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CURRENT PROBLEMS IN RESEARCH

Animal Domestication in the Prehistoric Near East

The origins and history of domestication are beginning to emerge from archeological excavations.

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The long path in time leads to ourselves from a hominoid group which abandoned forelimb brachiation for hindlimb bipedalism. Once on that path, we can say with the wisdom of hindsight, man was unique as no other animal group ever had been. Combining ever greater skill at abstraction and communication with ever-increasing utilization of energy sources, the main pattern of human culture has led through the successive major steps of tool invention, tool improvement, plant cultivation, animal domestication, urbanization, and political integration, and so finally to the industrial revolution. Looking forward, this path bids to lead us to other planets and other planetary systems.

Seen thus in the long perspective, the initiation of cultivation and domestication—the Neolithic or "food-producing revolution" (*1*)—was one of three or four great cultural innovations, and a fundamental and necessary prelude to civilization (*2*, *3*). (I claim no originality for the above ideas; they are discussed at length in many anthropological writings.) It is true, however, that in spite of our certainty that agriculture and stockbreeding must have had beginnings, changing man from a roving hunter and gatherer to a settled village-farmer, and in spite of our knowledge of the vast ultimate consequences of this technical revolution, we know as yet very little about the details of these origins. Archeology, the discipline upon which we have traditionally depended for our understanding of these beginnings, has been either uninterested—spending its vigor instead in more glamorous pursuits—or incapable of the fine analyses necessary (*4*). For we have here a difficult field of paleonatural history, where the geomorphologist, climatologist, soil scientist, paleoethnobotanist, agronomist, ecologist, geneticist, taxonomist, and comparative anatomist must add their skills to those of the field archeologist. Not all of them have yet done so, and certainly the future will witness greater coordination all along the line.

The literature which shows the attempts of an earlier generation of Near Eastern archeologists to be their own natural-history experts, particularly in the field of zoological identification, is generally a sorry one and should be quietly disregarded. Inevitably and unfortunately, however, the conclusions published in these primary sources are those which have become crystallized into subsequent review papers and textbooks. Too often, also, the intriguing discoveries of the cultural complexity uncovered in the daily digging (particularly in the mounds representing remains of prehistoric towns) argued so strongly for an agriculturally based economy with assured food production that flocks and cultivated fields were assumed. Since the actual proof of the presence of the plants and animals was not thus regarded as necessary, the carbonized grain and the broken animal bones, which should have been considered of primary importance whenever they were uncovered, were too often shoveled onto the dump heap (*5*).

Often, simply, the archeologists of an earlier day—trained as they were in the arts, and in the literature of classical or Biblical history—simply did not know what to look for, and the institutions financing them were not interested in excavating for "natural" (nonartifactual) materials which yielded merely ideas. Instead, the archeologists sought what their home institutions expected of them: display objects, written records, sculptures, and monuments. The more subtle interpretations that are made possible by the cooperation of teams of archeologically oriented natural scientists, working at the excavation, have thus only recently become intellectually and financially possible, and even now the budgetary problems involved in including all of the desired personnel in a major archeological expedition are very great (*6*).

With the exception of a forthcoming book by F. E. Zeuner, none of the major works on the origins of animal domestication (*7*) are in English; this field of study has been preeminently a German one. Previous summaries were limited (as is always the case) to the knowledge available at the time; most such information was of the European Neolithic and the *historical* periods (as gleaned from writings and pictures) of the ancient Near East. Except for the peripheral Iranian site of Anau (*8*), little was known of the all-important late *prehistoric* cultures of southwestern Asia—the cultures actually representative of the period and the area of incipient domestication.

The more recent summaries on domestication by Herre (*9*) are those of an

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experienced morphologist with full knowledge of modern taxonomic practice and evolutionary theory, yet these do not attempt to make an evaluation of the kind attempted here—a critical analysis of our present knowledge of particular phases of the origin of animal domestication by one who has collected and worked in southwestern Asia, who has excavated much of the pertinent material at several of the most important sites, and who is studying the collections from these and other important sites.

Difficulties

In spite of a prolific literature, dating well back into the 19th century, the central problems concerned with the origins and early history of animal domestication remain unsolved. In large part, as mentioned, this unfortunate situation is due to archeology's not having asked itself the right questions, or, if it has done so, to its having assumed the answers without having saved the evidence. Thus, too many of the reports on prehistoric Egyptian and southwestern Asian cultures merely assert the presence of domestic animals without offering any anatomical proof.

Even if saved, the "evidence" may well run to tens of thousands of broken animal bones, which have to be cleaned, sorted, and individually studied in an effort to identify the bone and to determine the age, sex, and species of the animal (when this is possible). Where wild and domestic forms existed together in the same area, attempts must be made to segregate them.

Heretofore, a major deficiency in attempting in America to study the faunal remains from archeological sites in the ancient Near East has been the almost complete lack of comparative skeletal material with which to make correct identifications. Ideally, one should have complete skeletal series of all the species which existed in the area of the prehistoric culture, to allow one to study age, sexual and individual differences, and differences between wild and domestic forms of the same species. But far from having such series, we had, until recently, practically no study skeletons from the Near East in the Western Hemisphere; indeed, several of the species have become extinct within historical times, and others are perilously near that state. However, a beginning, at least, of such a collection has now been gathered and is available for study in Chicago (*10*).

Piles of dirty broken bones have little appeal to most zoologists, busy with their own researches, nor is the upper Quaternary (particularly the sub-Recent, with its modern-type fauna) of interest to most paleontologists. Such problems really, then, must be undertaken by zoologists who know the area concerned and who have collected in it, who have worked cheek-by-trowel with the archeologists, and who are not only ecologically sensitive to the environmental problems presented but are also anthropologically oriented to the nuances of evolving human cultures. Such zoologists are few [although the field, open and new, will be a promising one once it acquires the respectability of institutional support (*4*)].

Under these conditions, even when osteological collections from important sites have been made, the bones have sometimes lain around for years while the archeologist vainly tried to get someone to study them. Perhaps finally succeeding, he has in turn too often been handed a list of generic and specific names, meaningless to him, to be duly published as an appendix to the site report.

Without interpretation, both environmental and cultural, biological studies related to prehistoric sites have practically no meaning.

Another basic difficulty—aside from the fundamental one of the tremendous expense of putting properly staffed expeditions into the field halfway around the world—is the real paucity of fundamental evidence to date. We have less than a dozen sites in the time range immediately prior to incipient domestication (and not all of these have been studied in detail or published completely), and we have fewer yet for the suspected crucial period of actual domestication. Furthermore, due to political accidents of modern history, these sites cluster either in Palestine or in Iraq, with the intervening gap archeologically unexploited.

A last difficulty, and at the moment one of the most frustrating, is the failure of the radiocarbon (C^{14}) technique to yield dates of certain dependability. Although it was hailed as the answer to the prehistorian's prayer when it was first announced, there has been increasing disillusion with the method because of the chronological uncertainties (in some cases, absurdities) that would follow a strict adherence to published C^{14} dates. This is not to question the validity of the physical laws underlying the principle used, or the accuracy of the counters now in operation around the world; the unsolved problem, instead, seems to lie in the difficulty of securing samples completely free from either older or younger adherent carbon. At least to the present, no kind or degree of chemical cleaning can guarantee one-age carbon, typical only of the time of the site from which it was excavated. What bids to become a classic example of "C^{14} irresponsibility" is the 6000-year spread of 11 determinations for Jarmo (*3*), a prehistoric village in northeastern Iraq, which, on the basis of all archeological evidence, was not occupied for more than 500 consecutive years.

The Problem

What is needed—and what the various members of the Iraq-Jarmo Project are trying to accomplish—is a thorough analysis of all the evidence bearing on the origins of agriculture, animal domestication, and the village-farming way of life. The parts of the problem have different degrees of dependence upon each other (for instance, most of the geological and climatic events would have transpired in the absence of man), but all are intertwined. One cannot think of domestication, thus, as happening independently of the geographical factors (terrain, climate, flora) that always determine animal distribution, or independently of the culture—including the primitive agriculture—of the domesticators.

We must then, like good reporters, try to answer the five *W*'s and the lone *H*: When, Where, Who, What, Why and How?

When

Although it has been suggested that reindeer were domesticated during the upper Paleolithic in western Europe (*11*), no real evidence of animal domestication can be shown for any Pleistocene period (*12*); we are dealing entirely, so far as is known, with terminal-Pleistocene and post-Pleistocene phenomena.

Stockbreeding, assuring a steady supply of animal fat and protein, came somewhat later than incipient plant cultivation—so far as we know. (The necessarily recurrent use of the phrase "so far as we know" illustrates how badly needed are thorough investigations of sites falling within the time range of "incipient cultivation" (*3*, *13*), when

animal domestication was also undoubtedly being initiated.) There is no *proof* as yet that any of the "incipient-cultivation" sites known—Karim Shahir (*2*), Zawi Chemi (*14*), Mallaha (*15*), and the various Natufian sites in central Palestine—had domestic food animals, and I personally am doubtful concerning the presence of the Natufian dog (discussed below).

Although we must be properly cautious in accepting as valid any lone C^{14} determination from an individual locality, the four available dates for sites of the period of incipient cultivation have a comforting closeness in time, being close not only to each other but also to what we had expected on the basis of accumulating evidence of the last few years. The date for the short-time occupation site of Zawi Chemi is 10,870 ±300 years and that for a typologically contemporaneous level in nearby Shanidar Cave is 10,600±300 years (*16*). Two determinations for Early Natufian levels at Jericho are 9850±240 years and 9800±240 years (*17*). Since milling stones were present at Zawi Chemi and mortars and pestles, plus flint sickles, are known from early Natufian sites in Palestine, we can say, in easily remembered round numbers, that by approximately 10,000 B.P. (before the present), reaping and milling of wild cereals was most probably a reality, with purposeful planting a possibility.

Domestication of the primary food animals followed (*18*)—but by how long? We cannot be certain as yet. I am convinced, however, that in the somewhat later village-farming community of Jarmo we have found multiple specimens of domestic goats, as indicated by the shape of the male horn cores. The time is difficult to assess, in view of the

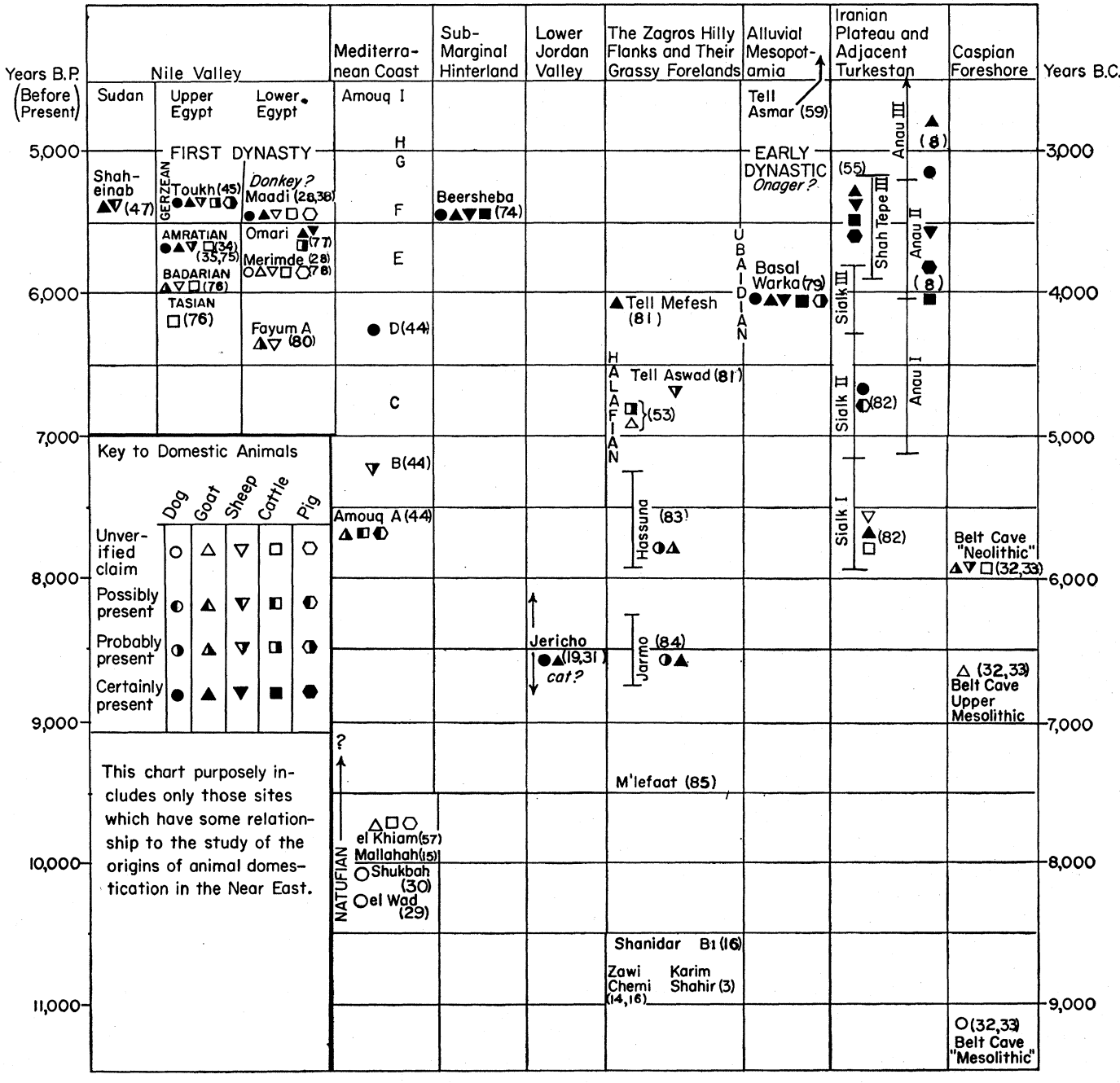

Fig. 1. A chronological chart, subdivided into geographical areas, of the known history of animal domestication in the prehistoric Near East. The estimated time is not to be regarded as absolute; the top of each column is fairly well fixed, temporally; but any part of any column may become elongated or shortened as a result of future discoveries (*73*).

6000-year spread of C^{14} "dates," but probably Braidwood's estimate (*3*) of about 8500 B.P. is as accurate as any that can be obtained now. The conclusion that the domestic goat was present in an early level at Jericho (Tell es-Sultan), although based at first on a single male horn core (*19*), has since been verified by finding additional material (*20*).

There is no *proof* as yet of domestication of any other food animal at Jericho or Jarmo (see the discussion below concerning the dog), or for some time thereafter.

Thus, at present we can only say that domestication of the goat probably falls within the millennium between 9000 and 8000 B.P., and that the domestication of the other three primary food animals (cattle, sheep, pigs) followed some time thereafter (see Fig. 1). We cannot say anything as yet, however, about the absolute time or the chronological order of domestication of these three.

Where

All archeological work to date in the Near East suggests that both agriculture and animal domestication (with the possible exception of that of the dog) had their origins in the hilly, grassy, and open-forested flanks of the Zagros, Lebanese, and Palestinian mountains (see Fig. 2). These data have been treated fully elsewhere (*2, 3, 21, 22*) and need not be repeated here. On the basis of the data assembled by Dyson (*22*) and of recent archeological evidence from central Asia, the highly respected ethnologist von Fürer-Haimendorf (*23*) has strongly discounted the old notion that animal domestication arose during an early stage of pastoralism. He stressed that, although the dog appeared with preagricultural hunters, the basic food animals always appeared in a context of early village-farmers. Further, he said, the domestication of the horse and reindeer, it must now be realized, came relatively late and had no influence on the earliest agricultural communities or their immediate historical derivatives.

From the primary center in the open-forest hills of southwestern Asia, the village-farming way of life diffused in all directions, carrying with it its trademarks: the village, cereal agriculture (wheat and barley, primarily), and the basic domestic food animals. In Egypt, in Thessaly, in Baluchistan and the Indus valley, probably even in China (at least in northern China), the beginnings of village-farming life were later and seem to have received a cultural stimulus from southwestern Asia.

The case of Egypt is particularly instructive, as wheat, goats, and sheep do not occur wild in Egypt [nowhere in Africa do true sheep and goats occur wild (*24*)] and so, obviously, were introduced as cultivated and domesticated species. If the radiocarbon dates for the Egyptian Fayum are accurate (possibly they are not, as we do know of some later radiocarbon dates for Egypt which are obviously too recent), the earliest and simultaneous appearance of cereal agriculture and domestic goats (or goats *and* sheep?) in Egypt, at Fayum, was considerably later (about 6200 B.P.) than the probable time of their earliest associations in Asia (about 8500 B.P.).

Who

The people who first turned the trick —who first grew grains and domesticated hoofed mammals—were, on the basis of skeletal evidence, modern-type men of the Mediterranean race. Doubtless they would pass unnoticed, if suddenly resurrected, among the people of today in the hill country where they lived.

Questions arise, to which we have no answers: Would the "agricultural revolution" have had its start where and when it did if another people, of different color or head shape, had lived there? Or would these important events have occurred if our same Mediterranean peoples had had, by a historical accident, some slightly different cultural pattern?

What

It seems logically probable—although we have as yet no direct evidence—that the cultivation of wheat and barley (or, at first, possibly of wheat alone) induced (or should we be more cautious, and say "allowed"?) the formation of the permanent villages. Probably both agriculture and village development were a necessary prelude to domestication of the basic food animals, although there are contrary views (*25*). These food animals, which undoubtedly contributed so much to the evolution of late prehistoric cultures in the Near East, were goats (*Capra hircus*), sheep (*Ovis aries*), cattle (*Bos taurus*), and pigs (*Sus scrofa*) (*26*). The dog (*Canis familiaris*) was also undoubtedly present (although its presence is poorly documented) but probably did not enter importantly into the cultural picture of the increasingly more complex village-farming and town-farming communities.

In addition, the zebu (*Bos indicus*) was certainly present prehistorically in Baluchistan (*27*), and subsequently in the Indus valley. This whole area, however, is peripheral to the central (or "nuclear") Near East with which we are mainly concerned, and the earliest suggested date for domestic cattle (about 5000 B.P.) is late by Near East standards. The donkey (*Equus asinus*), domesticated from the Nubian wild ass, is of a similar antiquity, having been reported from the site of Maadi in Lower Egypt (*28*). By this time, too, the Syrian onager (*Equus hemionus hemippus*) probably had been domesticated in Mesopotamia. The other domestic animals, both birds and mammals (ducks, geese, chickens, horses, camels, yaks, water buffaloes, reindeer, rabbits, and so on), which we rightly consider to be and to have been important in various human cultures, were not present as domesticants in the late prehistoric of the Near East and so are not here considered.

Dog (*Canis familiaris*). Since Bate (*29, 30*) announced that a domestic dog was present in the Natufian period, prehistorians have generally assumed that the dog was the Near East's first domestic animal, ubiquitously present for a period of nearly 10,000 years. However, examination of her published reports and figures has not convinced me that she excluded the possibility that the bones being considered were those of the large Egyptian or golden jackal, *Canis aureus lupaster*, possibly still present in Palestine. If the Natufians did not have a dog, then the earliest records would seem to be from the 7th millennium B.C., by which time dogs are known from the Maglemosian period in northwestern Europe and from Jericho in southwestern Asia. Domestic goats are also known at this time, however, from both Jericho and Jarmo, so we can no longer be so certain that the dog was "the first domestic animal," as has been so glibly stated for decades.

The earliest valid evidence of the dog in all the Near East is from a lower "plaster-floor level" at Jericho (*31*); dogs nearly as small as fox terriers are reported, while others are almost the size of wolves. The status of an even earlier "dog" from Belt Cave in Iran, with a C^{14} age of 11,480±550 years (*32, 33*)

must await the result of a study by a specialist in canid osteology.

I have not been able to convince myself that there were dog bones among the midden remains from Jarmo, although wolf and fox have been identified. However, since the bones are all extremely fragmented, a large dog could easily be mistaken for a wolf. The best evidence for a Jarmo dog is cultural, not zoological; several clay statuettes of what certainly appear to be dogs (the tail is curled over the back) have been found among several thousand statuettes, many of them identifiable as mammals native to the area. Even when identifiable as goats or sheep, however, these figurines are too crudely modeled to yield any clues about domestication.

In Egypt the first valid evidence of the dog is also artifactual; four dogs, led on leashes by one man, are represented on a pottery bowl (*34, 35*) of the Amratian period. They already show characters of the greyhound or seluki type, which by this time is also known (although the build is somewhat sturdy) from the Ubaid period in Mesopotamia by skeletons and, from a somewhat later time, by carvings on cylinder seals (*36; 37*, plate iv*a*). The presence of this specialized breed at this time at both ends of the Fertile Crescent indicates a long, although undocumented, period of artificial selection in the Near East. Not until the late Gerzean period do we find definite skeletal evidence of the dog in Egypt (*38*).

The general lack of skeletal evidence of prehistoric dogs in southwestern Asia and in Egypt is probably in part a reflection of the lack of attention given to such skeletal materials when they were found by archeologists during the last century, but perhaps in part it reflects the fact that dog carcasses were more likely to be available to scavengers than were the bones of the food animals. Perhaps, too, dogs were relatively rare as compared with the hoofed domesticants.

The wolf (*Canis lupus*) has generally been regarded as the ancestor of the dog. This supposition has been based (i) on the great morphological similarities, particularly as to dental details, between the wolf and the earliest dogs of the Mesolithic of western Europe; (ii) on the complete interfertility of dogs and wolves (with fertile hybrids); and (iii) on the great similarity of behavior (*39*).

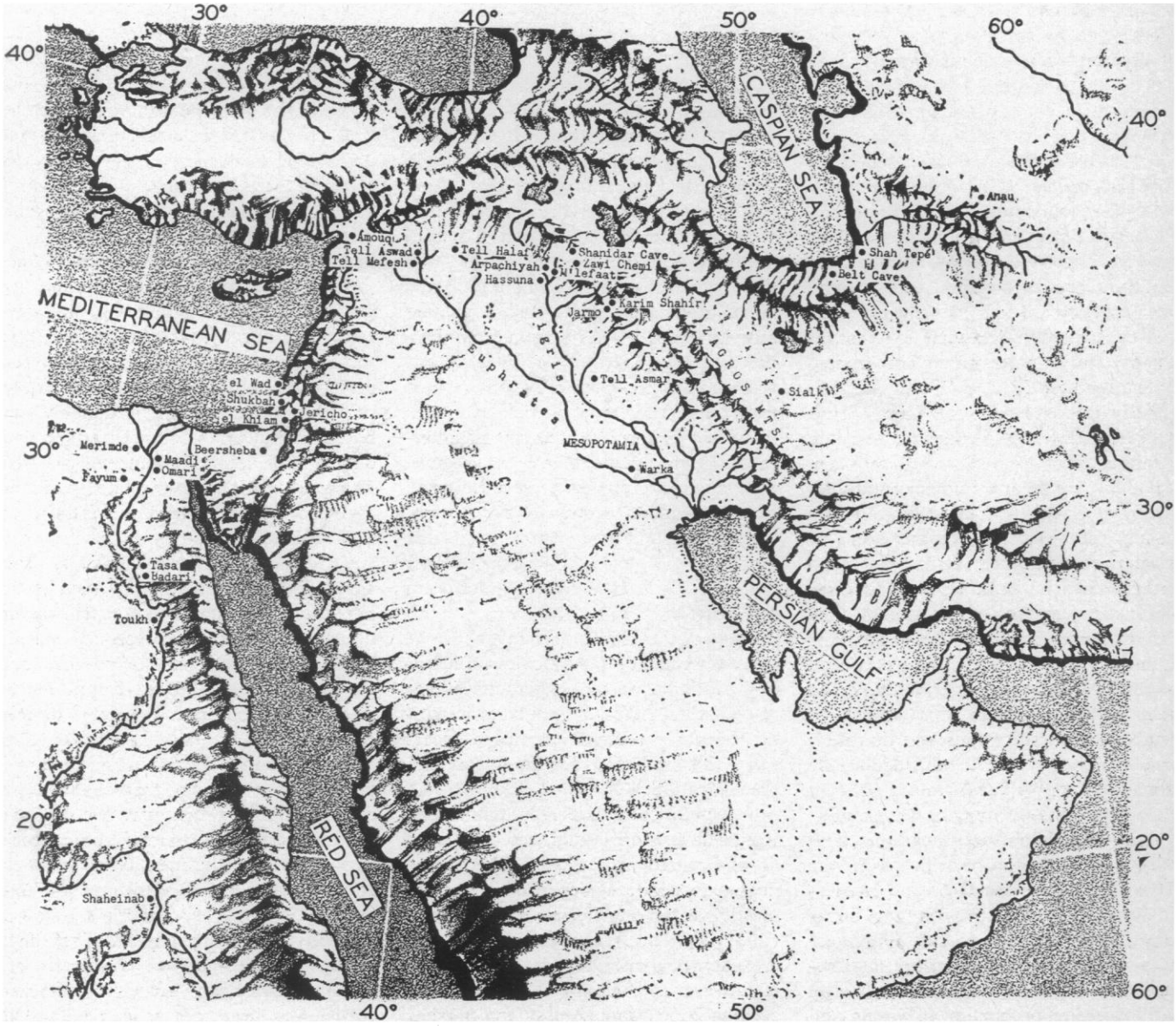

Fig. 2. The Near East. Of the numerous archeological sites which have been excavated in the area shown, only those are included here which have some relation to the study of the origins of animal domestication.

In spite of such evidence, however, several authors have suggested the golden jackal, *Canis aureus*, as the dog's ancestor, usually admitting later admixture with wolves for the more boreal breeds (*40*). Certainly Bate (*29*) regarded the supposed "dog" from the Natufian of Palestine as jackal-ancestored (although, as mentioned above, the animal may well *be* jackal and not dog). However, dog and jackal are dissimilar with respect to certain definite dental characters, and they have a different chromosome number (dog, 78; jackal, 74) (*41*). While dogs and jackals do interbreed, the fertility of the resulting hybrids seems not to have been established with the certainty usually assumed. Although the problem cannot be said to have been settled and there may have been some interbreeding of dogs (once established) with jackals, the preponderance of evidence indicates the wolf as the primary ancestor of the first dogs. The third possibility, that a hypothetical "wild dog" (*42*) or the pariah dog (*43*) actually represent an ancient stock from which the domestic dog was derived, lacks any historical evidence and fails to find (in my opinion, at least) the necessary paleontological support.

Goat (Capra hircus) and sheep (Ovis aries). Most of the bones—although not the horn cores or metapodials—of these two species are so similar that the species are often included together as "sheep/goat" or "caprovid" in archeological reports. Even when they are supposedly distinguished, one must always be suspicious of the validity of the identification.

Much careful archeological and zoological work remains to be done before we can know certainly whether sheep or goats were domesticated first, but present evidence indicates it was the goat. With goats, as with other animals, the earliest domesticants would be identical with, or very similar to, the wild form. Only after many generations could mutations accumulate that would so mark the domestic population that their broken bones would be distinguishable from those of wild individuals brought into the village by hunters. (Even now, where it is available, wild game is typically brought into the villages in the Near East for food.) However, population-age analysis based on the bones may show a shift from a stratigraphically lower level with random age distribution to a higher, and thus later, level with a greater proportion of young and near-mature animals. Such a shift would certainly suggest a change from wild-killed animals to domesticated ones, most members of the herd being harvested at optimum times. It is on the basis of this type of evidence, although on a rather limited series, that Coon (*32*) made a claim for the domestication of goats and sheep at Belt Cave in northern Iran (C^{14} date of about 8000 years ago). At or before this time, however, domestic goats—as identified morphologically—are known from Jericho and Jarmo.

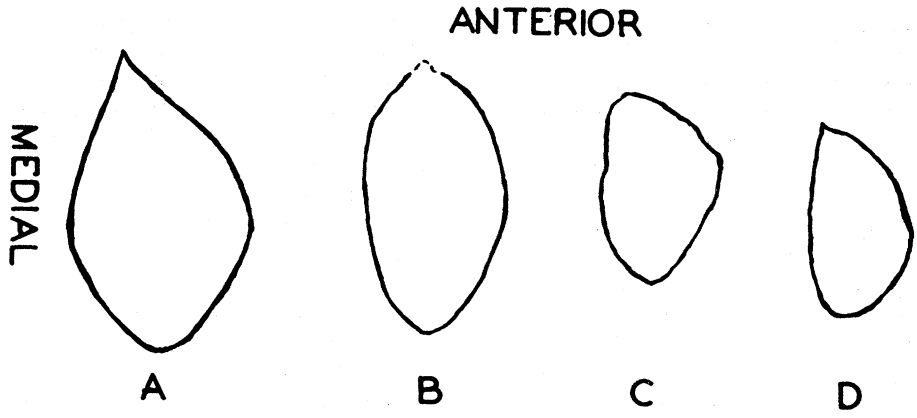

Fig. 3. Cross sections of male horn cores of typical wild and domestic goats, at approximately one-third of the distance from the base of the core toward the tip. All are from northeastern Iraq. (*A*) Right horn core of a wild goat (*Capra hircus aegagrus*). Note the general quadrilateral shape (Chicago Natural History Museum specimen No. 84493). (*B*) Left horn core of a domestic goat from prehistoric Jarmo, drawn as if from the right side. This core is similar in its lozenge shape to the core of the first domestic goat from prehistoric Jericho (*19*) (Iraq-Jarmo field specimen No. J55-194). (*C*) Right horn core of a domestic goat from prehistoric Jarmo. Note the flattening of the medial surface (Iraq-Jarmo field specimen No. J55-191). (*D*) Right horn core of a domestic Kurdish goat, killed in 1955. Note the flattening of the medial surface (Chicago Natural History Museum specimen No. 57253). (×0.82)

These Jarmo goats are distinguished from the wild type (which are also numerous in Jarmo) primarily by differences in the shape of the male horn core (Fig. 3) and, furthermore (in some of the Jarmo specimens), by a slight twisting of the horn. In contrast, the horns of wild goats, while curved over the animal's back like a scimitar, are not twisted.

Most of the archeological work in the Near East has been so lacking in attention to animal remains (*5*) that we cannot be certain of the presence of domestic sheep for some thousands of years after the probable beginning of that domestication.

It would seem probable that sheep would have been domesticated as early as, or not long after, goats. Whereas we do have definite evidence of many domestic goats at Jarmo and Jericho (about 8500 B.P.), the records for sheep are extremely meager [if all unverified claims are discounted (*5*)] for the succeeding 2500 years. Amschler (*44*) has reported both domestic and wild sheep from the Amouq sequence, but the sheep bones are exceedingly rare in comparison with the other domestic artiodactyls. It is only *after* 6000 B.P. that we find convincing evidence of sheep, from the Gerzean period in upper Egypt (*45*), Warka in Sumerian Mesopotamia (*37*, plate iii*a*), and the Anau II level (*8*) in what is now the Turkoman S.S.R.

Throughout much of this period, between about 8500 and 6000 B.P., our record for goats is little better than that for sheep, but by the latter part of the period these domestic animals were probably raised not only in upper Egypt but up the Danube as well (*46*), and only a little later in Baluchistan (*27*). The goat, curiously, was late in reaching north into the oases of west-central Asia; it is reported only from the upper levels of Anau, whereas domestic sheep are definitely known earlier there (*8*). Up the Nile, however, goats—albeit dwarfs — seemingly preceded sheep; goats are known from the Sudan about 5300 B.P., while the contemporaneous evidence for sheep is meager and uncertain (*47*).

If we assume, as we must on the basis of present evidence, that the earliest domestication of the goat occurred in southwestern Asia, there is little problem concerning the identity of the wild ancestor, as there *is* only one population (*Capra hircus aegagrus*) of wild goat in southwestern Asia. The ibex, various species of which occur in Europe, Africa, and Asia, has presumably never been domesticated and so does not complicate the problem, and the only other goat, *C. falconeri*, lives

further east. With sheep, however, the pattern is not clear at all, due to multiple and conflicting taxonomic and nomenclatural problems. Students of domestication have argued endlessly about which kinds of sheep were evolved from which species of wild sheep, without ever really knowing what a species of sheep is, how many valid species occurred (if there was more than one in central and western Eurasia), how much actual interbreeding (and thus gene-flow) occurred between the different populations variously described as species or subspecies, or what genetic factors underlie the characters of horn, head, tail, and fleece that have been so ardently discussed.

The genetics of most of these characters is still largely unknown, and a true classification of Old World *Ovis* is now extremely difficult, due to dwindling numbers of many of the populations (*48*). However, if it were sufficiently comprehensive, a gene-frequency study (*49*) of ovid blood factors (potassium and sodium concentrations, hemoglobin types, blood groups), of both wild and domestic sheep would undoubtedly help clarify the muddled taxonomic situation and would also aid in tracing the ancestries and interbreedings of the different races of domestic sheep. Additionally, detailed study of many bones from many archeological sites would give valuable collaborative evidence with historical depth. Until such data are forthcoming, I prefer the simplified taxonomic scheme of Tzalkin (*50*), who believed that, aside from *Ovis canadensis* of far eastern Siberia, all the Old World sheep belong to several subspecies of but one species, *O. ammon*. Thus, the detailed anatomical differences which have been so thoroughly studied and discussed by many students of sheep domestication in tracing the phylogeny of different breeds would never have had more than subspecific value.

Cattle (Bos taurus). The large, long-horned, wild *Bos primigenius* illustrated with such magnificent artistry at Lascaux, hunted and portrayed by the Assyrians, described with wonder by the Romans, and extinct in 1627, was distributed throughout the forested regions of Europe, North Africa, and southwestern Asia into historic times. Whether or not a second, short-horned species (*B. longifrons*) occupied much of the same area has been endlessly disputed; perhaps these short-horned animals were merely females of *B. primigenius* (*51*).

In addition, the European bison (*Bison bonasus*) extended its range into southwestern Asia, and in Iraq, at least, a wild water buffalo (*Bubalus*) undoubtedly existed (*52*). In the marshes of the Nile of prehistoric Egypt, in addition to true wild cattle, probably at least one kind of African buffalo (possibly two) existed (*5*).

The simultaneous presence of these several Bovini in the Near East, the nuclear area of animal domestication, is important—primarily because of the very fact that it has been generally disregarded. The result has been that any large bovines from prehistoric sites have usually, in the archeological literature, been labeled "domestic cattle" if, in any particular archeologist author's opinion, the time range fell within the limits of expected animal domestication. Generally the very real problem of the great difficulty of distinguishing between these various genera, particularly on the basis of a few teeth or broken bones, has simply not been recognized. Additionally, there is the much greater problem, even if the animal is *Bos*, of determining its status—wild or domestic.

The value of the scientific material relative to large bovines that has been thrown away unstudied is fantastic; in some cases the "identification" of the native workmen at the excavation has been accepted on the spot, and the skeletons or skulls have been discarded. The result is a woeful ignorance about the origins of cattle domestication; instead of evidence we have sweeping fictions by archeologists and culture-historians concerning the increasing complexity of human cultures throughout later prehistoric times, as based upon the presumed utilization of cattle and other livestock.

Bulls were important in the emotional life of the Halafian people, it is true, as shown by their art and deduced for their religion (*53*); this emotional attachment of people to their cattle is a very real thing, with multiple manifestations, in all cattle-breeding peoples. Probably the Halafian and other Near Eastern peoples of the period *did* have domestic cattle, but the only evidence I can find has been hitherto overlooked (at least, so far as I can discover; certainly evidence has not been demanded in the archeological literature!). The particular item is a small but clear reproduction of a cow's head, from a basal Halafian level at Arpachiyah (*53*), which has horns that are short and curve forward, quite like those of some cows today.

It is not until very late prehistoric times (about 6000 to 5000 B.P.) that we find actual proof, both zoological and cultural, of domestic cattle. The beautifully clear delineations on the cylinder seals of Warka and other early Sumerian towns testifies to the importance of cattle in these communities, as do the careful anatomical studies of Duerst (*8*) and Amschler (*55*) on the cattle bones from the roughly contemporaneous Iranian sites of Anau II and Shah Tepé III, respectively.

In Egypt, throughout this same 4th millennium B.C., most prehistorians discuss with confidence the cattle-breeding cultures of the Badarian, Amratian, and Gerzean periods, without realizing that valid evidence of domestic cattle is lacking. As with the Halafian and some other Mesopotamian periods, the conclusions were too often assumed, while the need for evidence was ignored. Only at the Gerzean site of Toukh (*45*) was a careful study made of the faunal remains; here Gaillard emphasized the resemblance of the excavated bones of the short-horned cattle to those found in adjacent but earlier Paleolithic sites, and also stressed their resemblances to bones of known domestic short-horned cattle, both prehistoric and modern. He never, however, spoke of the Toukh cattle as being domestic, particularly as wild cattle of that type were living in Egypt then and later. Even the relative youth of most of the cattle killed cannot be considered evidence of purposeful control of domestic herds, as the gazelle bones in the same middens were also mainly from subadult individuals. (Were, then, the gazelles perhaps domesticated?)

The prehistorians are probably correct in thinking that domestic cattle were present and important in the human cultural evolution of Egypt of the 4th millennium B.C., prior to dynastic times and the beginning of written history, but these same prehistorians must become aware of the lack of zoological or cultural evidence for their assumptions.

Pig (Sus scrofa). During the late prehistoric times here considered, many subspecies of wild pig were native to North Africa and much of Eurasia. In spite of this wide distribution, the ancestor of *all* domestic pigs has been singled out as one southeastern Asiatic subspecies, *S. s. vittatus* (*18, 56*); if it is true that this subspecies is the common ancestor, domestic pigs must have been moved westward, presumably slowly, to reach the Near East and most of Europe in prehistoric times. As yet I have not investigated this problem, but the gen-

eral pattern seems illogical. I suggest that we at least reinvestigate the possibility that domestication of pigs may have occurred several times, from different wild populations.

Pigs are not as difficult to tame as one might imagine; an adult wild boar or sow, it is true, is not an animal one approaches casually, but several people have easily reared the young of wild pigs to adulthood, the females having then produced litters to be reared in captivity (*5*). Such pigs are surprisingly docile.

Although a domestic pig has been mentioned for the Natufian (*57*), the evidence—a single phalanx—is unacceptable. The earliest record to merit serious consideration is that for Amouq A, in the northern Levant. Here, as in later levels of the Amouq sequence, Amschler (*44*) listed both domestic and wild pigs, but without any explanation of his basis for differentiation.

Other than for the Amouq, there is little osteological evidence for the presence of domestic pigs in the prehistoric Near East except in the north across Iran, near the base of Anau II (*8*), where domestic pigs were suddenly introduced with no prior, and little subsequent, evidence of wild pigs having been hunted. By this time (about 3800 B.C.) or before, the pig was quite probably an important food animal in southern Mesopotamia, although this conclusion is based on what I consider to be slight cultural evidence (*58*). Certainly, pigs are known to have been important in Sumer in early historic times. However, the only study (*59*) on the osteological remains from a Sumerian city (Tell Asmar) is from a time so late as not to appear on my chronological chart.

Egypt, it would seem to me, might well have been an independent center of pig domestication, considering its semi-isolated position and late cultural development. It is difficult for me, for instance, to imagine pigs being driven across the desert of Sinai, but the *idea* of domestication could pass readily, perhaps by way of a Syrian visitor. There are numerous pig bones from the sites of Merimde and Maadi in northern Egypt, but there is no published study of them known to me to vindicate Menghin's oft-quoted claim (*28*) that pig breeding represented an important cultural difference between the late prehistoric cultures of upper and lower Egypt. When Gaillard, an experienced morphologist, *did* carefully examine the numerous bones of pigs from the midden of Toukh in upper Egypt he was unable to determine whether the animals had been wild or domesticated (*45*). Domestic pigs may well have been present and important in the economy of prehistoric Egypt, but until we have zoological or cultural evidence for such domestication we must assume that the numerous bones of pigs found in the remains of prehistoric villages represent wild pigs from the adjacent Nile marshes.

Why

Why did men domesticate animals at all? A religious motif has often been suggested (*42*), but probably at first there was little realization of what was occurring; there was merely a gradual strengthening of an association between two species of social animals (man and dog, man and goat, and so on), preadapted by their respective evolutions to be of mutual benefit. Everything we know about preliterate cultures argues against a sudden realization of the potential values of animal domestication, followed by planned action; man could have had no concept of the future values of animals' milk, or of wool not yet of useful length on the hairy wild sheep. Later, in literate societies, there *were* purposeful efforts at domestication. Some, such as the Egyptian Old Kingdom domestication of the hyena, of certain antelopes, and of the Nilotic goose, were seemingly successful but were later abandoned. The era of planned domestication was not limited to peoples of ancient history, however, for we note the successful 19th-century domestication of the budgerigar parrot and of the laboratory rat. Today, planned domestication of two large mammals is in the experimental stage—that of the eland (*Taurotragus*) in Rhodesia and of the musk ox (*Ovibos*) in northern North America (*60*). The latter experiment, at least, is showing promise of success.

How

Man probably entered into a state of beneficial mutualism with certain animal species because, to put it in very general terms, the animals were already socially and psychologically preadapted to being tamed without loss of reproductive abilities. A second factor was the necessary one that the human culture milieu had evolved to a state of organization such that the animals could be controlled, and maintained generation after generation in a condition of dependence. At least to some degree the animals must be protected from predators and provided with food—the latter perhaps only in times of scarcity. The detailed pattern of the process leading to domestication naturally varied with both the particular species and the human culture that were interacting; certainly the domestication of the wolf to the dog by the Maglemosian hunter-collectors of northwestern Europe was different in detail from the domestication of the hoofed food animals by the post-Natufian cultivators. Unfortunately, we know nothing of the details of either process, partly because of our inability to reconstruct the behavior and cultural environment of the people involved and partly because of our ignorance of the psychology of the various wild animals involved.

With the exception of one of the most recently domesticated mammals, the laboratory rat, we know little enough about the behavior patterns of our common domestic animals, but we know much less about the behavior of their wild progenitors. Furthermore, detailed comparative observations of wild and domestic *Rattus norvegicus* emphasize the tremendous behavioral changes undergone by a species during domestication (*61*). Thus, psychological studies on domesticants probably cannot yield the total behavior pattern of the wild ancestors. It was, however, these wild ancestors that man first tamed and reared.

The social enzyme that activated the union of man and beast was undoubtedly the human proclivity, not only of children but of women also, to keep pets (*25, 42, 62*), although purposeful capture of young animals by men, to serve as hunting decoys, may well have been another avenue toward domestication.

The psychological factor of "imprinting," explored particularly by Lorenz in a notable series of animal experiments, was undoubtedly a major influence in the domestication of birds with precocial young (chickens, ducks, geese, turkeys, and so on). *Imprinting* refers to the tendency, most pronounced in such precocial birds, to recognize, and psychologically to attach themselves to, the most frequently seen and heard living thing during an early and short "critical period." Typically this would be the mother, and we have thus an instinctive mechanism for recognition of the parent by an active newborn.

For mammals, we probably cannot speak of "imprinting" in as complete a sense as we do for birds. There are, of course, definite sequences of actions whereby mother and young learn to recognize each other; for the young mammal this is certainly a "critical period." Such recognition of the mother is then enlarged to include other members of the species. A lamb reared in isolation, for instance, rather thoroughly ignores other sheep for the remainder of its life (*63*), even though it will mate and produce young. We would seem to have here, in correlation with the abovementioned tendency to keep pets, a mechanism for the switching of psychological recognition and social dependence from a real mother to a human foster mother.

The "critical period" for hoofed mammals—whose behavior is similar in some respects to that of precocial birds —is within a few hours of birth, but for helpless-born young it comes several days or weeks later [three weeks and later for the dog, for instance—a phenomenon associated with myelinization of cephalic neurons (*64*)]. In such mammals, the critical period is probably not so limited in time or so well defined as to pattern as in the hoofed animals. The essential point, however, is that in the domestic mammals that have been studied, and presumably in the others, there is such a patterned behavior system as is here discussed, a biological mechanism so basic that it remains essentially unchanged in the transition from wild to domestic status.

Since the "critical period" in mammals always comes prior to weaning, we must assume that there was a human wet nurse for whatever small helpless suckler might be brought into the village; there are women of primitive tribes who still act thus and provide the proper model (*42*). Once the domestication of sheep and goats had been accomplished and the practice of milking had been established, milk would have been available for orphaned calves and colts, and thus the way for domestication of larger species would have been opened.

It is not, however, only the young of many mammals that can be kept and reared; even the adults of some artiodactyls seem to seek domestication. Arkell (*65*) tells of a female wart hog, with young, that made a nuisance of herself about one of his camps during a famine period, and I myself have had the experience of having my car stopped (*not* during a famine period!) on a major American highway by two large males of that supposedly wild species the big-horn sheep, who then stuck their heads in the open windows begging for tidbits. These animals may not have known it, but they were *asking* to be domesticated.

Once the nuclei of herds had been established, human selection against the aggressive and unmanageable individuals would have been automatic, resulting in the decrease in production, generation by generation, of the adrenocortical steroids (with multiple attendant physiological changes)—a process that has been studied in detail for the short history of the laboratory rat (*61*). Eventually submissiveness becomes geneticallly ingrained in the population (although some species, such as the sheep, seem more susceptible to such manipulation than others). Furthermore, those animals naturally adapted to breed best in captivity would contribute their characters in larger numbers to the gene pool of each succeeding generation. Such unplanned selection of various sorts must have long preceded the methods of purposeful artificial selection which led eventually to the establishment of different breeds within a domestic species.

However it originated, once domestication had occurred, the idea could be transferred to species other than the original ones—a type of cultural shift which seems to account for the domestication of the reindeer. I find no reason, either, to believe that domestication of the same species could not occur in different places at different times, probably as the result of diffusion of the idea. Thus, pigs and cattle could have been domesticated in both southwestern Asia and in Egypt, the stimulus having been transferred from the former area to the latter in the mind of a human migrant.

A last factor that must be considered in a discussion of the origin of domestication of animals in the Near East is the "propinquity" or "riverine-oasis" theory of domestication (*66*). Briefly, the increasing desiccation of the Saharan and Arabian areas during the post-Pleistocene supposedly enforced the juxtaposition of man and the potentially domesticable animals around the disappearing water sources, leading to conditions of beneficial mutualism and thus to domestication.

Aside from the fact that a variety of ecological and distributional data argue against the validity of such a view (*5*), accumulating evidence indicates that the known climatic sequence itself makes the idea untenable. I suspect that the adherents of the "riverine-oasis propinquity theory" have been overly impressed by the grand sweep of the very real desiccation of North Africa since the Allerod (about 11,000 years ago) without having given due regard to the fluctuating climatological conditions (*67, 68*) that existed. There were, beginning in the late Pleistocene, several fluctuations of temperature and rainfall which had profound ecological consequences for the biologically sensitive area of North Africa, where the evidence is best known. However, there is no evidence of domestication during the periods in question (about 15,000 to 7000 B.P.) in this or in any other desert area. There then began the "Neolithic wet phase" [Butzer's Subpluvial II (*67*) and Alimen's "second wet phase" (*68*)], lasting from about 7000 to 4500 B.P. During much of this time (*69*) domestic bovids (sheep, goats, and cattle) were present all across the Sahara, as shown by innumerable engravings and paintings (*68*), and the subsequent dramatic desiccation to present conditions thus occurred long after the full pattern of domestication had been established.

The "oasis theory," based as it originally was on an idea of continuous desiccation during the post-Pleistocene North African climatic sequence, loses all meaning when transferred to southwestern Asia, the actual site of original bovid domestication. Here data on Saharan rainfall and temperature fluctuations *may* apply to the central desert areas proper (the evidence is scant and inconclusive) but seemingly have much less meaning elsewhere.

Particularly throughout the hills of the Zagros-Palestinian chain there was relatively little climatic change within the transition period from the upper Pleistocene to the early Recent (*70*); in fact, these terms have relevance in a climatic sense only as we can correlate them with regions of former continental glaciation.

My own unfinished studies on the bones collected from half a dozen sites in northern Iraq, which bridge some 90,000 years of the late Quaternary, show that an essentially modern fauna has occupied the area during this period. This does not mean that there has been no climatic change during this time in these hills and mountains, but it does mean that such variations as have occurred in temperature and precipitation have done little more than simultaneously depress and/or elevate the upper and

lower tree lines. The fauna (including prehistoric man, undoubtedly) moved slowly with the flora to the extent necessary to maintain a fairly static ecologic situation.

We must then face the seeming enigma that cultural evolution occurred even though the Hilly Crescent of southwestern Asia passed through no such end-of-the-Pleistocene environmental crisis as was experienced by Europe, North Africa, and North America. For Europe particularly, with the correlated cultural change from Paleolithic to Mesolithic (a degree of change perhaps often overemphasized), the idea that there was intensive post-Pleistocene human adaptation to changing environments is generally accepted, usually accompanied by the concept (even though unexpressed) of the development of greater cultural complexity ("progress") in answer to the changing conditions.

In southwestern Asia, however, we have at approximately this time the profound cultural change to incipient cultivation, if not to actual cultivation, within that millennium which includes the Karim Shahir and Zawi Chemi materials of Iraqi Kurdistan and the Natufian of Palestine. But here we cannot point to a dramatic climatic change, furnishing a stimulus for sudden cultural evolution.

Indeed, the available evidence is quite the contrary; true, the Natufian had a more complex set of tools than any of its upper Paleolithic predecessors in southwestern Asia, and the culture was marked particularly by large numbers of very small flake tools (microliths) and by the introduction of mortars and pestles for seed grinding, but the whole assemblage is in the blade-tool tradition of some 40,000 years of Levantine history and undoubtedly evolved *in situ*, with a minimum of external influence (*71*).

Still eluding us are the factors that led these particular peoples to inaugurate cereal agriculture, however incipiently, and thus, by way of many changes to furnish the food base of today's technological society. But increasingly the archeologist is looking for a greater variety of data from his excavations and asking different questions of those data. Increasingly, too, natural scientists are helping him collect and interpret that evidence. It is certain that, under these circumstances, we shall be getting more and better answers to our questions concerning the many unsolved problems in the study of the relationships between climate, man, and the origins of agriculture and domestication (*72*).

Conclusions

Concerning the animal aspect of the "food-producing revolution," present evidence indicates that domestication of goats and sheep occurred in a central core area in southwestern Asia in prehistoric times, probably about the 7th millennium B.C., cattle being domesticated somewhat later, and pigs even later.

Domestication of the food-producing animals probably occurred in village-farming communities in the Hilly Flanks area of southwestern Asia; thus, cereal agriculture and the settled village are considered to antedate the domestication of all animals except the dog.

Present archeological data indicate (although many archeologists have tended to ignore or discard the evidences) that relatively intensive and successful agricultural and stock-breeding (mixed-farming) societies developed in the Zagros hills and their grassy forelands (as well as in the lower Jordan valley) prior to the appearance of the earliest societies of this type elsewhere; similar Iranian and Egyptian cultures seemingly developed later and peripherally. At least for Egypt this seeming lateness—a matter of two thousand years or more—is probably not just a reflection of accidental or incomplete sampling.

No dramatic end-of-Pleistocene environmental change has been detected for southwestern Asia; thus, the all-important "food-producing revolution" was seemingly not stimulated by the challenge of a post-Pleistocene climatic change (*70, 71*).

References and Notes

1. We are indebted to V. G. Childe for stressing the importance of this fundamental concept. The development of Childe's ideas, which have had such a profound influence on the history of thought, are interestingly outlined in an autobiographical note: V. G. Childe, *Antiquity* **32**, 69 (1958).
2. R. J. Braidwood, *The Near East and the Foundations for Civilization* (Univ. of Oregon Press, Eugene, 1952).
3. ———, *Science* **127**, 1419 (1958).
4. ———, *Natl. Acad. Sci.–Natl. Research Council Publ.* **565**, 16 (1957).
5. These general statements will be discussed and documented more fully in a forthcoming paper (C. A. Reed, *Studies Ancient Oriental Civilization, Univ. Chicago*, in press).
6. W. W. Taylor, Ed., *The Identification of Non-artifactual Archaeological Materials* (National Academy of Sciences–National Research Council, Washington, D.C., 1957).
7. *Domestication* to me means simply that the animals are under the control of man to such a degree that, if he wishes, their choice of mates is determined. Artificial selection is thus possible and usually, to some degree at least, inevitable. In a very important sense, then, domestic animals (as well as plants) are a type of human artifact, since they exist in a form changed by man.
8. J. U. Duerst, *Carnegie Inst. Wash. Publ. No. 73* (1908), p. 339.
9. W. Herre, "Domestikation und Stammesgeschichte," in Heberer, *Evolution der Organismen* (Stuttgart, 1955); "Die geschichtliche Entwicklung der Haustierzüchtung," in Zorn, *Tierzüchtungslehre* (Ulmer, Stuttgart, 1958).
10. A grant from the National Science Foundation to the department of anthropology of the University of Chicago allowed me to spend the year 1954–1955 in southwestern Asia, collecting living animals in addition to doing archeological work with the Iraq-Jarmo Project. The zoological specimens collected were deposited in the Chicago Natural History Museum.
11. E. Patte, *Compt. rend.* **246**, 3490 (1958).
12. I follow the common practice of most European geologists and of the U.S. Geological Survey [H. B. Morrison *et al., Am. J. Sci.* **255**, 385 (1957)] in dividing the Quaternary into Pleistocene and Recent, although at least one eminent authority rejects any such differentiation [R. F. Flint, *Glacial and Pleistocene Geology* (Wiley, New York, 1957)]. The Recent is generally considered to have begun between 10,000 and 11,000 years ago, the difference depending only upon whether the several hundred years of the Younger Dryas is included in the Pleistocene [H. E. Wright, Jr., *Am. J. Sci.* **255**, 447 (1957)] or in the Rece ➡ [W. S. Cooper, *Bull. Geol. Soc. Am.* **69**, 941 (1958)].
13. R. J. Braidwood and C. A. Reed, *Cold Spring Harbor Symposia Quant. Biol.* **22**, 19 1957).
14. R. S. Solecki, *Quaternaria* **4**, 1 (1957); *Trans. N.Y. Acad. Sci.* **21**, 712 (1959).
15. J. Perrot, *Antiquity and Survival* **2**, 91 (1957).
16. R. S. Solecki and M. Rubin, *Science* **127**, 1446 (1958).
17. K. M. Kenyon, *Antiquity* **33**, 8 (1959).
18. But see C. O. Sauer, *Agricultural Origins and Dispersals* (American Geographical Society, New York, 1952) for the conflicting opinion that the pig was domesticated earlier, in southeastern Asia, and was then brought westward.
19. F. E. Zeuner, *Palestine Explor. Quart.* **1955**, 70 (1955).
20. Personal communication from F. E. Zeuner, 22 Oct. 1958.
21. R. J. and L. Braidwood, *J. World Hist.* **1**, 278 (1953).
22. R. H. Dyson, Jr., *Am. Anthropol.* **55**, 661 (1953).
23. C. von Fürer-Haimendorf, *Yearbook Anthropol.* **1**, 149 (1955).
24. D. M. A. Bate (*47*) has accepted a description of native goats in Algeria [A. Pomel, *Service Carte Geol. Algeria, Paleontol. Monogr. No. 13* (1898), p. 1], but the age of the materials from which Pomel described these goats is uncertain [C. Arambourg, *Bull. soc. hist. nat. Afrique du Nord* **20**, 78 (1929)], and there is a distinct possibility, thus, that Pomel's "*Capra promaza*" is based upon Neolithic domestic goats.
25. F. E. Zeuner, in *A History of Technology*, Charles Singer *et al.*, Eds. (Oxford Univ. Press, London, 1954), vol. 1, p. 327. This paper is an important one on the "why" and "how" of domestication and forms a foundation for much of what I am saying here, even though I do not agree with Zeuner in every detail.
26. It is interesting to note that all of these animals belong to the same order, the Artiodactyla, and that except for the pig they are not only all ruminants but are all bovids. Other bovids (water buffalo, zebu, yak) were subsequently domesticated, and many species of gazelles and antelopes, particularly, seem to be potentially domesticable. No other family looms so importantly in the history of domestication. Factors involved in the late origin (Miocene) and rapid and successful evolution of the Bovidae may perhaps play some role in their versatile adaptations to domestication. Actually, there may be no bovid which could not be domesticated.
27. W. A. Fairservis, Jr., *Am. Museum Nat. Hist. Anthropol. Paper No. 45* (1956), p. 167.
28. O. Menghin, *Anz. Akad. Wiss. Wien, Phil.-Hist. Kl.* **70**, 82 (1934).
29. D. M. A. Bate, *The Stone Age of Mt. Carmel* (Clarendon, Oxford, 1937), vol. 1, part 2.
30. ———, *Proc. Prehist. Soc.* **8**, 15 (1942).
31. F. E. Zeuner, *Palestine Explor. Quart.* **1958**, 52 (1958).
32. C. S. Coon, *Cave Explorations in Iran 1949* (University Museum, Univ. of Pennsylvania, Philadelphia, 1951).
33. E. K. Ralph, *Science* **121**, 149 (1955).
34. M. Hilzheimer, *Antiquity* **6**, 411 (1932).

35. E. Massoulard, *Trav. et Mem. inst. ethnol. Univ. Paris* **53**, 1 (1949).
36. A. J. Tobler, *Excavations at Tepe Gawra* (Univ. of Pennsylvania Press, Philadelphia, 1950), vol. 2, plate 37b.
37. H. Frankfort, *Cylinder Seals* (Macmillan, London, 1939).
38. Y. S. Moustafa, *Bull. inst. Egypte* **36**, 105 (1955).
39. J. P. Scott, *J. Natl. Cancer Inst.* **15**, 739 (1954).
40. K. Z. Lorenz, *Man Meets Dog* (Houghton Mifflin, Boston, 1955).
41. R. Matthey, *Mammalia* **18**, 225 (1954).
42. C. O. Sauer, *Agricultural Origins and Dispersals* (American Geographical Society, New York, 1952).
43. B. Vesey-Fitzgerald, *The Domestic Dog: An Introduction to Its History* (Routledge and Kegan Paul, London, 1957); F. S. Bodenheimer, *Bull. Research Council Israel* **7B**, 165 (1958).
44. J. W. Amschler, *Identification of the Animal Bones from the Amouq* (unpublished manuscript in the personal files of R. J. Braidwood). This collection of bones from the excavations of the Oriental Institute's Syrian Expedition is now in Chicago and is to be restudied before final publication of the results.
45. C. Gaillard, *Arch. musée hist. nat. Lyon* **14**, 1 (1934).
46. V. G. Childe, *Antiquity* **31**, 36 (1957).
47. D. M. A. Bate, in A. J. Arkell, *Shaheinab* (Oxford Univ. Press, London, 1953), pp. 11-19.
48. F. Harper, *Extinct and Vanishing Mammals of the Old World* (New York Zoological Park, New York, 1945).
49. J. V. Evans, *Advances in Sci.* **13**, 198 (1956).
50. V. I. Tzalkin, *Materials for the Recognition of the Fauna and Flora of the U.S.S.R.*, published by the Moscow Society of Naturalists, n.s., *Zoological* **27**, 1 (1951).
51. F. Koby, *Bull. soc. prehist. franç.* **51**, 434 (1954); F. E. Zeuner, *Man* **53**, 68 (1953).
52. R. T. Hatt, "The Mammals of Iraq," *Misc. Publ. Museum Zool. Univ. Michigan*, **106**, 1 (1959).
53. M. E. L. Mallowan and J. C. Rose, *Iraq* **2**, 1 (1935).
54. ———, *ibid.* **2**, plate vi(a) (1935).
55. J. W. Amschler, "Report of Scientific Expedition to the Northwest Province of China under the Leadership of Dr. Sven Hedin (The Sino-Swedish Expedition)," *Archives* **4**, 35 (1939).
56. B. Klatt, *Enstehung der Haustiere* (Berlin, 1927).
57. R. Vaufrey, *Mem. arch. inst. paleontol. humaine* **24**, 189 (1951).
58. E. D. Van Buren, *Analecta Orientalia* **18**, 1 (1939).
59. M. Hilzheimer, *Studies Ancient Oriental Civilization* **20**, 1 (1941).
60. M. Burton, *Illustrated London News* **229**, 234 (1956); J. Desmond Clark, personal communication; J. J. Teal, Jr., *Exploration J.* **36**, 13 (1958).
61. C. P. Richter, *Am. J. Human Genet.* **4**, 273 (1952).
62. R. M. Gilmore, *Bull. Bur. Am. Ethnol.* **143**, 345 (1950).
63. J. P. Scott, in *Interrelations between the Social Environment and Psychiatric Disorders* (Milbank Memorial Fund, New York, 1953), pp. 82-102.
64. ———, E. Fredericson, J. L. Fuller, *Personality: Symposia on Topical Issues* **1**, 163 (1951).
65. A. J. Arkell, *Kush* **5**, 8 (1957).
66. V. G. Childe, *The Most Ancient East* (Kegan Paul, Trench, Trubner, London, 1928); M. Wheeler, *Antiquity* **30**, 132 (1956); R. J. Braidwood, *ibid.* **31**, 73 (1957).
67. K. W. Butzer, *Erdkunde* **11**, 21 (1957); *Bonner Geograph. Abhandl.* **24**, 1 (1958).
68. H. Alimen, *The Prehistory of Africa* (Hutchinson, London, 1957).
69. This North African "Neolithic wet period" is to be correlated approximately with the central part of the "Atlantic" period of some authors, the "Hypsithermal" of others. See W. S. Cooper, *Bull. Geol. Soc. Am.* **69**, 941 (1958), for a summary of a confusing terminology.
70. L. Picard, *Bull. Geol. Dept., Hebrew Univ.* **4**, 1 (1943); N. Shalem, *Research Council Israel, Spec. Publ. No. 2* (1953), p. 153; H. E. Wright, Jr., *Studies Ancient Oriental Civilization*, in press; C. A. Reed and R. J. Braidwood, *ibid.*, in press.
F. C. Howell, *Proc. Am. Phil. Soc.* **103**, 1 (1959).
72. This article is the third in a series appearing in *Science* on the prehistoric Near East, having been preceded by articles by R. J. Braidwood [**127**, 1419 (1958)] and by Hans Helbaek [**130**, 365 (1959)].
73. The chronological chart was based primarily on *Relative Chronologies in Old World Archeology*, R. W. Ehrich, Ed. (Univ. of Chicago Press, Chicago, Ill., 1954). Radiocarbon dates, to mid-1958, are summarized by R. J. Braidwood [*Osterr. Akad. Wiss. Phil.-Hist. Kl. Anz. Jahrg. 1958* No. 19, 249 (1959).)] Additionally, I had advice from staff members of the Oriental Institute, University of Chicago. Other sources consulted were E. Massoulard (*35*); I. Rizkana, *Bull. inst. du desert* **2**, 117 (1952); and R. P. Charles, *J. Near East. Studies* **16**, 240 (1957).
74. T. Josien, *Israel Explor. J.* **5**, 246 (1955).
75. T. E. Peet, *Mem. Egypt Explor. Fund* **34**, 6 (1914); J. W. Jackson, *Mem. Egypt Explor. Soc.* **42**, 254 (1937).
76. G. Brunton, *Qua and Badari I* (Quaritch, London, 1927); ——— and G. Caton-Thompson, *The Badarian Civilization and Pre-dynastic Remains near Badari* (Quaritch, London, 1928); ———, *Mostagedda and the Tasian Culture* (Quaritch, London, 1937).
77. F. Debono, *Ann. service antiq. Egypte* **48**, 561 (1948); E. A. M. Greiss, *Bull. Inst. Egypte* **36**, 227 (1955).
78. H. Junker, *Anz. Akad. Wiss. Wien., Phil.-Hist. Kl.* **66**, 156 (1930).
79. My acceptance of the presence of five domestic animals for southern Mesopotamia at the beginning of Sumerian culture is based on a number of sources. All five are depicted on cylinder seals of immediately subsequent periods (*37, 58*), and skeletons of dogs are known [*36*; S. Lloyd, *Illustrated London News* **123**, 303 (1948)].
80. C. Caton-Thompson and E. W. Gardner, *The Desert Fayum* (Royal Anthropological Institute of Great Britain and Ireland, London, 1934), vol. 1, p. 34.
81. M. E. L. Mallowan, *Iraq* 8, 128 (1946).
82. R. Vaufrey, *Musée Louvre, dept. antiq. orient., ser. Arch.* (1939), vol. v, p. 193. The horn cores Vaufrey assigned to *Ovis vignei* I refer to domestic goats, on the basis of their great similarity to those of domestic goats at Jarmo. The teeth Vaufrey assigned to domestic sheep could belong to these same goats, so the presence of sheep at Sialk remains in doubt.
83. S. Lloyd and F. Safer, *J. Near East. Studies* **4**, 284 (1945). In spite of numerous subsequent statements by different authors concerning the presence of various domestic animals at Hassuna, the original report makes no such claim. However, in view of the geographical location and the chronological position, I believe that domestic dogs and goats, at least, were "probably present."
84. See discussion in text and in *Studies Ancient Oriental Civilization, Univ. Chicago*, in press.
85. C. A. Reed, *Sumer* **10**, 134 (1954). I can state definitely now that there is no evidence to support the preliminary claims, made in 1954, for domestic animals at M'lefaat.

Basic Research at State Stations

Twenty-two percent of federal-grant payments to state agricultural experiment stations support basic science.

H. C. Knoblauch

The state agricultural experiment stations, comprising a group of 53 state institutions, are conducting a broad and comprehensive program of research in phases of the life, physical, and social sciences related to agriculture. These stations, generally associated with land-grant colleges or state universities, have a long and successful history of research experience, and many of their findings have blazed new trails in basic fields of science. The federal government, recognizing the important part scientific research could play in solving farm problems, encouraged the establishment of state agricultural experiment stations and a continuing grant-in-aid program through passage of the Hatch Experiment Station Act of 1887. The program was further strengthened by subsequent passage of the Adams Act of 1906, the Purnell Act of 1925, the Bankhead-Jones Act of 1935, and the amendment to the Bankhead-Jones Act of 1946. Each of these provided for further endowment and increases in the federal-grant payments to states. In 1955, the five measures were combined by Congress into the Hatch Act Amended, which serves as the present authorization for grant-in-aid payments to the states.

In terms of the original goals for which the agricultural experiment stations were established, they have gone far beyond the most imaginative concept of their founders. The station system, as developed in the United

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