BOOK REVIEWS

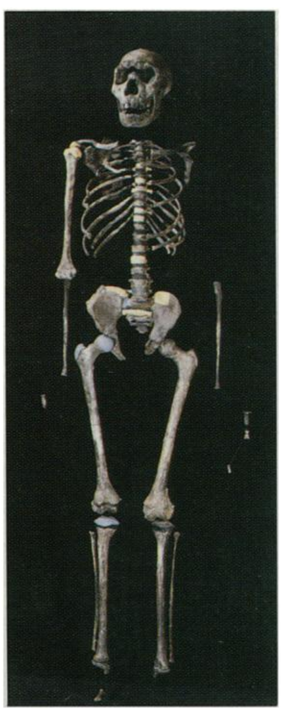
WT 15000

The Nariokotome *Homo erectus* Skeleton. ALAN WALKER and RICHARD LEAKEY, Eds. Harvard University Press, Cambridge, MA, 1993. x, 457 pp., illus., + plates. $125.

In August 1984, a small piece of human cranial bone was recovered by the redoubtable Kenyan fossil-finder Kamoya Kimeu at a site located near the Nariokotome sand river, some 5 kilometers inland from the western shore of Lake Turkana, northern Kenya. By the end of September, sieving of surface deposits along with excavation of sediments at this site, designated Nariokotome III, yielded most of the skull and many postcranial elements from a single human skeleton. Two subsequent field seasons produced other elements, and by the close of excavations in 1988, Kimeu's cranial fragments formed part of the most complete early human skeleton known from any period prior to the advent of intentional inhumation.

Subsequent analyses of the Nariokotome skeleton, known as KNM-WT 15000 (its accession number at the National Museums of Kenya), have revealed the specimen to be a relatively early member of the taxon *Homo erectus*. WT 15000, who died at between 11 and 15 years of age, was a male, whose stature of 160 centimeters is estimated to indicate a surprising 185 centimeters (6 feet 1 inch) at adulthood. The skeleton's geological context and extrapolation from datable volcanic tuffs (both at Nariokotome and elsewhere in the Turkana Basin) indicate a chronological age between 1.51 and 1.56 million years, later than the earliest dated specimens of *H. erectus* from Koobi Fora (on Turkana's eastern shore) but earlier than most *H. erectus* specimens from Eurasia and the rest of Africa.

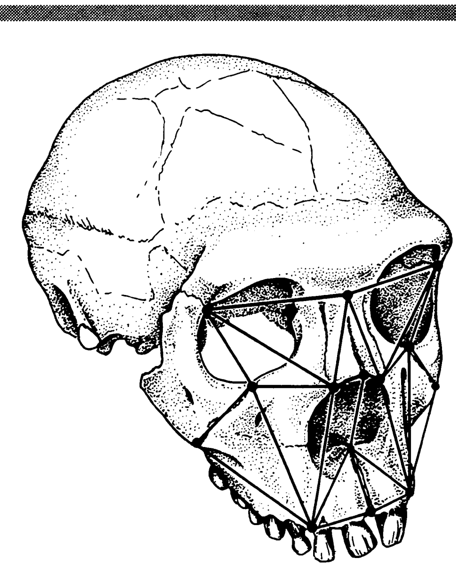
Obviously, any fossil human specimen, especially one this early, is an important source of information about our evolutionary history. But what makes WT 15000 particularly informative is its relative completeness. This completeness allows scientists to be more certain of various body proportions and the relationship of cranial capacity to body size in early Pleistocene humans, much as the famous Lucy skeleton has done for our very earliest unequivocal ancestors. Such information provides critical insights into the course of human evolution that are not obtainable from less complete specimens. Furthermore, WT 15000 serves as a kind of "Rosetta stone" that permits more secure taxonomic attribution of many less complete specimens, especially postcrania and mandibles from this period in East Africa. It is altogether fitting that a specimen of this significance has received the type of top-quality analysis and presentation reflected in this volume.



The Nariokotome skeleton, KNM-WT 15000. [From *The Nariokotome* Homo erectus *Skeleton*]

The Nariokotome volume has three major divisions. Part 1 provides detailed background on the Nariokotome III site, including the faunal remains, the taphonomy of the human skeleton, and the geology and chronology of the site. Part 2 is a basic description of the skeleton, with chapters on the skull (Walker and Leakey), postcranial bones (Walker and Leakey), and dentition (Brown and Walker). These descriptions are characteristically thorough and detailed and include comparisons with other appropriate early African *Homo* specimens and some dental comparisons with the Chinese *H. erectus* sample from Zhoukoudian. Walker, Leakey, and Brown conclude that the anatomical features of WT 15000 are commensurate with its taxonomic placement in *H. erectus*. But they also note that there is considerable cranial variability in the early African representatives of this taxon and that tooth morphology cannot be used to separate *H. erectus* and *H. habilis*.

Part 3 presents a series of



The Nariokotome skull reconstructed. [From *The Nariokotome* Homo erectus *Skeleton*]

excellent analyses concerning specific aspects of WT 15000's morphology. Several of these suggest that early *H. erectus* was already very much like us. Reconstruction of the pelvis (Walker and Ruff) suggests a small birth canal relative to adult brain volume, implying that early *H. erectus* already exhibited the uniquely human feature of giving birth to secondary altritial infants. This is also indicated by an analysis of the pattern of growth in WT 15000's brain size (Begun and Walker). The lumbar and thoracic portions of the spine (Latimer and Ward) are "strikingly similar to humans in nearly all significant respects" (p. 292). Likewise the rib cage (Jellema *et al.*) exhibits an essentially modern human form.

One of the most provocative analyses concerns body size and shape. Ruff and Walker conclude that WT 15000 had a body proportioned similarly to modern human tropical-adapted populations, with a relatively thin trunk and long limbs. Viewed in the context of thermoregulation, WT 15000's projected adult stature is not as extraordinary as was initially claimed. Indeed it makes sense in the context of human adaptation to "diurnal activity in a hot, relatively dry climate, that was probably more open than closed" (p. 262).

In other features, WT 15000 is not as similar to modern people. In both cranial capacity (909 cubic centimeters) and various encephalization quotients (Begun and Walker), WT 15000 falls in with other *H. erectus* specimens, yielding intermediate values between australopithecines and recent humans. The pattern of facial growth (Richtsmeier and Walker) shares similarities with both *Pan* and *H. sapiens*, and analysis of skeletal growth and dental development (B. H. Smith) may indicate absence of the characteristic human adolescent "growth spurt." Furthermore, MacLarnon shows that WT 15000's thoracic neural canal (from T3 to T11) is not as expanded as in modern humans. She rejects the earlier suggestion that this would reduce muscular control to the upper extremities, arguing instead that this condition implies reduced innervation of the mid or lower trunk. This is likely to be associated either with decreased muscular movement or control of the trunk or with decreased control of breathing. Walker combines this "decreased control of breathing" interpretation with the fact that the cerebral assymetries and presence of Broca's cap on the endocast do not necessarily demonstrate language ability to argue that *H. erectus* did not possess fully developed human language and speech.

As Walker aptly states in his summary discussion of the specimen, WT 15000 "has changed the narrative of our own evolution and illuminated yet other areas of our ignorance" (p. 411). The information provided by the various studies reported in this volume is of immense value to our knowledge of human evolutionary history. The authors and editors have provided a model for descriptive and comparative analyses against which all subsequent endeavors will be measured. In my opinion, this work will stand as one of the classics of paleoanthropology.

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An Energy Alternative

Renewable Energy from the Ocean. A Guide to OTEC. WILLIAM H. AVERY and CHIH WU. Oxford University Press, New York, 1994. xxx, 446 pp., illus. $65. Johns Hopkins University Applied Physics Laboratory Series in Science and Engineering.

An enormous renewable energy resource exists in the tropical oceans. The authors of this book state that this resource could be exploited to produce a large fraction of the world's energy needs in the form of methanol or ammonia and that any associated deleterious environmental effects would be minimal.

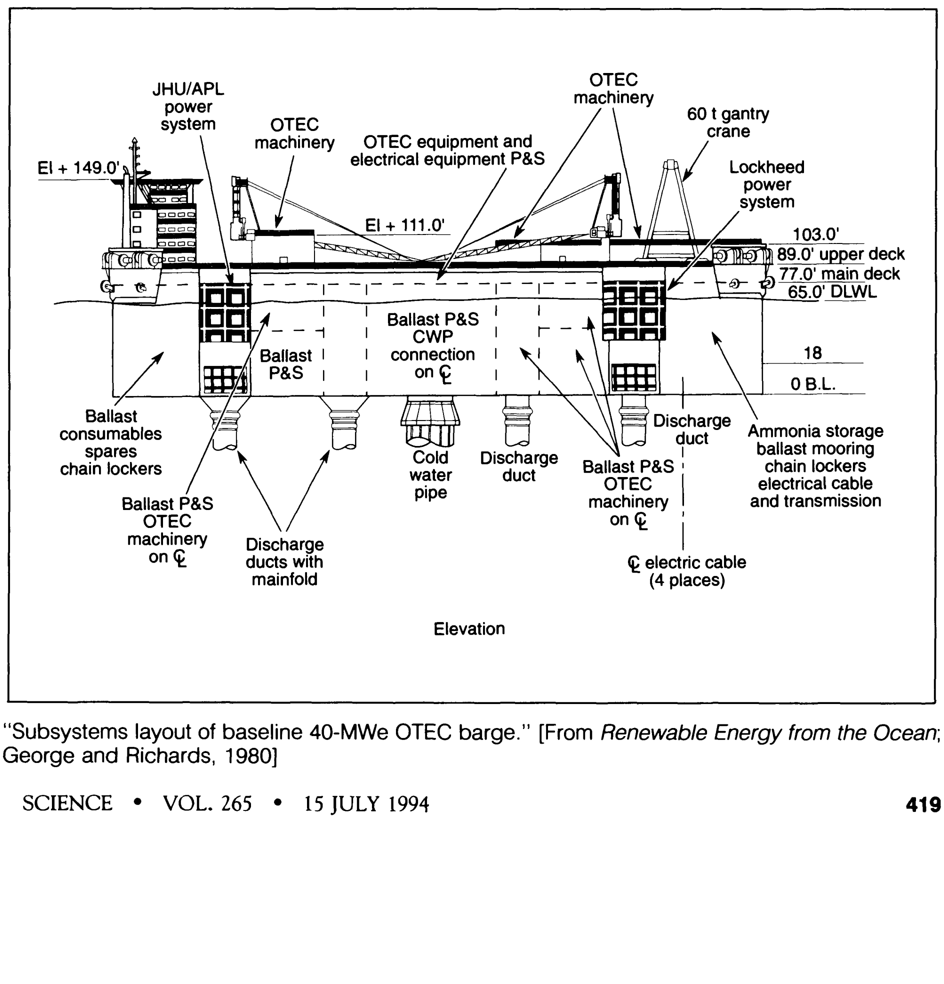
The sunlight that falls on the oceans is strongly absorbed in the upper 100 meters, raising the temperature of a top layer of tropical oceans to about 28°C. This temperature is nearly constant day and night and month to month. In contrast, most of the deep portions of the oceans are at temperatures of 4°C or less. Scientists and engineers have long been aware of methods of exploiting the temperature difference. As a result of the energy crisis of the 1970s, the United States invested $260 million for research and development of Ocean Thermal Energy Conversion (OTEC). Other nations, including France and Japan, were similarly active. Engineers from U.S. national laboratories and high-tech companies carefully considered the many detailed aspects of design of practical long-term seagoing plants. Sufficient progress was achieved that in 1980 Public Law 96-310, establishing goals that included the creation of 500 megawatts of OTEC electrical energy or energy products' equivalent by 1989, was enacted.

In September 1980, the Department of Energy issued a Program Opportunity Notice (PON) inviting industry to participate in a program to produce a 40-MWe OTEC pilot plant. The PON stated that the department would fund five to eight contracts at $900,000 each for the first phase of a six-step program leading to a successful venture. Industrial response was enthusiastic. Eight proposals were received. After the 1980 election, however, the federal support fizzled out.

One of the key participants in OTEC studies was William H. Avery. His participation and that of his employer, the Johns Hopkins Applied Physics Laboratory, began in the early 1970s. Since then, Avery has been steadfast in his commitment to OTEC. He has taken part in many national and international meetings concerning it and has created and maintained a database that includes 2500 items, most of which are detailed technical articles. Together with Chin Wu of the U.S. Naval Academy, he has prepared a heavily referenced book that will be invaluable to those who will later seek to exploit OTEC on a large scale.

The book treats in detail solutions to the many problems that must be dealt with to create successful large-scale 200- to 400-MWe OTEC plants. For example, it was determined that seagoing vessels housing the plant should be constructed of reinforced concrete and in one design should be 275 meters long, 119 meters wide, and 27.4 meters in the vertical dimension. Concrete would be used because it is cheaper than steel and not subject to corrosion. The plants would be designed for a long life and for resistance to hurricane conditions. One of the many other considerations included provisions to supply about 500 tonnes per second of cold water drawn from 1000 meters below the surface.

In the conversion of thermal to electrical energy, a working fluid (ammonia) in a boiler would be heated by the warm water, creating a vapor pressure of about 9 atmospheres. The vapor would drive a turbogenerator to produce electrical energy. The ammonia vapor would be cooled and condensed on surfaces chilled by the cold water and then recycled. The electrical energy would be used to electrolyze water to hydrogen and oxygen. The hydrogen would be reacted with nitrogen from air were ammonia the desired product. Ammonia could be used as a motor fuel if greenhouse problems



"Subsystems layout of baseline 40-MWe OTEC barge." [From *Renewable Energy from the Ocean*; George and Richards, 1980]