J. Rauscher, Jr., the first chief of the "war on cancer," resigned when repeated efforts to get Congress to raise his $38,000-a-year salary failed. (Rauscher joined the American Cancer Society as a $75,000-a-year vice-president.) Responsibility for finding a replacement fell to Benno Schmidt, the first and only chairman of the three-member President's Cancer Panel that is meant to be a direct link between the NCI and the White House. Schmidt was open to suggestions but everyone knew that he would make the choice himself. There was no search committee, no lengthy process of screening candidates. In relatively short order, Schmidt settled on Arnold Brown, chairman of pathology at the Mayo Clinic and former member of the National Cancer Advisory Board. Word that Brown was Schmidt's choice sparked little enthusiasm but provoked no strong criticism either and Schmidt sent his name to the White House, hoping against hope that President Ford could be persuaded to act quickly. But it was October, the President was in the middle of the campaign, and no one could be bothered at the time with the NCI. Ford never did get around to making the appointment and the matter fell to the Carter Administration for resolution.

Unlike his Republican predecessors, Carter apparently is willing to let Cabinet members handle "Presidential appointments" of this sort, essentially leaving the decision in the hands of Health, Education, and Welfare Secretary Joseph A. Califano, Jr. Califano decided there should be a search committee. He established one in April and instructed it to report back within weeks with the names of no more than three or four individuals who already had agreed to take the job if offered it.

Eric Poggenpohl

Arthur C. Upton

The search committee was chaired by Ivan Bennett, Jr., provost and dean of New York University Medical Center (NYU). Members included Schmidt, who continued to back Brown, and NIH director Donald S. Fredrickson.* Among Upton's backers was Bennett himself. Fredrickson is said also to have favored Upton. Within a couple of weeks, Califano had the "short list" of candidates he had asked for: Brown and Upton. Committee members said they would be satisfied with either man. Though they leaned toward Upton, there was speculation that Brown might get the job as a courtesy to fellow Minnesotan Hubert H. Humphrey, who was among the congressmen with whom the names were cleared.

As is painfully typical of the process by which political appointments are made, through all of this Brown and Upton were in the dark. At the end of April, Brown told *Science* he had "heard from no one" and was "just sitting around acting like a pathologist and proceeding with my work." Upton said he had not "had a single hint from Washington one way or the other," and was trying to carry on as usual, though he admitted that the "matter intrudes on my consciousness from time to time." "I've just assumed that this appointment is like an airplane stacked up over Kennedy and that sooner or later it will come down," he offered philosophically.

Although Upton is highly regarded in the cancer research community and has been president of the American Association for Cancer Research (1963–1964), he remains something of an outsider to the inner political circles of the NCI and the American Cancer Society (ACS). Upton is an M.D. (University of Michigan—1946) but has no demonstrable ties to the clinicians who run the nation's influential cancer hospitals. He has never served on the National Cancer Advisory Board, though he is a member of the board of scientific counselors that evaluate NCI's intramural research. His association with the ACS has been minimal.

Upton's most visible connection to NCI occurred during the past couple of years when he was chairman of the Radiation-Carcinogenesis panel of a three-group committee to evaluate the risks and benefits of mammography in screening for breast cancer. The jointly sponsored NCI-ACS breast cancer screening program, to which the leaderships of both organizations were committed, carried something of the aura of a sacred cow. Upton's group was the first to state unequivocally that it had substantial flaws. It was Upton's data and his clear and persistent defense of them that, more than any other single factor, led the NCI to abandon routine breast x-rays for women under 50 (*Science*, 13 August 1976). A lot of the clinicians (many of them surgeons) who run the breast cancer screening centers think Upton and his kind, who are persuaded more by "theoretical" estimates of radiation risk than by day-by-day experience in the operating room, have done the cancer program a grave disservice. If he has any reluctant supporters as he comes to office, it is here.

After graduating from medical school, Upton stayed at the University of Michigan for 5 years for his internship and residency in pathology. Then, in 1951 he moved to the Oak Ridge National Laboratory in Tennessee where he remained for 18 years, concentrating on experiments on the effects of long-term exposure to low levels of radiation. Even in his research, Upton's ties to the NIH-NCI establishment have been slight. Whereas it is commonplace (and perfectly understandable) for most biomedical researchers to depend on NIH for their daily bread, Upton's support came primarily from the Atomic Energy Commission which was interested in his work on the relation between low-level radiation exposure and leukemia, among other things.

Inevitably, one of the first questions Upton gets—from the press, from scientists, from Congress—has to do with NCI's support of environmental re-

*Other members of the committee were: Bruce Ames, University of California at Berkeley; Harold Amos and Mary Ellen Avery, Harvard; Robert Gallo, NCI; and Charles Moertel, Mayo.

search and cancer prevention. It is increasingly popular to talk about cancer as an environmental problem, and NCI has been roundly criticized for not pumping more money in this direction. Some see in environmental carcinogenesis research the answer to many, indeed most, questions about cancer. Others see it as a fad and worry that NCI may go overboard in response to environmental hype.

Upton does not seem to be a man likely to go overboard, however. Former colleagues at Oak Ridge recall that the kinds of experiments he did required long-term observations of hundreds of animals and great commitment and patience; it was not the kind of work that led to a paper a month. "If anyone really has the experience to understand environmental carcinogenesis—and not many people do—it is Art Upton," one of his admirers said.

Upton, for his part, sees public awareness of environmental factors in cancer in historical perspective. "There has been a remarkable change of attitude in the past decade," he remarked, noting that when he began his own research career "there was great doubt that there was a relationship between cancer and exposure to small doses of radiation or that one could make linear extrapolations downward from what we knew about one-time exposure to massive doses. Now, we're beginning to understand—about radiation, about chemicals, about smoking. It is revolutionary. But I also believe that genetics plays an important part in the development of many cancers. We can't write it all off on the environment."

If one were going to put new emphasis on certain areas of research, what would it be? "We need a lot more good epidemiology," Upton observed. "It can tell us not only about environmental factors but also about genetic influences and we really do need to know about both." Another area in need of special attention is screening of suspected carcinogens. Even though there has been progress recently, science has a long way to go to achieve the kind of accurate, fast testing people would like—what Upton idealizes as a "tumor in a test tube within 48 hours." Citing just one of the current limitations, he says, "We think there is a better than 90 percent correlation between mutagenicity, which we can detect fairly easily, and carcinogenicity. But 90 percent isn't good enough, especially when we *know* that some cancer-causing hormones such as DES [diethylstilbestrol] aren't mutagenic in tests we have."

One environmental issue that is bound to raise substantial controversy is whether NCI should assume responsibility for testing the hundreds of chemicals that have to be screened under the Toxic Substances Control Act. Sentiment within NCI is sharply divided, the environmental scientists, whose numbers would grow were NCI to take on testing, being more or less for it, the rest being distinctly opposed. "NCI will be destroyed if it becomes a testing and regulatory agency" is a common forecast. On this issue, Upton seems to be of two minds. "I have no doubt that it is NCI's responsibility to do *research* on testing," he says, "but I don't know about the testing itself. Certainly I'd be against it if it would eat up our budget, and I suppose it could. But my gut feeling is that we have a duty to involve ourselves in this."

Upton's interest in environmental carcinogenesis should not be construed as evidence of lack of support for other areas of research—particularly not viral research, which has in the past several years consumed considerable amounts of NCI's money and attention. He sees viral oncology as a problem of genetics, of "understanding the information in viral genes, not trying to get a whole virus out of a tumor," and expects "great headway in the next decade."

In fiscal terms, the next decade—or at least the start of it—is likely to be a more modest one for NCI. Much of the political rhetoric that accompanied the passage of the National Cancer Act of 1971 has died down now. And those who, from the beginning, warned against NCI growing too big too fast are being heard. Sentiment now leans in favor of restoring a modicum of balance among the NIH institutes and bringing NCI back into the fold. Upton seems sympathetic. "Cancer is a biological problem," he says. "I can't see NCI fluorishing separate from NIH." Upton comes to his job armed not with stentorian pronouncements but with a moderate, patient attitude that may be just what NCI needs.—BARBARA J. CULLITON

China After Mao: Science Seeks to Be Both Red and Expert

The Chinese, who invented printing, gunpowder, paper, and the clock, seem about to go at it again by placing new emphasis on science and technology, and particularly on the role that they can play in the modernization of their vast country.

The leaders who have come to power since the death of post–World War II leader Mao Tse-tung in September 1976, have included science and technology as one of the "four modernizations" on which they place top priority. Chinese journals, papers, and broadcasts in recent months have been loaded with assertions about the importance of science and technology, and how scientists should not only practice their individual talents but also remember the class struggle so they can be, in one popular slogan, "both Red and expert."

The campaign to upgrade science and technology still consists mostly of propaganda, but American experts and others who have visited China recently believe that the new line presages real change in the way China spends her resources, in the technology she will seek from abroad, and in the Chinese educational system.

The emphasis represents a new crest in the up-and-down cycles science and technology have experienced in China under Communist rule. Science and technology enjoyed political favor in the mid-1950's, when China was emulating the Soviet Union, and again in the mid-1960's. But each period of favor has been followed by a downgrading, first in the Great Leap of 1958 and then in the Cultural Revolution of 1966. During the Cultural Revolution, universities were closed and scientific journals ceased publishing. When, in the early 1970's, universities and technical institutes reopened, it was without exams and with the requirement that students and their teachers go "down to the countryside" for prolonged periods to work on farms or in factories, so they would not become too "expert" and would also serve by being suitably proletarian and "Red."