A genetic relationship between two or more language lineages is demonstrated by a large cognate vocabulary united through regular rules of sound change to a shared proto-lexicon and to a shared grammar; the cognate terms fit into the grammar in such a way that cognate terms belong to the same arbitrary grammatical classes across the daughter languages. Multi-layered homologies like these can be explained systematically - that is, by reference to a standard set of rules and principles - only by proposing a genetic relationship. No body of theory or method explains systematically how such deeply seated structural and lexical similarities could arise through convergence or borrowing. Scholars who specialize in the study of linguistic convergence (Nichols 1992; Thomason & Kaufman 1988) accept that convergence does not, as far as we know, produce similarities such as these. Even extreme cases of convergence - for example, where a linguistic enclave has been surrounded for centuries by a dominant language group that has exerted strong political, economic and military pressure to force linguistic conformity - do not produce linguistic similarities that simulate those between the Indo-European languages.
The reconstruction of an extinct proto-lexicon is an inseparable part of the comparative method. A phonologically consistent parent term is the residue of a successful comparison of cognates; it is the proof that the words being compared are indeed cognates. For example, *kmtom- (one hundred) is thought to be a good approximation or reconstruction of the Proto-Indo-European root that developed into the cognates simtas (one hundred) in Lithuanian, centum (one hundred) in Latin, and satem (one hundred) in Old Persian. The parent term *kmtom- was reconstructed phoneme by phoneme. It is possible to reconstruct a parental phoneme such as the initial 'k' in *kmtom- only when the initial phoneme in each cognate can be derived from the reconstructed parental phoneme according to the rules of evolutionary sound change that are known to have operated independently in each attested language lineage that has a cognate. The development of initial *k in PIE into initial s in Lithuanian is subsumed under a law (palatalization of initial consonant in specific kinds of phonetic environments) that applies generally in Lithuanian. The comparison can be derailed at any point if a single daughter language contains a single phoneme that cannot be linked to a mutually acceptable parent phoneme by the rules of evolutionary sound change. For this reason many comparisons fail, and it is possible to reconstruct only random pieces of any proto-language. However, when the method succeeds with a large and geographically diverse group of cognates, it is highly likely that the reconstructed proto-term is a relatively close approximation of a term that actually existed in a real proto-language. Reconstructed terms are static idealizations, and their proto-meanings are particularly difficult to interpret, but this is true of all words in all ancient languages for which we have texts, and we still find uses for the records of Egypt and Mesopotamia.

The problem of borrowing

A proto-lexicon of reconstructed terms is useless to archaeologists if linguists assign to it terms that in fact did not exist in the parent language, but were introduced and widely borrowed between daughter languages at a later date. The comparative method can be used to identify and exclude borrowed terms. Much of what we know about the extinct pre-Indo-European languages of Europe and the Aegean derives from studies of non-Indo-European loan words that survived in Indo-European languages (Hainsworth 1972; Polome 1986; Huld 1990). These misfits can be identified as borrowed terms even though the borrowing occurred thousands of years ago and the parent language is extinct and unrecorded, because the borrowed terms remain phonologically or morphologically inconsistent with the rest of the language in which they occur. Comparative analysis of widely diffused borrowed terms like 'coffee' would not - contra some critics - yield an anachronistic proto-Indo-European or Latin root for 'coffee'. The multiple inconsistencies that these terms exhibit within languages, in phonology and between languages, in expected phonological relationships, make reconstruction of a parental root term impossible. Many cases of very ancient borrowing remain obvious today.

Borrowing between daughter languages may complicate reconstruction of a parent language if the speakers of the daughter languages re-established contact soon after their languages evolved and remained in contact for a long time. Words that were introduced and diffused among closely related daughter languages early in their evolution might be impossible to distinguish from terms that were inherited from the parent. Some coevolutionary borrowing of this kind probably occurred between some early IE daughters, but it is not likely to cause significant problems for reconstruction of PIE because it was not systematic. PIE appears to have split into numerous fairly distinct branches very early (Nichols 1994: 36-7), and the daughter languages were carried into regions quite distant from each other (Anatolia, Europe, the eastern steppes). Cognates that are attested in the early IE languages of Europe, Anatolia and the east are not likely to have been borrowed into IE after the dispersal.

The recent tension between archaeologists and traditional historical linguists is ironic. Comparative linguists represent perhaps the most cautious and conservative branch of linguistics. They explain language change first and foremost by reference to internal phonetic inconsistencies or tensions; these cause shifts in phonology which lead to changes in morphology and syntax. Comparativists are prejudiced against external causation. When external causes of change are suggested - structural analogical change or borrowing from some other language - traditional comparativists tend to respond that internal causes have not been sufficiently explored (Thomason & Kaufman 1988: 59). Contemporary western archaeologists have precisely the same prejudice. We are deeply suspicious of explanations for culture change that stress external agents - migrations or cultural diffusion - and tend to ask if internal cultural, political or economic causes for an observed change have been adequately explored. Yet when Western archaeologists turn to historical linguistics, many choose diffusionist arguments, preferring to explain linguistic similarities through borrowing rather than internal development from a common ancestor.

I believe that the explanation for this inconsistency is that historical linguists stress the purely mechanical aspects of internal linguistic change. Historical linguistic change is constrained by phonetics; that is what makes it predictable. Sound change is in fact more regular, once it gets started, than the cultural changes that set it in motion. Linguists have been able accurately to predict the existence of undocumented aspects of archaic languages (like certain labiovelars in Mycenaean Greek) prior to their discovery in ancient inscriptions (Bynon 1977: 72). No comparable methodology permits any archaeologist to predict the artefact forms that will be found in
Wheels and the date of the Indo-European spread

Reconstructed proto-Indo-European (PIE) represents a real ancient vocabulary that is potentially of inestimable value to archaeologists. Historical linguists have established that the speakers of PIE were familiar with wheeled vehicles, reconstructing at least six PIE terms that refer to them: three terms for wheel (perhaps an indication of the importance of wheels in PIE life), one for axle, one for 'thill' (the draft pole to which the yoke is attached) and a verbal root meaning 'to go or convey in a vehicle' [ILLUSTRATION FOR FIGURE 1 OMITTED]. Cognates for these terms exist in all branches of Indo-European, from Celtic in the west to Sanskrit and Tocharian in the east, and from Baltic in the north to Hittite and Greek in the south (Schrader 1890: 339; Specht 1944: 99-103; Gamkrelidze & Ivanov 1984: 718-38; Anthony & Wailes 1988; Anthony 1991; Meid 1994). The PIE terms probably referred to the earliest form of wheeled vehicle - the solid-wheeled wagon or cart, pulled (slowly) by cattle. There is no single shared root for 'spoke', a later refinement in wheeled-vehicle technology.

Renfrew and others have suggested that none of these terms need derive from PIE; all of them might have spread through the IE languages as wheeled vehicle technology diffused, long after the separation and formation of the IE daughter tongues (Renfrew 1987: 86, 110; 1988: 464-5; Zvelebil & Zvelebil 1988). A post-PIE date for the diffusion of wheeled vehicles is unlikely for four reasons.

First, the cognate vocabulary consists of not one term, but at least six. Entire technical vocabularies have rarely been borrowed intact over so large an area in the absence of sophisticated communications and literacy. The core wagon vocabulary is distributed from India to Scotland with no terms confined to just the western or just the eastern IE languages. It if diffused after the IE dispersal it must have spread as a single semantic unit over a very large region that was fragmented linguistically, ethnically and ecologically [ILLUSTRATION FOR FIGURE 1 OMITTED]. The diffusion of other post-PIE technologies (notably the spoke and iron) through the IE-speaking world was not accompanied by the spread of standardized vocabularies in the manner proposed for wheeled vehicles.

Second, the diffusion of the earliest wheeled vehicle technology occurred so rapidly that we cannot now determine if it was invented by a single donor culture and diffused, or if it was independently invented in several regions (Piggott 1983: 63; Hauser 1994). The post-PIE theory assumes a single donor culture whose vehicular vocabulary was adopted across the entire territory between India and western Europe. No archaeological evidence has been offered for this proposition, and much contradicts it.

Third, since five of the six Indo-European wheeled-vehicle terms (all except 'thill' or draft-pole) have good Indo-European etymologies - they are derived from recognizable IE verbal or noun roots - the core vocabulary must have been created by an Indo-European-speaking group, which places additional constraints on an already awkward diffusionary hypothesis.

Finally, there is simply no internal phonetic or morphological evidence for borrowing within the relevant Indo-European vocabulary. None of these terms - and there are at least 35, when the six roots are multiplied by the number of IE languages in which they appear - is a phonological or morphological misfit within its language lineage (Gamkrelidze & Ivanov 1984: 718-38; Meid 1994; Mallory & Adams forthcoming). If the wheeled-vehicle vocabulary originated in an Indo-European daughter language after the separation of the IE languages into numerous distinct phonological and morphological systems, then the phonetic and morphological traits of that language should be detectable in at least some of the borrowed vocabulary, given the phonological distinctiveness of the IE daughter languages. The absence of such evidence indicates that the IE wheeled-vehicle vocabulary was not borrowed, but inherited from PIE.(1)

None of these problems has been explicitly addressed or acknowledged in print, beyond a brief discussion in Current Anthropology (Renfrew 1988). While the diffusionary scenario for IE wheeled-vehicle terminology remains an assertion, largely unanalysed and undefended, the genetic-inheritance explanation has been researched and supported in specialized studies by linguists (Specht 1944: 99-103; Gamkrelidze & Ivanov 1984: 718-38; review in Anthony 1991: 198-201; Meid 1994; Mallory & Adams forthcoming). The simplest and most widely accepted explanation of the linguistic evidence is that the speakers of PIE were familiar with and had a vocabulary for wheeled vehicles. Coleman's (1988) brief linguistic dissent stands alone against a body of scholarship to which he did not refer. If we accept the majority interpretation, PIE should have existed as a unified speech community after wheeled vehicles were invented. Archaeological evidence places this event after 3500 BC.
Between about 3300 and 3100 BC wheeled vehicles appeared for the first time in eastern Europe and the Near East in four different media: in Late Uruk written signs in the Near East, in 2-dimensional representations on a TRB pot from southern Poland and in a late TRB tomb at Zuschthen, in 3-dimensional models in Baden graves in Hungary and in actual vehicle burials in Yamna graves in the steppes of Russia and Ukraine (Piggott 1983: 38-58; Gei 1991; Izbitser 1993; Hauser 1994). It is unlikely that wheeled vehicles existed earlier, given the diverse range of media in which they suddenly appeared after 3500 BC. PIE existed as a single speech community late enough to experience and create words for wheeled vehicles, or after 3500 BC. Its expansion and differentiation must have occurred later.

When did the dispersal begin? The separation of Hittite, Indic, and Greek by 1800-1500 BC suggests that PIE must have broken up and begun to diversify before around 2000 BC, probably long before. From what place? Where was the PIE homeland? This is not merely an academic question. If we can link one or more archaeological cultures with the reconstructed PIE vocabulary, the effect on European prehistoric archaeology will be analogous to the discovery of a substantial text - the protolexicon - from a remote period beyond the reach of direct textual evidence. The fact that the text is fragmentary, idealized and difficult to decipher does not lessen its significance. It becomes useful, however, only if we can provide a reliable archaeological context for it.

The location of the Indo-European homeland

Any explanation of the location of the PIE homeland must recognize three constraints.

First, the PIE language community could not have covered an area larger than about 500,000-750,000 sq. km (Mallory 1989: 145-6; Anthony 1991: 196-8). There are simply no historic or ethnographic examples of a single-language community larger than this among non-state agriculturalists; most are very much smaller. Reconstructed PIE subsistence terms indicate that the speakers of PIE were herders and farmers: they were familiar with ards or ploughs, domesticated cereals and domesticated sheep, pigs and cattle. We are, then, looking for a discrete linguistic territory not much larger than Spain, as a maximum order-of-magnitude estimate.

Second, numerous specialists have noted strong linguistic parallels and early episodes of borrowing between PIE on the one hand and both the proto-Caucasian (Gamkrelidze 1966) and proto-Uralic (Collinder 1965; Joki 1973) language groups on the other. This suggests that PIE was spoken in a territory between the Caucasus and the Ural Mountains.

Third, the clearest and most discontinuous archaeological boundary in all of Europe during the period 5000-3500 BC was at the Dnieper River in modern Ukraine (Anthony 1995). The Tripolye culture, west of the Dnieper, was utterly distinct from the groups east of the Dnieper in ceramic shapes, decoration and technology; in metallurgy; in the use of female figurines; in mortuary rituals; in house forms and construction methods; in settlement size and organization; in several aspects of lithic tool production; in economy; and in the developmental trajectory that led to its appearance. Archaeological cultures do not correlate with prehistoric language groups in a predictable manner, but in many ethnographic situations, material culture does correlate with language (Clarke 1968: 384-5; Hodder 1978: 9-10; Jorgensen 1980: 88; Weissner 1983: 272; Moore & Romney 1994: 387-8). The Dnieper divide is likely to represent a 4th-millennium BC language boundary because: it originated as a boundary between immigrant farmers (west) and indigenous foragers (east); it was remarkably persistent, enduring for 1500 years, even after the societies east of the Dnieper adopted food production; and it separated people who produced fundamentally different material cultures, reflecting basic differences in domestic and economic organization, ritual practice, technological expertise and social display (Anthony 1995: 189-90).

The Dnieper boundary is among the best candidates for a linguistic boundary in 4th-millennium BC Europe. PIE should be placed on one side or the other. The linguistic links to Uralic and Caucasian, just mentioned, and the archaeological background of early Indo-Iranian-speaking groups far to the east combine to suggest a PIE homeland east of the Dnieper. These new arguments lead to an old conclusion: that the PIE homeland was in the Pontic-Caspian steppes, north of the Black and Caspian Seas.

The archaeology of the early Indo-European expansion

How can this conclusion be reconciled with the archaeological evidence from the region? Gimbutas' (1977) scenario of three waves of outward migration caused by shortages of pasture in the steppe is too broad, difficult to support chronologically and fails to address the social dynamics of migration or language shift. Mallory (1989) has offered an alternative interpretation, which I have largely supported (Anthony 1986; 1991), although I have perhaps placed greater stress on the dynamic role of innovations in transportation technology.

Brown and I have proposed that horseback riding began in the Pontic-Caspian steppes by 4000 BC, a conclusion based on the discovery of microscopic bit wear on horse premolars at the Sredni Stog culture site of Dereivka (Anthony & Brown 1990; Anthony et al. 1991; Anthony 1994) [ILLUSTRATION FOR FIGURE 2 OMITTED]. In
I.162; O'Flagherty 1981: 91) the legs of the ritual horse were carefully cut apart and offered in a specified way. The remainder of the body was not included - presumably it was consumed by the celebrants. In the Rig-Veda (RV) there are references to sacrifices involving horses, and in many cases these sacrifices were associated with the ritual burial of the horses in a pit with the horses' heads (tibias grouped with metacarpals, metatarsals, and phalanges), but in many cases the heads were not included. The method of sacrifice also matches the Vedic rite - at Sintashta the horses' legs were carefully segmented and placed in the burial pit with the horses' heads (tibias grouped with metacarpals, metatarsals, and phalanges). Other early examples of sacrifice have been observed by Anthony and Brown on about 10% of the horse lower second premolars at the site of Botai in northern Kazakhstan, dated c. 3100-3400 BC (Zaibert 1993). The Botai data reinforce the 4th-millennium evidence forbitting in the Eurasian steppes.

Solid-wheeled wagons and carts, probably pulled by oxen, appeared in steppe wagon graves of the related Yamna culture (3500-2500 BC) by about 3100-3000 BC (4370 [+ or -] 120 b.p. (KI-606) for a Yamna wagon grave at Bál'ki on the lower Dnieper, 4440 [+ or -] 40 b.p. (LE-2963) for a late Yamna/Novotitorovskaya wagon grave at Ostannin in the Kuban River region). While earlier steppe cultures, including Sredni Stog, had been centred on the forested river valleys, Yamna cemeteries appeared in deep steppe locations far from major river valleys. The saiga antelope, an animal of the deep steppe, appeared occasionally among the Yamna fauna; it had not appeared in Sredni Stog sites. Yamna metal-workers were the first intensively to exploit steppe copper ores (Chernykh 1992). Yamna settlements seem to have been located at sites previously little used and/or were occupied for significantly shorter periods, particularly in the Volga-Ural region, where intensive field surveys have yielded very little settlement evidence to accompany the rich Yamna cemeteries (Merpert 1974; 1991; Bondar & Telegin 1988). The appearance of the Yamna culture in the deep steppe signified a watershed in the cultural ecology of Eurasia.

I have argued that steppe pastoralism was dependent on the triad of grazing animals (sheep or cattle), horseback riding and ox-wagon transport (Anthony 1986: 310; 1994: 193-4). Horses improved long-distance scouting for pastures, herd management, long-distance trade and warfare. Wagons (probably drawn by oxen) provided the bulk transport for tents, food and supplies that for the first time freed herders from logistical dependence on the river valleys and permitted them to move deep into the steppes with their herds for an entire season. The Yamna culture, the first steppe culture of Eurasia to possess riding horses and wagons, seems to have been the first archaeological culture strongly oriented towards stock-breeding deep in the steppe. The final period of PIE linguistic unity and the initial differentiation of IE languages probably occurred within the context of the Yamna culture.

The Yamna culture area extended eastward no farther than the Ural River valley. East of the Urals were very different archaeological cultures (Botai/Surtanda) with no wagon graves, little metal, few domesticated animals except horses and very distinctive ceramics, mortuary rituals and settlement patterns. However, at about 2000 BC a new and remarkable archaeological culture appeared east of the Urals, apparently at least partially derived from a late Yamna variant (the Poltavka culture) on the middle Volga. This new group, the Sintashta-Petrovka culture, established compact, heavily fortified settlements in the northern steppes east of the Urals; engaged in bronze metallurgy on an unprecedented scale; raised herds of cattle, sheep, and horses; and practised complex mortuary rituals that parallel in many specific details the Aryan rituals described in the Rig-Veda (Anthony & Vinogradov in press; Gening et al. 1992; Kuzmina 1994: 226-8; Parpola 1995). Vehicles, buried in the richer Sintashta-Petrovka graves, as they had been earlier in Yamna graves, now included spoke-wheeled chariots, buried with two-horse chariot teams. Recent AMS dates of 2000 BC have established that these are the oldest directly dated chariots (or, some would argue, proto-chariots) in the ancient world.(2) It is likely that Sintashta-Petrovka represents the ancestral Indo-Iranians, whose traditions were later carried into India and Iran. Archaeologically, Sintashta-Petrovka is accepted as the formative phase in the development of the Andronovo horizon, which later (1800 BC) spread across the steppes from the Urals to the Tien Shan (Zdanovitch 1984; Mosin 1990; Malutina 1991).

The Sintashta-Petrovka culture was the first Eurasian steppe culture to display several traits later central to the cultures of the Indo-Iranian-speaking Aryans. These included: compact fortified settlements; chariotry, which was much more than transport, for it provided many of the essential metaphors that colored Vedic mythology and prayer; lavish expenditures of resources on the graves of the elite; and elaborate mortuary animal sacrifices that regularly involved the ritual slaughter of horses and cattle. In the Rig-Veda, the horse sacrifice - the central ritual of early Vedic myth - was preceded by the slaughter of a goat, the goat being the symbol of Pusan, the god of paths and ways. In several instances at the Sintashta cemetery, horses and cattle were sacrificed with a single ram. The ram at Sintashta may have served a role like that of the scapegoat of the Vedas - to guide the sacrifices on the right path to the spirit world. The horses in the Vedic rite were racehorses. The chariot equipment and two-horse teams sacrificed in some Sintashta-Petrovka graves suggest that these also were racehorses. The method of sacrifice also matches the Vedic rite - at Sintashta the horses' legs were carefully segmented and placed in the burial pit with the horses' heads (tibias grouped with metacarpals, metatarsals, and phalanges), but in many cases the remainder of the body was not included - presumably it was consumed by the celebrants. In the Rig-Veda (RV I.162; O'Flagherty 1981: 91) the legs of the ritual horse were carefully cut apart and offered in a specified manner.
sequence, while the flesh was cooked and consumed by the celebrants. In these and other ways, Sintashta-Petrovka customs anticipated those of the Vedic Aryans. While the Indo-Iranian language might have been emerging from a PIE dialect on the eastern margins of the Yamna territory before 2000 BC, it was with the Sintashta-Petrovka culture that the defining ritual aspects of Indo-Iranian identity seem to have solidified.

The dynamics of Indo-European expansion

The expansion of the Indo-European languages must have involved many episodes of language shift over a long period of time. There is no single explanation for these many episodes; they occurred in different places, at different times, for many different reasons. Even the initial expansion seems to have been facilitated by different processes to the east and to the west of the PIE core area.

Language shift has been modelled by archaeologists in two ways: demographic expansion and elite dominance. In the first, a group with a more intensive economy and a denser population replaces or absorbs a group with a less intensive economy, and language shift occurs as an epiphenomenon of a wave-like demographic expansion (Renfrew 1994; Bellwood 1989). In the second, a powerful elite imposes its language on a client or subject population. While both processes can be important, language shift is more complex than these models imply. Language shift can be understood best as a social strategy through which individuals and groups compete for positions of prestige, power, and domestic security (Anthony in press). What is important, then, is not just dominance, but vertical social mobility and a linkage between language and access to positions of prestige and power (Mallory 1992).

The expansion of the Indo-European languages eastward into the steppes was linked to innovations in transport. The resultant development of deep-steppe pastoralism combined with river-valley agriculture made it possible for a substantial population predictably and productively to exploit the grasslands that occupy the center of the Eurasian landmass. The conquest of the grasslands permanently changed the dynamics of historical development across the Eurasian continent by establishing a bridge, however tenuous, between the previously isolated societies of China, Iran, the Near East and Europe. In a sense, the eastward expansion of the pastoral-agricultural economy might be analogous to the ‘demographic wave’ that Renfrew and others have applied to the Indo-European expansion in Europe. However, the cultural-archaeological context shows that the steppes were already populated; the process by which this resident population became IE-speakers was cultural, not just demographic.

A relatively small immigrant elite population can encourage widespread language shift among numerically dominant indigenes in a non-state or pre-state context if the elite employs a specific combination of encouragements and punishments. Ethnohistorical cases in Africa (Kopytoff 1987; Atkinson 1989) and the Philippines (Bentley 1981) demonstrate that small elite groups have successfully imposed their languages in non-state situations where they:

* imported a powerful and attractive new religion or ideology (as the Sintashta-Petrovka culture seems to have done);
* controlled sufficient wealth to offer gifts and loans on a lavish scale (documented in the metallurgical wealth of Sintashta-Petrovka);
* controlled sufficient military muscle to punish those who resisted (chariotry might have increased the power of the Sintashta-Petrovka people);
* occupied strategic positions on critical trade routes (Sintashta controls access to the Orenburg gateway between Europe and the steppes);
* and actively pursued marriages and alliances with the more powerful members of indigenous groups, offering them enhanced prestige and vertical social mobility in the new order.

Simply defeating and dominating the indigenes is insufficient, as the Norman conquest of England and the Celtic conquest of Galatia demonstrate. Language shift occurs when it confers strategic advantages on those who learn the new language. An elite must be not just dominant, but open to assimilation and alliance, and its language must be a key to integration within an attractive socio-political system, as it was for the Roman state at one end of the political spectrum and for Baluchi nomads (Barth 1981) at the other.

The diffusion of the IE languages eastward into the steppes should be understood as a social process, not as an epiphenomenon of a demographic shift. The diffusion westward into Europe was fundamentally different in ecological, cultural and economic terms. It also probably began much earlier. Intrusive kurgan cemeteries in the
lower Danube valley (Panaiotov 1989) and eastern Hungary (Ecsedy 1979; Sherratt 1983) probably testify to a sustained Yamna incursion at about 2900-2700 BC (Anthony 1990). Yet the small-group social dynamics responsible for language shift might have been very similar in Europe and the steppes. In a European context in which wagons and animal traction were becoming increasingly important in the domestic economy (Bogucki 1993), the pastorally-oriented societies of the western steppes might have been seen not as culturally backward 'Huns', but rather as enviably rich and worthy of emulation. Wheeled vehicles may have significantly altered the organization of agricultural labour in eastern Europe, since one person with a wagon and oxen could transport crops from field to farm that would earlier have required the co-operative labour of a group (Bankoff & Greenfield 1984: 17; Bogucki 1993). Wagons made systematic manuring possible, opening areas with less productive soils to agricultural exploitation. Wagons required draft oxen, enhancing the overall importance of cattle-raising, while horseback riding made cattle stealing easier, encouraging inter-community raiding and warfare. Wagons may have encouraged the evolution of increasingly dispersed and individualizing social communities (as automobiles have done in this century). Shifts in values may have been encouraged by changes in eastern European community organization and economy that were themselves caused partially by the adoption of wheeled vehicles and horseback riding. All of these changes might have set the stage for the adoption of new languages just at the time that the Yamna incursion into the grassy plains of the lower Danube valley and eastern Hungary began.

At the root of both expansions lie the speakers of PIE, whose kinship systems, religious concepts, and social organization can be understood through their own reconstructed vocabulary - an unprecedented opportunity for anthropological archaeologists, if we can agree on how it should be exploited.

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1 I have not proposed that wheeled vehicle technology originated in the PIE homeland, a position that has been attributed to me by Hausler (1994: 223). I have proposed only that most of the IE vocabulary for wheeled vehicles originated in PIE.

2 The Krivoe Ozero dates were AMS dates run by the University of Arizona laboratory on bone from the two horse skulls deposited on the floor of grave 1, kurgan 9, excavated by Nikolai Vinogradov of the State Pedagogical Institute in Chelyabinsk. The horses, the chariot, numerous grave gifts and an adult male were lying on the same floor. The uncalibrated dates were: 3580 [+ or -]50 b.p. (AA-9874a), 3525[+ or -]50 b.p. (AA-9875b), 3700[+ or -]60 b.p. (AA 9875a) and 3740[+ or -]50 b.p. (AA 9874b) (see Anthony & Vinogradov 1995). Littauer (pers. comm.) has recently argued that true chariots of the classic Near Eastern type required a yoke saddle to adapt the vehicle yoke to horse anatomy, and that without such a device the steppe examples should be considered proto-chariots or spoked-wheeled carts. No yokes, yoke-saddles or draft poles are preserved in the steppe chariot graves.

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