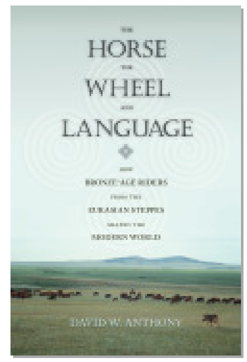
The Horse, the Wheel, and Language

David W. Anthony



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Appendix

Author's Note on Radiocarbon Dates

All dates in this book are given as BCE (Before the Common Era) and CE (Common Era), the international equivalent of BC and AD.

All BCE dates in this book are based on calibrated radiocarbon dates. Radiocarbon dates measure the time that has passed since an organic substance (commonly wood or bone) died, by counting the amount of ^{14}C that remains in it. Early radiocarbon scientists thought that the concentration of ^{14}C in the atmosphere, and therefore in all living things, was a constant, and they also knew that the decay rate was a constant; these two factors established the basis for determining how long the ^{14}C in a dead organic substance had been decaying. But later investigations showed that the concentration of ^{14}C in the atmosphere varied, probably with sunspot activity. Organisms that lived at different times had different amounts of ^{14}C in their tissues, so the baseline for counting the amount of ^{14}C in the tissues moved up and down with time. This up-and-down variation in ^{14}C concentrations has been measured in tree rings of known age taken from oaks and bristlecone pines in Europe and North America. The tree-ring sequence is used to calibrate radiocarbon dates or, more precisely, to convert raw radiocarbon dates into real dates by correcting for the initial variation in ^{14}C concentrations as measured in a continuous sequence of annual tree rings. Uncalibrated radiocarbon dates are given here with the designation BP (before present); calibrated dates are given as BCE. Calibrated dates are "real" dates, measured in "real" years. The program used to convert BP to BCE dates is OxCal, which is accessible free for anyone at the website of the Oxford Radiocarbon Accelerator Unit.

Another kind of calibration seems to be necessary for radiocarbon dates taken on human bones, *if the humans ate a lot of fish*. It has long been recognized that in salt-water seas, organic substances like shell or fish bones absorb old carbon that is in solution in the water, which makes radiocarbon dates on shell and fish come out too old. This is called the "reservoir effect" because seas act as a reservoir of old carbon. Recent studies have indicated that the same problem can affect organisms that lived in fresh water, and most important among these were fish. Fish absorb old carbon in solution in fresh water, and people who eat a lot of fish will digest that old carbon

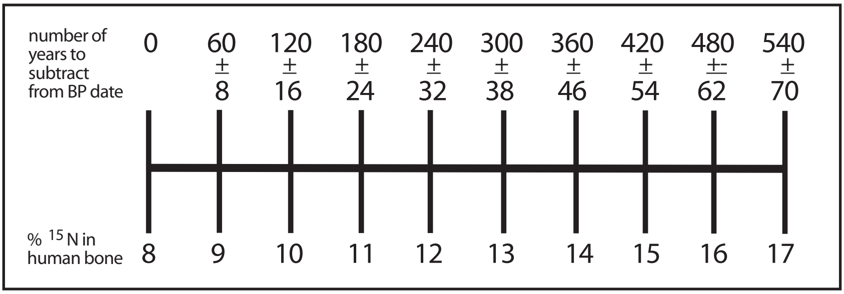

Figure A1. A proposed linear correlation between the % of ^{15}N in dared human bone (*bottom*) and the number of radiocarbon years that should be subtracked from radiocarbon dares (*top*) before they are calibrated.

and use it to build their bones. Radiocarbon dates on their bones will come out too old. Dates measured on charcoal or the bones of horses and sheep are not affected, because wood and grazing animals do not absorb carbon directly from water like fish do, and they do not eat fish. Dates on human bone can come out centuries older than dates measured on animal bone or charcoal *taken from the same grave* (this is how the problem was recognized) if the human ate a lot of fish. The size of the error depends on how much fish the human ate and how much old carbon was in solution in the groundwater where he or she went fishing. Old carbon content in groundwater seems to vary from region to region, although the amount of regional variation is not at all well understood at this time. The amount of fish in the diet can be estimated on the basis of ^{15}N levels in bone. Fish have much higher percentages of ^{15}N in their tissues than does any other animal, so humans with high ^{15}N in their bones probably ate a lot of fish. High ^{15}N in human bones is a signal that radiocarbon dates from those bones probably will yield ages that are too old.

Research to correct for reservoir effects in the steppes is just beginning as I write this, so I cannot solve the problem. But many of the radiocarbon dates from steppe archaeology are from cemeteries, and the dated material often is human bone. Widespread tests of the ^{15}N in human bone from many different steppe cemeteries, from Kazakhstan to Ukraine, indicate that fish was a very important part of most ancient steppe diets, often accounting for 50% of the meat consumed. Because I did not want to introduce dates that were probably wrong, I used an approach discussed by Bonsall, Cook, and others, and described by them as *preliminary* and *speculative*. They studied five graves in the lower Danube valley where human bone and animal bone in the same grave yielded different ages (see chapter 7 for references). Data from these graves suggested a correction method. The average level of ^{15}N in the human skeletons (15.1%) was equated with an average radiocarbon error (425±55) that should be *subtracted* prior to calibrating those dates. These averages could be placed on a scale between the known minimum and maximum levels of ^{15}N found in human bone, and, speculatively, a given level of ^{15}N could be equated with an average error in radiocarbon years. The scale shown in figure A.1 was constructed in this way. It seems to yield results that solve some long-problematic dating offsets in steppe chronology (see ch. 9, notes 4, 16, and 22; and ch. 12, note 30). When I use it—when dates are based principally on human bone—I warn readers in the text. Whatever errors it introduces probably are smaller than those caused by ignoring the problem. All the radiocarbon dates listed in the tables in this book are regular BP and calibrated BCE dates, without any correction for the reservoir effect.

Figure A.1 shows the correction scale I used to revise dates that were measured from human bone in regions where I knew the average ^{15}N levels in human bone. The top number is the number of years that should be

Table A.1

The average ^{13}C and ^{15}N% in human bone from seventy-two individuals excavated from graves in the Samara oblast, by time period.

Time Period	*Sample Size*	*C13*	*N15*	*Years to Subtract*
MESOLITHIC	5	–20.6	13.5	–330±42
NEOLITHIC	8	–22.3	11.8	–228±30
EARLY ENEOL	6	–20.9	14.8	–408±52
LATE ENEOL	6	–21.0	13.1	–306±39
EBA	11	–18.7	11.7	–222±30
MBA	11	–19.0	12.0	–240±32
POTAPOVKA	9	–19.1	11.3	–198±26
EARLY LBA	7	–19.1	11.4	–204±27
LATE LBA	9	–18.9	11.2	–192±26

subtracted from the BP radiocarbon date; the bottom number is the ^{15}N level associated with specific subtraction numbers.

Table A.1, based on our own studies in the Samara oblast, shows the average ^{15}N content in human bone for different periods, taken from measurements on seventy-two individuals.