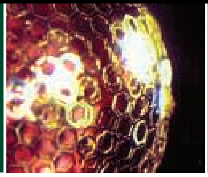

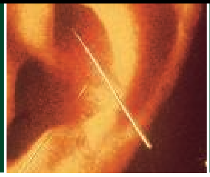

LETTERS

edited by Etta Kavanagh

How and When Was Wild Wheat Domesticated?

ESTIMATING THE TIME SPAN OF PLANT DOMESTICATION IS FUNDAMENTAL TO UNDERSTANDING AND reconstructing the cultural processes underlying the "Neolithic Revolution." In their Brevia "How fast was wild wheat domesticated?" (31 Mar., p. 1886), K. Tanno and G. Willcox argue for a gradualist model for wheat domestication in the ancient Near East and suggest that the domestication of cereals took over a millennium. Their biological explanation includes the difficulty of isolating nonbrittle spike genotypes and occasional collection from the wild at times of crop failure. This model is an important advance; however, several points require clarification.

First, spike disarticulation in wheat and barley is governed by major genes on chromosome group 3 (*1*), and therefore it is unlikely that the incipient farmers would have faced difficulties had they tried to select for such a phenotype once they noticed it in their cultivated fields.

Second, following Kislev *et al.*, it appears that considerable amounts of wheat and barley spikelets/grains may be gathered from the ground, after spike shattering (*2*). This may provide a possible mechanism underlying the gradual emergence of domesticated wheat, which is missing from the Tanno and Willcox model. If such practice persisted in early cultivated fields, it follows that the establishment of nonbrittle types would have been considerably delayed. This would probably be more significant than the effect of occasional gathering from wild stands, as suggested by Tanno and Willcox.

Third, in the context of the emergence of Near Eastern farming, the description of domestication as a series of events occurring at different places does not automatically follow from the data presented, nor is it in line with genetic evidence concerning chickpea, lentil, einkorn, and emmer wheat domestication, suggesting a localized event (*3*, *4*).

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IN THEIR BREVIA "HOW FAST WAS WILD WHEAT domesticated?" (31 Mar., p. 1886), K. Tanno and G. Willcox provide an interesting viewpoint regarding the possible rate of wheat and barley domestication during the Neolithic period. The authors wrongly assume that jagged broken nodes appear only on domesticated threshed cereals. Wild species produce jagged broken nodes on up to 10% of their spikelets, namely, those coming from the lower part of the ear (*1*). In addition, presenting the domestication of barley, einkorn, and emmer as proceeding with comparable rates seems inappropriate in view of their different anatomies, ecologies, and geographical distributions.

The authors did not fully consider the harvesting possibilities that would have affected the concentration of domesticated mutants with disarticulated ears in the plant population. Their suggestion of harvesting before full maturation helps us to understand how domestication occurred for short-awned einkorn. All wild cereal fields host early- and late-ripening plants. Therefore, when a field was harvested before full maturation and the disarticulation mutation occurred in early-ripening plants, these plants would experience a significant selective advantage. The harvested early-ripening plants produced larger grains with a higher germination capability than the later-ripening plants gathered with them. Consequently, sowing these grains would have automatically increased their percentage of germination and favored mutation accumulation in the population.

This accumulation mechanism can be applied to the short-awned einkorn, which was harvested by sickle. In contrast, long-awned emmer and barley can also be collected from the ground (*2*). The cereals growing in the south of the Fertile Crescent mature and disarticulate more quickly than those growing in the north, where einkorn was domesticated (*3*). Therefore, it is much more likely that early farmers collected fallen emmer or barley from the ground. Because only a fraction of the southern crops would have been harvested by sickle before full maturation, emmer and barley domestication would be expected to require an even longer period for domestication to take hold.

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Response

LEV-YADUN *ET AL.* RAISE THREE IMPORTANT points concerning wheat domestication. First, they are correct that selection for a phenotype that had lost its ability to disarticulate could be easy (*1*). However, it is not clear whether early farmers would have recognized rare nonshattering plants, and if they did, whether they

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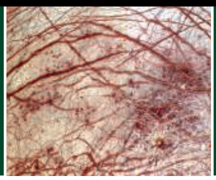

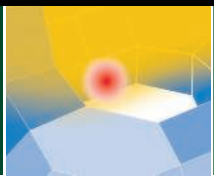

would have considered them advantageous. Isolation of nonshattering plants from shattering ones would have been difficult to achieve. If farmers succeeded in isolating nonshattering plants, they would create a homologous single-lined nonshattering population (these are predominantly self-pollinating plants) at the expense of a population consisting of diverse landraces. This would drastically decrease crop diversity, but may have increased its vulnerability (*2*) and hence would not have been so advantageous.

Second, we consider harvesting fallen spikelets from the ground in cultivated fields (also mentioned by Hartmann *et al.* in their Letter) to be improbable, particularly in light of archaeological evidence that farmers used sickles to harvest cereals. Micro-wear analysis of flint blades recovered from archaeological sites for the period indicates that they were used for harvesting cereal stems (*3*, *4*). A disadvantage of harvesting fallen spikelets is that the products become contaminated with soil.

Third, the genetic evidence (*5*) may identify the locality where ancestral populations grow today, but this does not rule out a series of events occurring at different places and different times. For example, a population of wild einkorn was identified and localized as the wild ancestor of domestic einkorn (*6*). This population may still have been domesticated more than once either in or outside its present-day habitat. Some domestication events may not be on the genetic record because cultivars have disappeared, and present-day populations represent a fraction of those in the past (*7*, *8*). Wild progenitor habitats have been reduced through human impact. These impoverishments were particularly strong in the area where agriculture arose.

Hartmann *et al.* are correct that a wild population can produce up to 10% of domestic type disarticulation scars, which come from the base of the ear (*9*, *10*), but this does not affect our interpretation. Their second point, that we present barley, emmer, and einkorn domestication as proceeding with comparable rates, is not the case. We are aware that our data are too fragmentary for such a conclusion; we observed that wild types persist alongside domestic types on the sites mentioned and indeed at other sites (*11*, *12*), which suggests that domestication was slow to become established.

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Maintaining the Foundations of Science

I APPLAUD THE RECENT EDITORIAL ("SCIENCE AS smoke screen," S. C. Trombulak *et al.*, 19 May, p. 973) decrying changes to the U.S. Endangered Species Act of 1973 outlined in the bill H.R. 3824. I attended the mark-up of H.R. 3824 in the House of Representatives Resources Committee and witnessed firsthand the contentious nature of the bill, as well as the influence of strong political will on the success of this legislation. I am concerned that given the current political direction and climate in the United States, the suggestion that an independent scientific advisory panel be assembled to advise the U.S. Secretary of the Interior on relevant scientific issues misses an important point. Although such a panel could be a step in the right direction, unless an entirely new framework for federal advisory committees is established, this panel ultimately would be at the discretion of political appointees. Thus, a new panel would likely be prone to the same fate as the Department of Energy's Scientific Advisory board: disbanded after a closed-door meeting (*1*). The abolishment of this independent board, reportedly because it was being deemed unnecessary (*2*) after nearly 16 years of service, demonstrates the lack of value ascribed to scientific input by the current administration and their subordinates. We need to emphasize creative solutions that provide an avenue for science in relevant policy-making and to protect this channel from the whims of changing political pressures or personalities.