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Red ochre and shells: clues to human evolution

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The 200-kiloannus (ka) use of red ochre and shells by humans is interpreted as a simple clue of symbolic thinking. Integration of multiple lines of evidence supports the opinion that the use of red ochre and shells might have had direct significance for human evolution. Use of seafood and red ochre supplies docosahexaenoic acid (DHA), possibly iron, and other essential nutrients for brain development and reproductive health, improving human fitness and triggering brain growth. The fitness advantages to humans of using shells, and possibly red ochre, might have selected for artistic and symbolic expression, and, thereby, lead to social cohesion. Current global health syndromes show that an adequate supply of seafood and iron continues to play a fundamental role in human health.

A 200-ka bond between shells, red ochre, and human evolution

Recent discoveries providing evidence of an early [> 200 ka; 1 ka = 1000 years before present (BP)] and independent development of symbolic expression in modern humans and Neanderthals [1–5] have important implications for our understanding of human evolution. This evidence relies heavily on the ornamental use of shells and red ochre [1–7], whose combined use by humans elapses over 200 ka, tracking human dispersal and cultural diversification to date (Figure 1; Box 1). However, the use of shells and red ochre is largely interpreted as a simple clue to symbolic and cognitive thinking, which carries evolutionary significance. In this opinion article, I bring together recent paleoanthropological, historical, physiological, oceanographic, and ecological evidence supporting the opinion that the 200-ka bond between the use of red ochre and shells by humans might have direct evolutionary significance, reflected in the benefits that a seafood diet supplemented with a source of iron, supporting reproductive and brain health, might have provided for human fitness and evolution.

Human use of red ochre and shells

Use of red ochre and shells by modern humans have been dated to a minimum of 160 ka in Blombos and Pinnacle Point caves, South Africa [1]. Evidence of early (ca. 200–250 ka) use of shells and red ochre by Neanderthals has been derived near Maastricht, The Netherlands [5] and the Benzú rock shelter (Ceuta, Spain) [3], although these findings provided no evidence for their symbolic use. Evidence for the significance of these items for early humans include the discovery of a 100-ka factory in Blombos Cave to produce red ochre pigments, which were stored in abalone shells [8], and evidence of trade for both these elements dating 80 ka [9]. Evidence of the symbolic use of shells and red ochre by Neanderthals dating 50 ka was derived from caves in the Iberian Peninsula [10]. Reports of the joint use of red ochre and shells by humans are rapidly growing in number (Figure 1), with cultural practices involving the joint use of red ochre and shells extending to date (Box 1).

A hypothesis linking shells and red ochre with human nutrition, health, and evolution

The sustained use of shells and red ochre for over 250 ka (Figure 1) suggests more direct and profound consequences for human evolution than just evidence for symbolic thinking. Use of shells indicate the use of seafood, an early underpinning of the food security of humans. Seafood can be gathered with little risk or technology in the intertidal zone, and is available in great quantities throughout the year in productive shorelines, such as the coastline of South Africa, where modern humans were first located, and the Indian Ocean, along which humans first dispersed [11]. Use of seafood allowed humans to cope with a climatically adverse period between 195 and 130 ka ago [9], and provided a reliable food source along the subsequent coastal dispersal of humans [11]. Seafood is rich in DHA, a polyunsaturated essential fatty acid with a fundamental role in brain growth, function, and evolution [12–15]. In addition, the marine diet is a key source of other oligoelements with a key role in brain health, such as iodine and lithium. Iodine plays a significant role in brain development, with iodine deficiency, conducive to brain damage [16], remaining the most frequent cause worldwide, after starvation, of preventable mental retardation in children [17]. Lithium is another trace element also present in seafood whose role as a human nutrient has been recently proposed [18], and is now used to treat bipolar disorder and neurodegenerative diseases [19]. Therefore, the hypothesis that the early use of the marine food web by humans, rich

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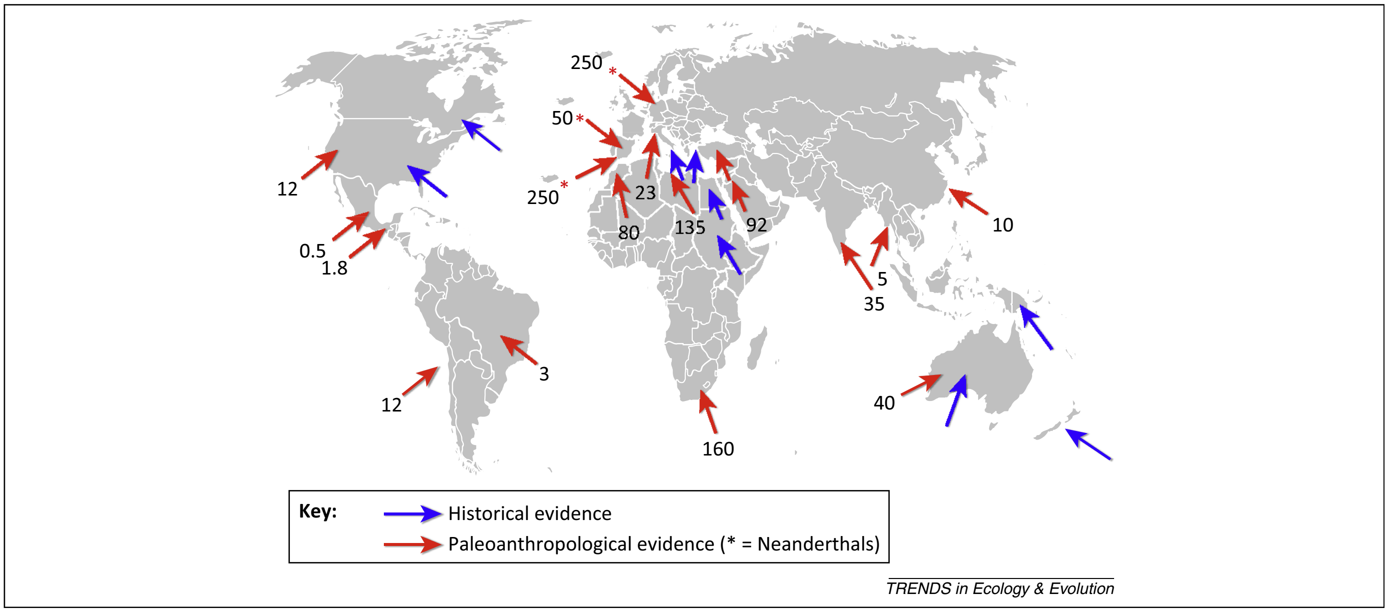

Figure 1. Reports of the joint use of red ochre and shells by humans are rapidly growing in number [40], including reports for both modern humans and Neanderthals (asterisks). Existing records track the reconstructed dispersal of modern humans, including findings of the joint use of red ochre and shells in Africa, Eurasia, Australia, and America, ranging from paleorecords starting in 250 ka (red arrows, paleorecords) to present (blue arrows, historical records, Box 1). For paleoanthropological evidence, the numbers show the dates in ka, where reported [40]. When multiple reports were available for a given region, the oldest one is shown.

in omega 3, DHA, and other critical nutrients for healthy brain development triggered the evolution of the large human brain [20], the cornerstone of human evolution, is now receiving ample support [13–15,20].

By contrast, the role of red ochre in human evolution remains confined to the development of symbolic and artistic expression, as 'the use of such material (red ochre) is unlikely to have had any value other than symbolic' [21]. However, I suggest in this article that use of red ochre might have also played a similarly direct early role on reproductive and brain health and, therefore, human evolution. Whereas there is solid evidence for the benefits of a seafood diet for brain development and human evolution, the hypothesis linking the use of red ochre with human iron nutrition has not been examined before. Whereas recent evidence suggests that this is a plausible hypothesis (Box 2), it needs be tested in the future.

Homo erectus was interested in red ochre since at least 1500 ka [21], and contemporary humans remain attracted to the color red [22], (Box 1). Australian aborigines, the oldest living culture, assign great health benefits to red ochre [21], which used has been linked with medical practices [23], and traditional Arab, Chinese, Egyptian, Greek, and Roman medicinal practices involved iron, despite the fact that the role of iron as an essential nutrient was only demonstrated by Boussingault in 1872 [24]. Findings at Blombos Cave showed that red ochre was powdered using grindstones and hammerstones and mixed with bone marrow and charcoal to derive a mixture [8]. Evidence that Neanderthals also used ochre prepared as an ochre-rich liquid substance has also reported [5]. The ingestion of mixtures of red ochre and bone marrow, deliberately or through contamination, would represent an iron-fortified food, comparable to fortified foods used today [25], as recent evidence shows that protein coatings increase the bioavailability of the metastable ferric forms present in red ochre (Box 2). Whereas ferric iron forms present low bioavailability, ferric iron forms present in red ochre, other than hematite, can be assimilated, particularly when combined with protein (Box 2). Indeed, ferric forms present in red ochre, such as ferrihydrate and maghemite, are used in pharmaceutical products to treat iron deficiency anemia in humans (Box 2). Iron deficiency anemia remains a serious heath issue affecting humans, particularly women, in both developed and developing nations, increasing the risk for preterm labor and infant mortality, and accounting for much of maternal deaths during pregnancy and childbirth [24,25]. Today, approximately 70% of women emerging from pregnancy suffer iron deficiency anemia [24,25].

Two iron-rich proteins, the oxygen transport protein hemoglobin, and the iron storage protein ferritin, which account for 70% and 25% of the iron in the human body, respectively, play a key role in brain health and function [26,27]. Hemoglobin carries oxygen from the lungs to the brain, which accounts for 20% of the total oxygen consumption with only 2% of body weight [24,26], and a smaller share of the metabolically-active mass. Iron supply-supporting loads of hemoglobin to satisfy brain oxygen requirements is, as is that of omega 3 and DHA, particularly critical during the early development of the brain [24,26]. Ferritin, particularly enriched in the human brain (30% of total ferritin) [27], plays a role in storing and releasing iron, buffering against iron deficiency and overload, and is particularly important for brain iron homeostasis and health [24–28]. Inside the ferritin shell, iron ions form crystallites similar to the mineral ferrihydrite, an iron oxide present in red ochre (Box 2). Therefore, red ochre can be, depending on the fraction of metastable sources and mixing with foods, a source of iron that can be stored in ferritin in the human brain, supplying iron where necessary to maintain adequate levels of hemoglobin and, therefore, oxygen supply for brain function.

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