Editorial & Letters

EDITORIAL

The Future of U.S. Science Policy

Although the United States' science and technology enterprise has achieved enormous success, it is essentially operating on autopilot. The policies that Vannevar Bush outlined in his 1945 report *Science—The Endless Frontier*, still, to a large extent, guide the research enterprise. The context in which science and technology presently operate, however, has changed remarkably since publication of *The Endless Frontier*. At the end of World War II, public support for funding of science was seen as critical in ensuring our nation's defense; the end of the Cold War has brought with it a vacuum in terms of a national imperative to justify research funding. Furthermore, the continuing increase in the cost of federal entitlements has caused decreases in federal research and development spending. The federal government cannot fund every worthwhile scientific project; thus, a policy for determining priorities is essential.

The changes are not limited to funding. Today, for example, the link between basic and applied research seems neither as clear nor as unidirectional as was once thought. Some large-scale scientific projects require more international participation. U.S. students are turning their backs on Ph.D. programs, seemingly viewing them as the training grounds for professions only some of them can enter. Our country's citizens are alarmingly scientifically illiterate in an era when the economy is increasingly driven by technology-based industries. In addition, as was pointed out in a recent editorial (*Science* 23 May, p. 1175), much of the scientific community remains unversed in political realities. These new times require us to reformulate our national science policy. I have been given that charge by House Speaker Newt Gingrich and House Science Committee Chairman James Sensenbrenner, who have also asked me to undertake a review of science and math education. Both will be bipartisan projects conducted within the auspices of the Science Committee, with recommendations stimulating a "national debate in Congress on science policy," according to Chairman Sensenbrenner.

It is important that such a policy be concise so it does not die of its own weight, as some previous attempts have. It must be comprehensive enough to encompass government, universities, and industry, and their relationships to science, technology, and engineering, and to each other. Finally, it must be coherent in that the parts must fit together; it must be a usable guide for Congress. To succeed, it is crucial that the policy be approved by the House, the Senate, and, ideally, the White House.

George Brown, the ranking minority member of the House Science Committee, summed up the present situation by saying, "We don't have a science policy; we have a budget policy." It is time to wipe the slate clean and decide on a future-based vision of where science can, and should, take the nation. Gingrich, in a recent speech to a group of scientists, urged us not to take the approach of working around the margins of our existing system when he said, "Give me a mission which will mobilize a nation … then make it my problem to go out and figure out how to find the money for it."

Thus, I ask each of you, "What are the most important intellectual challenges rising over the scientific horizon in the next half century? What will be the biggest problems facing our nation and our planet in the future, and how can science and technology help overcome or avoid them? What should our scientific and technological enterprise strive to be 10, 20, or 50 years from now? And what changes do we need to make in our present system in order to get there?" I do not ask these questions rhetorically. In October I heard from a number of leaders in science about where we need to go from here. Last month I met with a group of scientists in the early stages of their careers to obtain their perspective. And this spring, the Science Committee intends to hold hearings addressing these questions. I seek your input, too. You can contribute—as individuals, scientific societies,* or institutions—via the policy study's Web site at www.house.gov/science/science_policy_study.htm, which will be periodically updated with our progress and with specific requests for your contributions. Science has changed since 1945, and so has the world. It is time to address these changes and chart our course correspondingly.

Vernon J. Ehlers

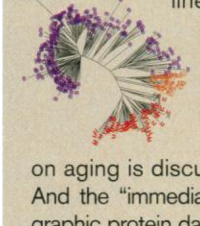
*AAAS will contribute to Representative Ehlers' Web site through its AAAS Conversation on Science and Society. The site is located at www.sciencemag.org/feature/data/aaasforum.shl.

The author is a Republican congressman from Michigan and vice chairman of the House Science Committee.

LETTERS

Roots and branches

A DNA fingerprinting study of einkorn wheat prompts a discussion about wheat genetics and the geography of its first domestication. [Left, tree showing genetic distances between some lineages of wheat; from M. Heun *et al.*, *Science* **278**, 1312 (1997)]. Pharmacological, clinical, and long-term observational research on aging is discussed by investigators. And the "immediate release" of crystallographic protein data is proposed.



Wheat Domestication

In their report "Site of einkorn wheat domestication identified by DNA fingerprinting" (14 Nov., p. 1312), Manfred Heun *et al.* make the interesting association between the genetic makeup of wild einkorn in the Karacadağ mountains in Turkey and the presence of nearby archaeological sites associated with early farming. They infer that the domestication, around 10,000 years ago, of einkorn and perhaps other founder crops was localized in this region. They also summarize the uncalibrated radiocarbon dates associated with the relevant archaeological sites. These range between 7600 and 6200 B.C., with domesticated einkorn first recorded at 7000 B.C.. Earlier farming sites are located about 800 kilometers to the south. At Jericho, Netiv Hagdud, and Gilgal (in the Jordan Basin), and Aswad (near Damascus), domesticated einkorn, emmer, and barley appear between 8000 and 7700 B.C. (*1*). In short, the Turkish sites are, according to published data, several centuries too recent to be contenders for the earliest farms.

Two observations are relevant. First, archaeological evidence for early domestication repeatedly does not map precisely onto the relevant genetic centers. In Central America, the early maize cobs from the Tehuacan occur several hundred kilometers east of the stands of wild maize genetically closest to cultivated maize. The earliest known rice-growing settlements, along the Yangtse River, lie well to the north of the core region of wild-rice diversity (*1*). Second, for various reasons, these geographical mismatches are not unexpected.

The hypothesis of a simple relationship between modern centers of genetic diversity and origins of domestication was proposed by Vavilov (*2*) before the dramatic advances in our understanding of changes in the Quaternary world. His then reasonable assumption of general biogeographical stability is now increasingly difficult to sustain, such was the scale and pace of early Holocene climatic change. Even where we can predict these shifts, we may still not expect domestication to occur at the core of a species' distribution. If fields of wild cereal are naturally thriving, why cultivate them? The added value of domestication is much easier to reconstruct out on the margins of a species' distribution than at its core. On a global scale, centers of past domestication will not be vast distances from centers of present genetic diversity, but the match is likely to be approximate.

The work of Heun *et al.* brings a valuable new data set to studies of early farming. However, the best evidence to date does not place the earliest farms and the closest wild relatives to domesticated einkorn in the same place. This difference should be expected, and we should not merge the two data sets to explain the origins of agriculture as a single, localized event. The earliest evidence of domestication in the Near East involves several species of crop, not einkorn alone, each with its own distinct genetic and biogeographical record. Our view is that the likelihood that the archaeological and genetic data for this suite of domesticated species can be conflated into a single event is diminished, not enhanced, by this recent work regarding einkorn.

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1. B. D. Smith, *The Emergence of Agriculture* (Scientific American Library, New York, 1994).
2. N. I. Vavilov, *Studies on the Origin of Cultivated Plants* (Institut Botanique Appliqué et d'Amélioration des Plantes, Leningrad, USSR, 1926).

Heun *et al.* identify a convincing progenitor for einkorn in the Karacadağ region of southern Anatolia. They also state that the this region is the most likely place where the cereal was first domesticated, but they do not discuss the fact that climate and the resultant pattern of vegetation in the Fertile Crescent have changed: Today, there is no precise analog to the situation of 11,000 years ago.

Why is this so? The Earth at that time had just emerged from the Younger Dryas, a period of near-glacial climate. The termination of the Younger Dryas coincided with the onset of pronounced warming, which elevated temperatures and precipitation above levels seen today (*1*). This combination of effects gave rise to the Mediterranean climate, which characterizes the region today and favors the growth of annual species, including the cereals (*2*). Because of the pattern of climate rebound after the Younger Dryas, it is unlikely that the Karacadağ region was the site of the first domestication; rather, the site should be sought farther to the south. A candidate archaeological site is Abu Hureyra, on the middle Euphrates of Syria, where einkorn and other species—which today are typical of montane zones like Karacadağ—have been recovered (*3*). Regardless of where the progenitors of any economic species lived, their domestication was a human achievement that depended on a combination of technological and social adaptations, as well as the availability of the requisite species (*4*).

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2. R. Byrne, in *Studies in the Neolithic and Urban Revolutions*, L. Manzanilla, Ed. (British Archaeological Reports International Series, Oxford, 1987), vol. 349, pp. 21–34; F. Di Castri, in *Mediterranean-Type Shrublands*, F. Di Castri, D. W. Goodall, R. L. Specht, Eds. (Elsevier, New York, 1981), vol. 11, pp. 1–52.
3. G. Wilcox, *A. R. X. World J. Prehist. Anc. Stud.* **1**, 9 (1995); *Vegetation Hist. Archaeobot.* **5**, 143 (1996).
4. J. McCorriston and F. Hole, *Am. Anthropol.* **93**, 46 (1991).

Response: With regard to the letter by Jones *et al.*, the most recent and complete review of the radiocarbon data is that of Nesbitt and Samuel (*1*); table 2 in their paper summarizes the available (uncalibrated) data (*2*). We controlled for their sources in our report. Jones *et al.* question our hypotheses on the origin of farming, but data on the domestication of einkorn that they cite match our data [compare their reference 1 to our note (*2*)]. The relation of archaeological to genetic data is a matter of debate: the frequently cited book of Zohary and Hopf (*3*) argues that data from these two disciplines complement and agree with each other.

With regard to the letter by Hole, Hillman (*4*) also suggests that in the late Pleistocene, *Tritcum monococcum* subspecies *boeoticum* may have grown near Abu Hureyra and Mureybit, two excavated sites in Syria. The problem with naming these as the sites of first domestication is that charred seeds of wild *T. m. boeticum* have been abundantly found, but no spikelets remain there. It has been hypothesized that wild einkorn was gathered at a distance, threshed at the camp collection site to reduce the volume, and transported (*5*). Where it was taken is not known. We have reported that *T. m. boeoticum* from Karacadağ is the progenitor of the cultivated einkorn and that the excavated sites cited in our report (which are near those mountains) reveal a transition from wild to cultivated genotypes. These were the observations on which the title of our report was based.

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References and Notes

1. M. Nesbitt and D. Samuel, in *Hulled Wheats*, S. Padulosi, K. Hammer, J. Heller, Eds. (International Plant Genetic Resources Institute, Rome, 1996), pp. 41–100.
2. The data available are Abu Hureyra, Prepottery Neolithic, 7700–5000 B.C., cultivated einkorn; Cafer Höyük, PPNB, 7600–6200 B.C., wild and cultivated; Cayönü PPN, 7500–6700 B.C., cultivated; Nevali Cori, PPNB, 7200 B.C., cultivated; and Jericho, PPNB, 7200–6800 B.C., cultivated. Other cited sites are more recent, including Tell Aswad (II), PPN, 6900–6600, B.C., cultivated. For Jericho, PPNA, 7400 B.C.; Tell Aswad (I), PPN, 7800–7300 B.C.; and Netiv Hagdud, PPNA, 8000–7400 B.C., no einkorn data are available.
3. D. Zohary and M. Hopf, *Domestication of Plants in the Old World* (Clarendon, Oxford, 1993).
4. G. Hillman, in *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, D. R. Harris, Ed. (University College London Press, London, 1996), pp. 159–203.
5. W. Van Zeist and W. A. Casparie, *Acta Botan. Neerl.* **17**, 44 (1968); G. C. Hillman, in A. T. M. Moore, *Proc. Prehistoric Soc.* **41**, 70 (1975); W. Van Zeist and J. A. H. Bakker-Heeres, *Palaeohistoria* **26**, 171 (1984).

Aging and Endocrinology

In their article "The endocrinology of aging" (17 Oct., p. 419), Steven W. J. Lamberts *et al.* describe many aspects of aging that are benefited by dehydroepiandrosterone (DHEA) or testosterone replacement. Not mentioned is the decline in melatonin production, correlated with increasing age-related disfunction, that can be partially ameliorated with melatonin therapy (*1*). Neither was there discussion of multiple hormone supplementation, synergistic effects, or other studies of the simultaneous replacement of DHEA and melatonin (*1, 2*).

In young mice with murine-acquired immune deficiency disease that results in B cell leukemia or in old mice with immunosenescence, replacing melatonin and DHEA had a synergistic effect: cytokine and immune regulation were normalized, and increased oxidation and loss of vitamin E were prevented (*3*). In older humans, we have found no toxicity resulting from supplementing melatonin and DHEA for 1 year. Also, treatment with melatonin, DHEA, and vitamin E together led to the regression of esophageal dysplasia in older people.

Lamberts *et al.* correctly note that many, perhaps millions, of Americans (and their doctors) are esentially testing the hypothesis that supplementing DHEA, melatonin, or testosterone will slow aging. Our studies suggest that long-term human trials should test the effectiveness and toxicity of not only single, but multiple, hormone replace-