plain the enigma of the mechanism of heartwood formation in living trees on the basis of a simple generalized process of excretion. Many excretory products have toxic or inhibitive properties with respect to the protoplasts of living cells and seem to be translocated along the rays away from the regions of secondary growth; that is, in the xylem they are translocated toward the center of the stem or branches.

Initially the xylem is composed entirely of sapwood, but in the region of the pith the concentration of toxic substances increases, and eventually the continued accumulation of excreta results in the death of all living xylary parenchyma cells near the pith, and so the first cylinder of heartwood is formed. The continuation of the process of translocatory excretion results in the outward movement of the sapwood-heartwood boundary.

The formation of tyloses and certain changes in moisture content within the sapwood seem to be associated with the formation heartwood in living trees.

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Distribution of Wild Wheats and Barley

The present distribution of wild forms may provide clues to the regions of early cereal domestication.

Jack R. Harlan and Daniel Zohary

The last decade has witnessed a major breakthrough in our understanding of the start of agriculture in the Old World. Archeologists, anthropologists, prehistorians, and historians have teamed with botanists, zoologists, and geologists in a concerted effort to discover when, where, and under what circumstances early domestication of cereals came about. Recent excavations that have yielded critical information include Ali Kosh, Tepe Sabz, and Tepe Sarab in Iran, Jarmo and Jawi Chemi Shanidar in Iraq, Çatal Hüyük, Hacilar, and Çayönü Tepesi in Turkey, Ramad in Syria, and Beidha in Jordan (*1*). Some of these sites have yielded abundant archeobotanical material, much of which has been critically examined by Hans Helbaek of the Danish National Museum (*2, 3*).

It is clear from these studies that, by 7000 B.C., more or less permanently occupied farming villages had been established over a wide arc from Khuzistan in southwest Iran, through the hilly country of the Zagros and Taurus mountains of Iran, Iraq, and Turkey, into central and western Anatolia and southward into Palestine. The permanence of these villages was made possible by cereal domestication that had taken place at some time preceding 7000 B.C. The first plant domesticates of major importance throughout the region were (i) two-rowed barley, (ii) emmer wheat, and (iii) einkorn wheat. Various leguminous crops and flax were also common at this time, but they were never as important in the diet as the early cereals. It is largely on the energy supplied by the wheats and barley that the first civilizations subsequently emerged in the Near East, and it was wheat and barley that made it possible for man to move from hunting and food collecting to farming in that region.

The present distributions of the wild forms of the three cereals could provide important information on the place or places of origin of Neolithic agriculture, provided they are properly interpreted. Any interpretation of mod-

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ern distributions must take into account (i) the possibility that the climate and the associated life zones may have changed in the last 10,000 years, and (ii) the possibility that the wild progenitors themselves changed, producing weed races whose ranges enlarged after the spread of agriculture churned up the landscape.

But, before any interpretation at all is possible, the present distributions of the wild forms must be established. When we became interested in this problem several years ago, we were amazed to find how little was known about the detailed occurrence and ecological behavior of the wild races of our domesticated cereals. The purpose of this article is to bring together in one place information we have been able to obtain on the present distribution and ecological behavior of the wild wheats and barley, and to try to interpret the significance of this information in relation to the origin of these important crops.

Nomenclature

The taxonomy of cultivated plants has traditionally suffered from a proliferation of names. No agreement has ever been reached as to a "correct" classification, but the excessive number of specific epithets and even generic names implies greater differences between taxa than the biological evidence can support. *Hordeum spontaneum* C. Koch is the most commonly used epithet for the wild and weed barleys. However, *H. spontaneum* has the same chromosome number as cultivated barley (*H. vulgare* L.); crosses between them are easily made, and hybrids are not uncommon in nature. The chromosomes show perfect pairing in the F_1 generation, and the hybrids are fully fertile. Wild and cultivated barleys do have different methods of seed dispersal, are adapted to different ecological situations, and do have different geographic ranges, but cytogenetically they belong to the same species. Such differences are usually recognized, in classification of noncultivated species, by use of an infraspecific epithet such as subspecies or botanical variety. The situation for the einkorn and emmer wheats closely parallels that for barley.

Bowden (*4*) has given a classification that recognizes the biological facts of life, but when the international rules of nomenclature are followed, strange and unfamiliar names and combinations are called for. In this article we simply use the terms *wild* and *cultivated*, but we also mention some of the commonly used names for the convenience of the reader. It should be emphasized that the wild and cultivated forms are very closely related in each case and would normally be included in the same species.

Barley

Probably the most important of the early cereals was barley. Analyses of archeobotanical material by Helbaek show clearly that the first barleys were two-rowed and resembled rather closely some races of the spontaneously occurring barley found in these regions today. Morphologically, the differences between cultivated two-rowed barley and the spontaneous forms are rather minor. The cultivated forms have a tough rachis that does not break even on threshing, while the wild forms have a brittle rachis that disarticulates at maturity into individual units each containing one seed and two sterile lateral spikelets. While the fragile rachis is a major adaptive feature distinguishing wild from cultivated barley, it is controlled by only two genes. Cytogenetically, there is no difference between wild and cultivated forms. They can be crossed readily; they hybridize rather commonly in nature, and the chromosomes of the hybrids give perfect pairing at meiosis.

Known and reasonably certain sites

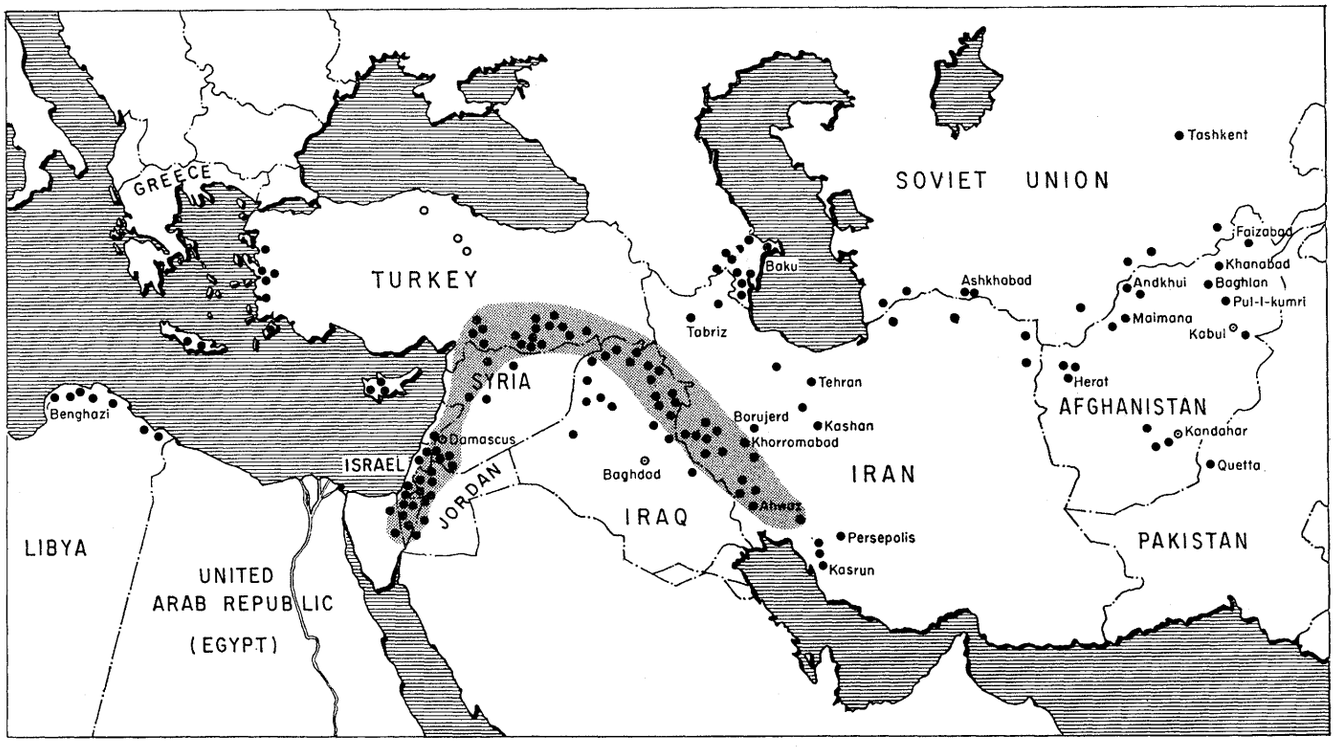

Fig. 1. Distribution of known and reasonably certain sites of wild barley. Massive stands in fairly primary habitats may occur within the shaded area. Elsewhere, wild barley may be abundant, but confined to highly disturbed habitats.

Fig. 2. Scatter of early farming villages and incipient farming sites so far excavated.

for wild barley are shown in Fig. 1. Locations of the sites in Turkey, Israel, and Iran are based mainly on our collections. Sites in Afghanistan are based on original collections by Vavilov, Gentry, Smith, Kihara, and Harlan which are a part of the viable collection of the U.S. Department of Agriculture. Several of the sites in the Soviet Union are also based on viable material, recently supplied to the U.S. Department of Agriculture by F. Kh. Bakhteyev (*5*). Most of the other sites are based upon specimens in the herbaria at Kew, Edinburgh, and Jerusalem. The two sites on Crete were reported by J. D. Hayes of Aberystwyth, Wales, who also collected in the western Turkish enclave near Izmir. The sites in North Africa are based in part on collections by Maire (*6*), and those in Sinai, on collections by Täckholm (*7*). Other useful floras are those of Mouterde (*8*), Pampanini (*9*), Komarov (*10*), and Grossheim (*11*). The three sites (open circles) in northern Anatolia were reported by Orlov (*12*), who indicated that wild barley was rare in those parts. With this statement we can certainly agree. We have both crisscrossed the Anatolian Plateau without ever finding wild barley, and we do not believe it to be a part of the natural vegetation there.

In general, wild barley does not tolerate extreme cold and is only occasionally found above 1500 meters. It has quite a wide ecological range, however, and is composed of a number of rather distinct races differing in ecology or morphology. Some races appear to be adapted to rather primary habitats while others are very weedy and have, no doubt, spread as a result of the disturbances of agricultural settlement.

The race so abundant in southeast Turkey and through the hilly parts of Iraq and along the slopes of the Zagros, at elevations from 500 to 1500 meters, in Iran is a weed race found primarily along roadsides, along the edges of fields, in gardens, and even on rooftops and mud walls. Scattered throughout the same area, however, are stands of wild barley in rather primary habitats. Wild barley must be considered a natural part of the rich grass cover of the open-woodland *Quercus brantii* belt in the Zagros of Iraq and Iran. It is clear that the weed race has spread out of this more or less original habitat into cultivated and heavily disturbed areas throughout the region.

At the upper margins of its present range wild barley seems to be always a weed of disturbed sites, while downslope it frequently spills out of the oak woodland zone and becomes a natural component of the annual flora of steppe and desert wadi bottoms. Indeed, a special wadi race can be recognized, distributed from the Negev and Sinai northward to the Turkish border and eastward to southern Afghanistan. Elevations for this race range from about 600 meters above sea level to 350 meters below sea level in the Jordan rift. It is a small, slender, very "grassy" type, easily distinguished from the more robust races of the lower, oak woodland belt. Intermediate types are often found about the edges of the plains and deserts, and when the Bedouins cultivate a little barley in the wadi bottoms in the good years, hybrid-swarms between the wild wadi race and cultivated barley can often be found. We consider the rather ephemeral annual flora of the wadis to be mostly natural, and the wadi race to be essentially a wild plant, modified only slightly by occasional introgression with cultivated barley.

Another distinct race is abundant in southwestern Syria, northwestern Jordan, and northern Israel; it is characterized by extremely large seeds, extraordinarily long awns, and a remarkable robustness in all features. While it has some segetal habits, it, too, is found in rather primary habitats and nonarable areas. This race is a natural component of the lush herbaceous vege-

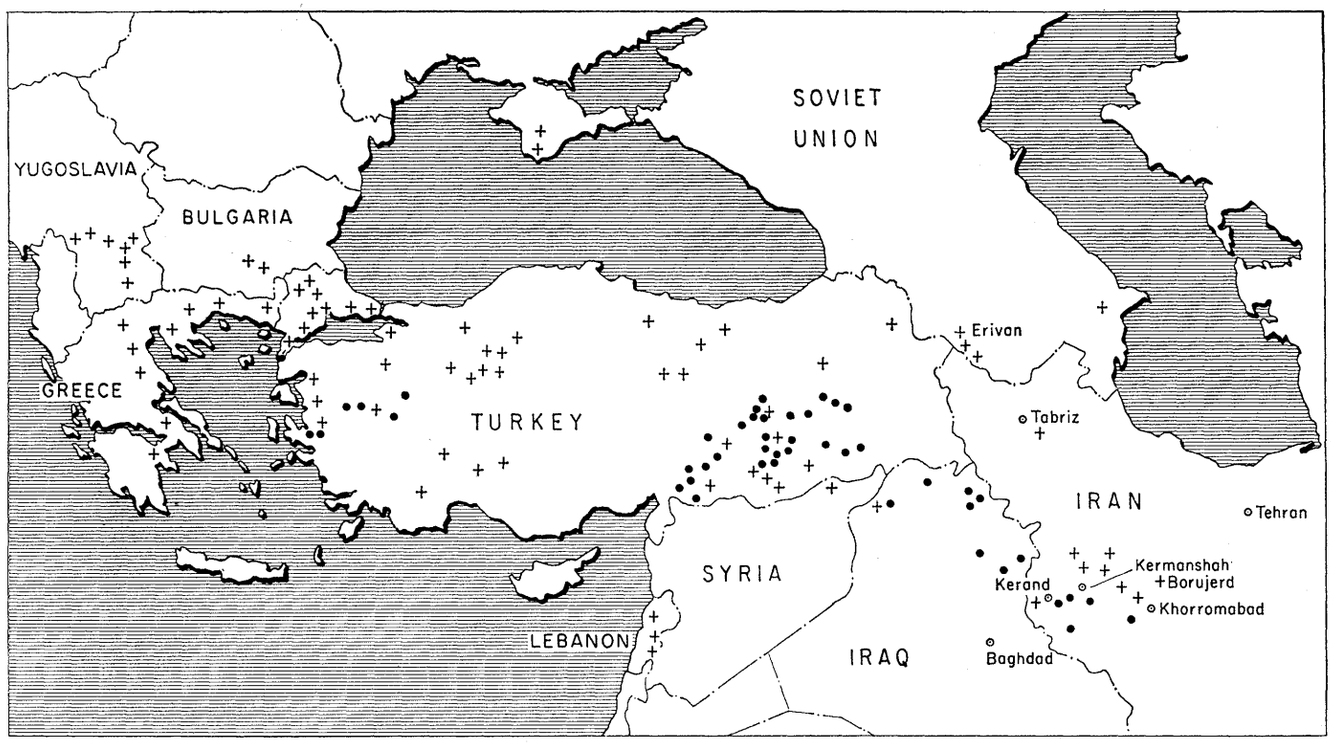

Fig. 3. Distribution of known and reasonably certain sites of wild einkorn wheat. (Solid circles) Fairly primary habitats; (crosses) definitely segetal habitats.

tation characteristic of the *Quercus ithaburensis* park forest belt in the catchment area of the Upper Jordan Rift Valley (eastern Galilee, Gilead, Hauran, and the lower slopes of Mount Hermon) and has probably not spread greatly since the arrival of agriculture. At the lower elevations in the rift, and toward the south and east, it tends to introgress with the small wadi race, and at higher elevations and toward the north it grades in the direction of the Turkish-Iraqi race already described.

The material found in Cyprus, Crete, western Anatolia, northern Iran, and southern U.S.S.R. appears to occur in secondary, disturbed habitats. Some of the material from Afghanistan, however, appears to represent a steppic race, which may have been a natural component of the open grasslands before they were degraded and nearly destroyed by farming and overgrazing. Aitchison's descriptions in 1888 (*13*) certainly suggest this, and the small wadi race occurs just west of Kandahar today. Material from Quetta and Tashkent is definitely weedy, however. We have not seen North African material, but Maire describes it as a common component of open woodlands and scrub in Cyrenaica (*6*).

In attempting to relate the present distribution and ecological behavior to the situation some 10,000 years ago we have made the following assumptions: (i) the weed races are derived, and areas where spontaneous barley is found *only* in highly disturbed habitats should be disregarded; (ii) primitive man would probably have been attracted by extensive natural stands and would have ignored regions where the barley was in sporadic or spotty stands; and (iii) the places where massive stands in rather primary sites occur today should offer the best clue to regions where man was first attracted to the species.

Massive stands of wild barley in rather primary habitats occur today along the lower part of the deciduous-oak woodland belt circling the Syrian plains and the Euphrates basin—more specifically the western Zagros, the southern Taurus and the Anti-Taurus, the Anti-Lebanon range, Hauran, and Jebel Druz and the Jordan catchment area. From this open park forest belt, wild barley spills down the wadis to the more desertic sagebrush (*Artemisia*) belt. If the climate 10,000 years ago was radically different from that of today, the present distribution means little, but if the climate has not changed greatly, the present distribution should be significant.

The abundance of wild barley around the flanks of the "fertile crescent" is evident in Fig. 1, and the distribution agrees rather well with the scatter of early farming villages studied to date (Fig. 2). But the wild barley is too widespread, and sometimes too conspicuously weedy, to do more than indicate the general perimeter of the most likely regions of early domestication. The wild wheats are, perhaps, more definitive.

Einkorn Wheat

Einkorn wheat is another cereal found in most of the early village sites (*3*). As in the case of barley, the wild and cultivated forms are very closely related. The most conspicuous difference is in the fragility of the rachis. Wild types have a brittle rachis, and the individual spikelets disarticulate at maturity to disperse the seed. In cultivated forms the mature ear stays intact and breaks only on threshing. In the threshed material the seed is still enclosed by the glumes, and further processing is required to extract the naked grains.

Wild and cultivated einkorn can be readily crossed, and the chromosomes pair regularly in most hybrids, which

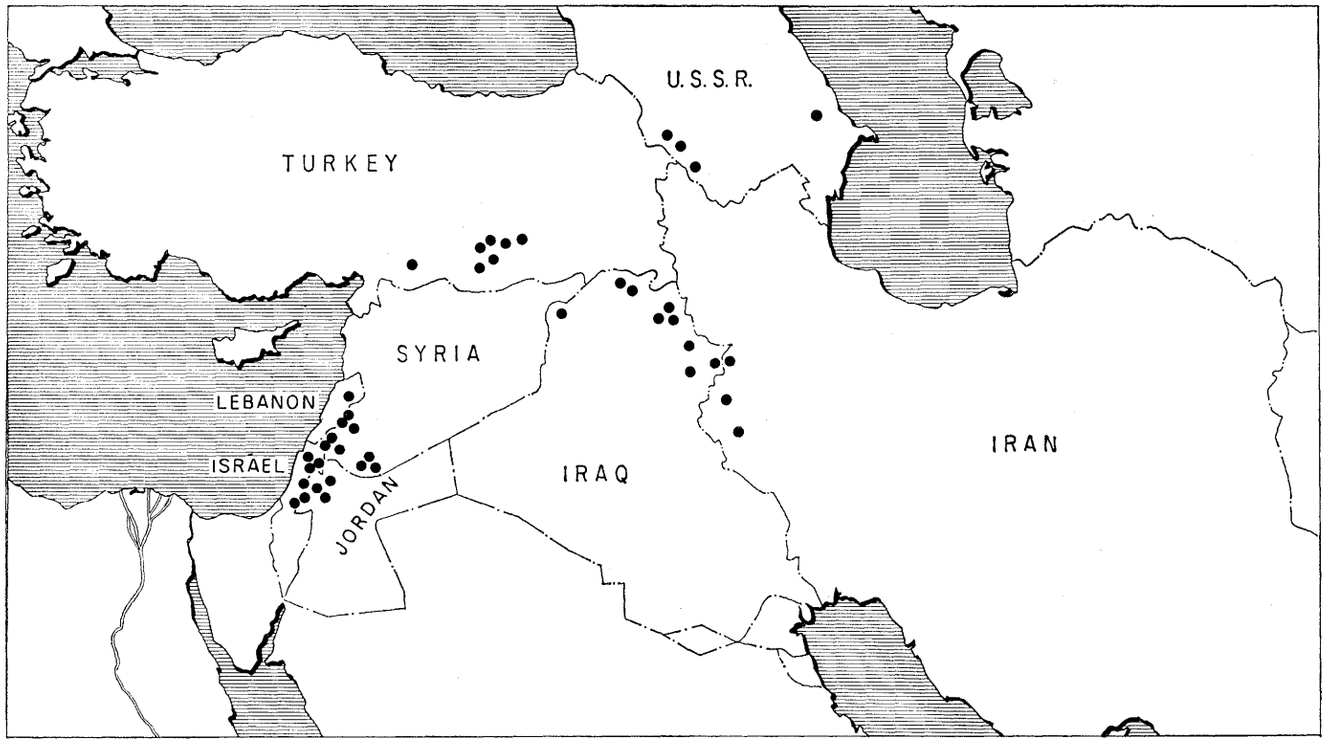

Fig 4. Distribution of known and reasonably certain sites of wild emmer.

are fully fertile. Translocation races are known (*14*), but the wild and cultivated forms are so closely related cytogenetically that they should be lumped together in one species. Traditionally, however, wild einkorn is designated *Triticum boeoticum* Boiss. emend. Schiem. (frequently but illegitimately called *T. aegilipoides*) and the cultivated einkorn is designated *T. monococcum* L.

There are two distinct ecogeographic races of wild einkorn: a small, usually one-seeded race characteristic of the Balkans and western Anatolia and a much larger, usually two-seeded race found in southern Turkey, Iraq, and Iran. In central Anatolia and in Transcaucasia all intergradations and intermediates between the two races occur. The small, one-seeded western race is often called *Triticum boeoticum* sp. *aegilopoides*, or *T. aegilopoides*, while the large, two-seeded race is often called *T. boeoticum* sp. *thaoudar*, or *T. thaoudar*.

Known and reasonably certain sites for wild einkorn are shown in Fig. 3. In designating these sites we have relied heavily on our own collections in Yugoslavia, Bulgaria, Greece, Turkey, and Iran. Sites in Iraq are based primarily on collections by Gillett, on file at Kew (*15*), and sites in Syria and Lebanon, on collections by Aaronsohn and Samuelsson (*16*); those in the U.S.S.R. are recorded in Grossheim (*11*), Troitsky (*17*), Jakubziner (*18*), Tumanjan (*19*), and Drozdov (*20*). The solid circles of Fig. 3 represent collections from fairly primary habitats, and the crosses represent definitely segetal sites.

Wild einkorn is more mesophytic and tolerant of cold than wild barley and occurs in massive stands as high as 2000 meters in southeastern Turkey and Iran. Over much of its present range it is a weedy plant growing along roadsides, field margins, and paths and often invading wheat fields in quantity. Sporadically in western Anatolia, and much more frequently in southeastern Turkey and northern Iraq, it is found in nonarable sites and areas not abusively overgrazed. If we disregard regions where wild einkorn is found only as a weed of disturbed habitats, the evidence leads us again to the Taurus-Zagros arc, this time with Palestine omitted.

Wild einkorn really seems most at home in southeast Turkey on basaltic cobble. The slopes of the volcanic mountain Karacadağ in the province of Diyarbakir are covered with basalt; this is weathered and broken sufficiently for wild stands of grasses to grow in it, but only in a few pockets on the lower slopes is the soil sufficiently deep for cultivation. Over dozens of square kilometers the rocky slopes are covered with almost pure stands of wild einkorn and *Triticum speltoides* (*Aegilops speltoides*). These two wild grasses are the parents of wild emmer, which is also present as a minor component of the annual vegetation. Other extensive stands of wild einkorn are found on rocky, usually basaltic, slopes in Malatya, Elaziğ, Bingöl, and Mus. Massive stands range from elevations of 2000 meters down to the edge of the plains in Urfa and Gaziantep (about 600 meters). Over many thousands of hectares it would be possible to harvest wild wheat today from natural stands almost as dense as a cultivated wheat field. If the present abundance is any indication of the situation 10,000 years ago, food gatherers and collectors would surely have been attracted to the stands in southeastern Turkey. Massive stands also occur, but less extensively, in northern Iraq and here and there in the Zagros of Iran.

Wild emmer is usually named *Triticum dicoccoides* in the literature, but

is so closely related to cultivated emmer that it makes little sense to separate them taxonomically. Again, the most conspicuous difference is the more fragile rachis of the wild races. The cultivated emmer is a glume wheat and does not thresh cleanly. Additional processing is required to extract the naked seeds from the glumes. The emmers are tetraploids, being composed of germ plasm from wild einkorn and *T. speltoides*, and they are closely related to most of the naked cultivated tetraploid wheats.

Known and reasonably certain sites for wild emmer are indicated in Fig. 4. The collections on which locations of the Turkish, Iranian, and Israeli sites are based are mostly ours; the Iraqi collection is mostly Gillett's, on record at Kew. Sites in Syria, Lebanon, and Jordan are largely based on collections of Aaronsohn, Samuelsson, and Mouterde and on the herbaria at Kew and Jerusalem. Sites in the U.S.S.R. are recorded in Grossheim (*11*), Troitsky (*17*), and Jakubziner (*18*).

Wild emmer is perhaps the most sensitive indicator of the three cereals with respect to region of domestication. It is not a weedy plant, and it is rather demanding in its requirements. There are two main races separated by the conspicuous discontinuity of Fig. 4. The race found in Turkey, Iraq, Iran, and the U.S.S.R. is never really abundant and occurs in sporadic, isolated patches and thin scattered stands in the lower oak-woodland belt, often in association with wild einkorn and wild barley. It is never the dominant species of the grassland flora and is usually found only as a minor component among the other cereals. This race is rather small, not much larger than the wild einkorn, and since it is not weedy its range and abundance may well have become restricted since the land was disturbed by agriculture.

The other race is centered on the upper Jordan Valley and is remarkably large and robust, with large seeds, heavy awns, wide leaves, and thick stems. It occurs in massive stands on basaltic and hard limestone slopes from eastern Galilee to Mount Hermon, the Jebel Druz, and the Gilead mountains. But it was not until the nation of Isreal was established and grazing was controlled that the abundance of these stands was recognized. Where grazing is controlled, nonarable sites support stands as dense as cultivated wheat fields. Presumably such stands once extended to the Es-Salt plateau and the Jebel Druz.

The two races of emmer are cytogenetically distinct (*21*). Hybrids between the Palestine race and most of the present tetraploid cultivated wheats, including cultivated emmer, are fertile; the chromosomes pair regularly and give every indication of close relationship. The Turkish-Iraqi race, however, shows rather poor pairing and decided sterility when crossed with the same cultivated tetraploid wheats. It shows closer affinity to *Triticum timopheevi* (*21*), a half-weed, half-cultivated wheat of Soviet Georgia and Armenia. Wagenaar (*22*) has shown that the pairing relationships are variable and probably genetically controlled. The pattern is complex, and even hybrids between Turkish and Iraqi races do not necessarily give good chromosome pairing. While this phenomenon needs more study, present evidence indicates that most of the modern tetraploid cultivated wheats stemmed from the race now found in the upper Jordan watershed. The other race did no more than contribute to the *T. timopheevi* complex.

More information is needed before firm conclusions can be drawn, but it would seem, from a tentative projection of the present situation backward to the time of incipient domestication, that the thin, sporadic stands of wild emmer in the Taurus-Zagros arc would hardly have been very attractive to the food-collecting cultures of the region. The massive stands around Lake Galilee would surely have been more useful to a harvester of wild grass seeds. The genetic and cytogenetic evidence tends to point in the same direction.

Conclusions

If we accept the evidence at face value, we are led to conclude that emmer was probably domesticated in the upper Jordan watershed and that einkorn was domesticated in southeast Turkey. Barley could have been domesticated almost anywhere within the arc bordering the fertile crescent. All three cereals may well have been harvested in the wild state throughout their regions of adaptation long before actual farming began. The primary habitats for barley, however, are not the same as those for the wheats. Wild barley is more xerophytic and extends farther downslope and into the steppes and deserts along the wadis. It seems likely that, while all three early cereals were domesticated within an arc flanking the fertile crescent, each was domesticated in a different subregion of the zone.

Lest anyone should be led to think the problem is solved, we wish to close with a caveat. Domestication may not have taken place where the wild cereals were most abundant. Why should anyone cultivate a cereal where natural stands are as dense as a cultivated field? If wild cereal grasses can be harvested in unlimited quantities, why should anyone bother to till the soil and plant the seed? We suspect that we shall find, when the full story is unfolded, that here and there harvesting of wild cereals lingered on long after some people had learned to farm, and that farming itself may have originated in areas adjacent to, rather than in, the regions of greatest abundance of wild cereals.

We need far more specific information on the climate during incipient domestication and many more carefully conducted excavations of sites in the appropriate time range. The problem is far from solved, but some knowledge of the present distribution of the wild forms should be helpful.

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Victim-Induced Criminality

Studies required by proposals for compensation of victims provide new insights for crime prevention.

Michael Fooner

Proposals for compensating victims of violent crime (*1*) are gaining widespread support in the United States, but studies analyzing the behavior of victims suggest that legislators should be alert to the possibilities that some compensation schemes may contribute to the growth of crime and add unwarranted complications to the administration of criminal justice.

The number of victims of violent crime in the U.S. is growing at a disturbing rate. In 1964 there was a national total of 2.6 million serious crimes, nearly 215,000 of which resulted in injury or death to victims (*2*). In 1966—to forecast from recent trends of criminality—there will be over 3 million serious crimes, of which over a quarter of a million will result in death or injury of the victims.

The history of crime and punishment in the whole civilized world reveals a steadily increasing concern with the treatment of the criminal, and a virtual blackout of attention to the situation of the victim. For more than 1000 years prior to the mid-20th century, the victim of crime in our society—and in the administration of justice—has been ignored.

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Meanwhile, principles of humane treatment for criminals have been extensively developed and applied. In the United States vast resources are devoted to the care and rehabilitation of the offender. Recently, the 89th Congress passed three crime bills, of which one was aimed at helping police agencies "fight crime" while two were aimed at helping convicted offenders through the easing of parole requirements and the improvement of rehabilitation services. Victims were not provided for.

In the past decade, however, a new line of interest has opened up. The victim has been "discovered," and there are signs of change. Victims, it is being said, are also human; they bleed and suffer; their children and spouses may be deprived of the breadwinner's support.

New Zealand (*3*), Britain (*4*), California (*5*), and New York City (*6*) have already installed victim-compensation systems and are paying out public money. Many other jurisdictions here and abroad are drafting such legislation.

One observer has suggested that legislators are finding the programs attractive, in the light of mounting public anger over alleged leniency in the treatment of offenders, as a means of placating constituents who demand stern measures against perpetrators of violence. The reasoning may be faulty, but there is public concern, and the sentiment has been gathering momentum.

Uncertainty about Objectives

Most people approve the humanitarian motivation of victim-compensation proposals. But there is a serious degree of uncertainty—even a degree of confusion in some quarters—about the specific objectives and proper functioning of the compensation-for-victims concept.

Compassion is but one consideration. Former Associate Justice of the Supreme Court Arthur J. Goldberg, speaking in favor of compensation, declared that the victim of a robbery or assault should be considered to have been "denied protection of the laws" and that "society should assume some responsibility for making him whole" (*7*). However, there are documented studies [those of Von Hentig (*8*) and Wolfgang (*9*), for example] which indicate that the victim himself often contributes to the occurrence of the crime—through his own carelessness, aggressive behavior, or imprudence.

Though some people may consider it paradoxical that criminals should be aided by their victims, this phenomenon is one with which criminologists are familiar. There is a growing literature on the role of the victim in crimes of violence; in addition, similar studies have recently been made in the field of property crimes (*10*).

These studies suggest that where, for example, a person has not acted with reasonable self-protective behavior in handling his money, jewelry, or other valuables, and has become the victim of a robbery, he cannot be considered an innocent victim—he has in effect created a "temptation-opportunity" situation, giving the criminal incentive and help.

In popular parlance, "he has himself to blame"; in the explorations of criminology he may begin to look very like an "accomplice" of the criminal. But under current compensation legislation he may be entitled to a cash award for injuries sustained while he was being robbed.