feel that it has gained so great a lead in some field of science that it may dare to launch an attack for world conquest. Although this error in judgment will almost certainly be answered by mutual annihilation approaching totality, every effort must be bent while we still have the chance to prevent such dreadful miscalculations from occurring. Scientists, it seems to me, might suggest to the statesmen that modern technology could make the greatest contribution to the security of great powers if statesmen would move as far as possible from the secret competitive development of technologies under which we have largely operated in recent years. The scientists might urge, indeed, that the race for atomic arms could best be halted by having new fields of science developed jointly by all nations.

Responsibility for World Cooperation

The responsibility for carrying forward the proposals here made for cooperative studies of weather modification and for world laboratories of science must be placed with some international organization. A natural agency for this purpose is the United Nations. Such responsibility, such new avenues for accomplishing good, will strengthen and expand the capacity of the United Nations for reaching its goal of creating a world at peace.

The procedure for putting into effect ideas of this kind must fit the pattern of life in each land, and therefore what we will need first will be suggestions for possible courses of action. I hope they will be forthcoming. For my part, I intend to discuss the question with my colleagues in the U.S. Senate.

If we do succeed, no nation can then make the fatal error of assuming that it has an overwhelming technical lead over a possible adversary. The recent International Conference on the Peaceful Uses of Atomic Energy in Geneva illustrated how similar the achievements were in different nations, even though each had pursued its program of research and development in careful secrecy. Such similarity of development will no doubt be the case in the future on arms as well as on peaceful atoms.

My own experience at Geneva persuades me that many nations know a lot about the atom. When India's Homi J. Bhabha opened the "pie" of thermonuclear power, the blackbirds from four and twenty lands began to sing! What was secret at breakfast was table talk at lunch. Nations rushed to hold press conferences and attend activities. Is it not possible that there might be a similar pattern in weapons, and that no one nation holds all the cards?

Something new seems to be needed in this disarmament business. The nations make little headway in finding grounds for agreement on reducing the size of armies or destroying parts of atomic stockpiles. Very well; why not try to think constructively about disarmaments in potential weapons, in "ultimate weapons." The problems here are simpler because no one nation has so strong a vested interest in the new field that it will be contributing much more than valuable scientific help. It would be a new try at disarmament, this "disarming the future," and it would lack some of the defects of proposals for present disarmament.

This is not a suggestion that all nations pool their efforts in the field of present atomic technology, or a hint that the testing of atomic weapons be stopped by any of the great powers, and surely it is not a proposal that Oak Ridge, Hanford, Livermore, and Los Alamos be leveled to the ground. It springs rather from the feeling that the new technologies may displace the old, and that a war-weary world might achieve in time a form of disarmament by obsolescence.

If and when that day should dawn, each new technology would no longer be a source of dread power to be somehow kept from destroying us in the convulsion of global war. Rather, it would become what men of science have always intended—a means for opening up a new dimension in human life for defining a greater destiny for the forward course of the human spirit.

Note on Absolute Chronology of Human Evolution

Cesare Emiliani

Pleistocene temperature variations of equatorial, tropical, and temperate marine surface waters were recently investigated by means of oxygen isotopic analyses of pelagic Foraminifera from deep-sea cores (*1, 2*), using a method that was devised by Urey (*3, 4*) and developed by Epstein, Urey, and coworkers (*5, 6*). A time scale since the Günz glacial age was established on the basis of Washington radiocarbon dates of deep-sea cores by Rubin and Suess (*7, 8*), on ionium dates from other deep-sea cores by Urry (*9, 10*), and by comparison with the insolation curve for the 65°N latitude as recalculated by Brouwer and van Woerkom (*11*). This time scale is only a tentative one because it is impossible at present to date reliably the lower parts of the cores, but it is probably correct within about 20 percent.

Temperature Variations and Correlation with Continental Events

A generalized temperature graph for the Caribbean Sea has been published, based on the two stratigraphically longest cores that offer a good temperature record (*1*). The two cores were raised in the Caribbean Sea by Ewing, director of the Lamont Geological Observatory of Columbia University, and his associates; they were selected from among more than a thousand Atlantic and Caribbean cores and kindly sampled and made available by Ericson. The temperature graph is reproduced in Fig. 1. Temperature variations in higher latitudes were considerably greater (*2*), but the trend is apparently similar. Thus, the temperature graph of Fig. 1 is believed to have general stratigraphic value.

The classic alpine terminology is shown in the lowest division of Fig. 1. The absolute chronology in thousands of years before the present (B.P.) is shown in the second division. This chronology is considerably shorter than the chronologies usually suggested in the literature. If correlation between core stages and continental stratigraphy is correct (*1*), the Pleistocene time since beginning of

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the Günz age appears to be only about 300,000 years. An approximately equal interval separates the beginning of the Pleistocene, as recognized in a Pacific deep-sea core, from the Günz (*1*).

Fossil hominids, whose stratigraphic positions in the continental column are reasonably certain, are shown in the fourth and fifth divisions of Fig. 1 at chronological levels that are presently considered to be most probable. Cultures are shown in the two uppermost divisions.

Boundary lines separating various fossils or fossil groups and various cultures are an obvious schematization presented for convenience. These lines should be considered transitional zones of varying durations, and their positions on the time scale may be different in different areas.

Correlations between the temperature curve and continental stages, as shown in Fig. 1, are considered reasonably certain back to the Riss-Würm interglacial age. Consequently, the chronological levels of fossils and cultures are believed to be correct back to about 100,000 B.P. The position of the Swanscombe remains is also probably correct (*12*), but those of earlier fossils are largely conjectural.

Figure 2 shows a generalized temperature graph based on oxygen isotopic analyses of pelagic Foraminifera from deep-sea pilot cores (*1*). These are short cores devised to sample the top few decimeters of bottom sediments, and were raised in the equatorial Atlantic by Kullenberg, of the Oceanografiska Institut of Göteborg, during the Swedish Deep-Sea Expedition 1947–48 directed by Pettersson. As in the graph of Fig. 1, temperature refers to superficial equatorial water, and the variations were certainly greater and more complex at higher latitudes (*2*). The detailed temperature record of the pilot cores may have been somewhat smoothed by reworking of sediments by bottom animals (*1*), but the trend is believed to have been preserved.

The beginning of the last temperature rise is thought to have occurred approximately 16,500 years ago. This figure is based on Washington radiocarbon dates of Rubin and Suess on Caribbean, Atlantic, and Mediterranean cores (*7, 8*) and on ionium measurements by Urry on Atlantic, Caribbean, and Pacific cores (*9, 10*). The last altithermal and the Fennoscandian (= Mankato) and Allerød (= Two Creeks) substages are shown in Fig. 2 by only minor temperature variations, and the Pomeranian (= Cary) is not clearly indicated in any of the pilot or longer cores (*1*). Thus, the aforementioned glacial substages appear to represent only ice readvances that were superimposed on a general trend of ice retreat (*13*).

Evolution of Man and Human Cultures

The approximate durations of the human cultures, as shown in Figs. 1 and 2, are summarized in Table 1. According to the chronology of Fig. 1, *Homo sapiens sapiens* is more than 50,000 and less than 100,000 years old, if the Fontéchevade remains are ancestral and are assigned to a different subspecies (compare *14*).

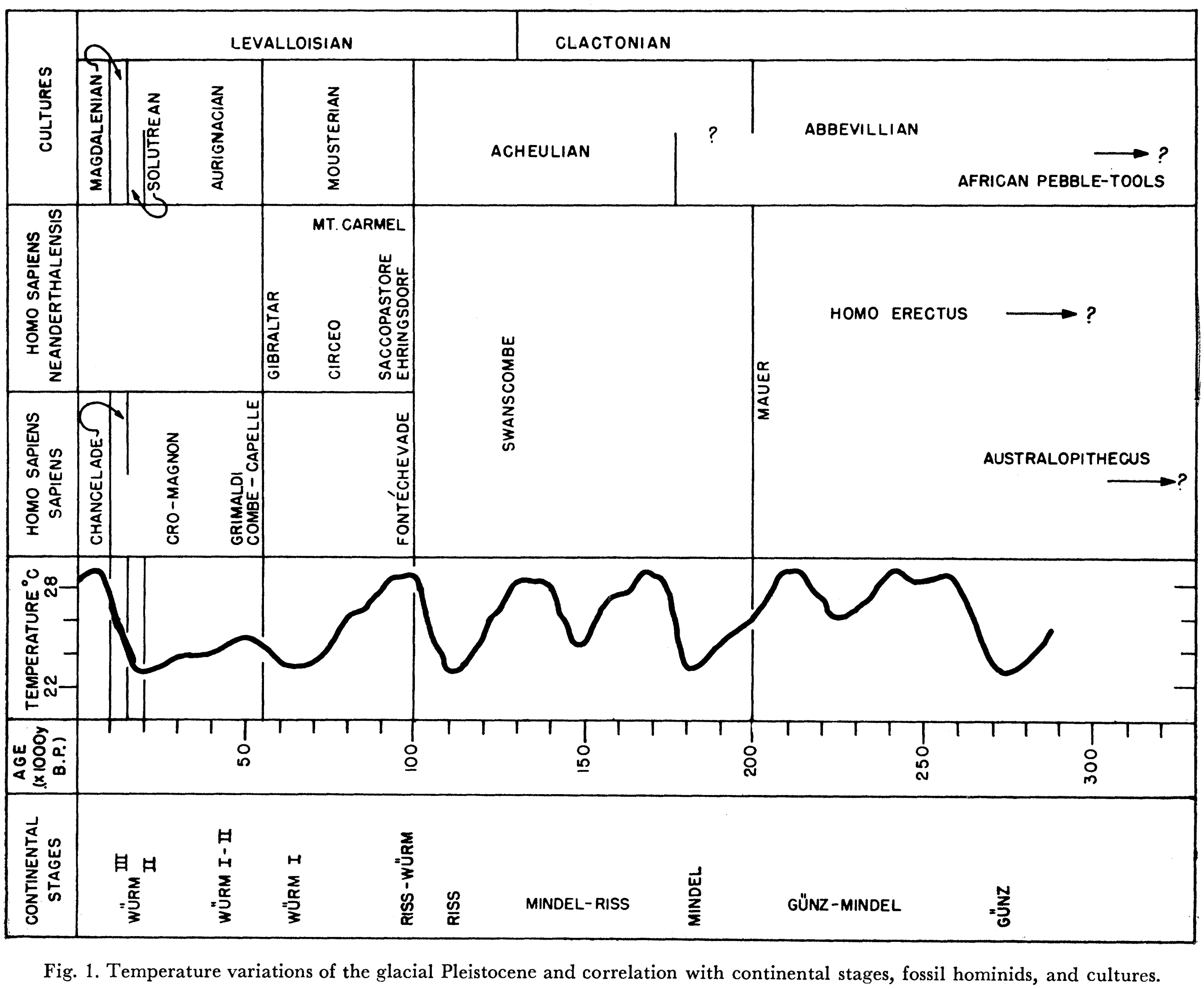

Fig. 1. Temperature variations of the glacial Pleistocene and correlation with continental stages, fossil hominids, and cultures.

On the other hand, if the *sapiens* subspecies is extended to include the Fontéchevade remains, its age is increased to at least 100,000 years, and even more if the Swanscombe skull bones are also included (*15*). Thus, the age of modern man is a problem of taxonomy as well as of dating, and its definitive solution may have to wait until more fossils have been discovered in the time interval between 50,000 and 150,000 years before the present.

"Classic" Neanderthals existed for only about 25,000 years, or about 1000 generations. If the Mount Carmel population was mutant rather than hybrid, the evolution of *Homo sapiens neanderthalensis* took about 50,000 years, involving about 2000 generations.

The surprisingly rapid evolution of the Neanderthals may indicate a more remarkable ability of *Homo* to speciate than hitherto has been suspected, and makes descent of *Homo sapiens* from *Australopithecus* through *Homo erectus* more probable. Oakley's objection that *Australopithecus* was not a tool maker and that the oldest known *Australopithecus* is not geologically old enough to have been the ancestor of the earliest pebble-tool maker (*16*) may be countered by observing that even if the first assumption is correct, which is not certain, the oldest known *Australopithecus* was almost certainly not the first in existence. In addition, the apparent ability of *Homo* to evolve rapidly, together with the rather uncertain stratigraphic relationship between pebble-tools and *Australopithecus* fossils, may not disprove descent of *Homo* from the latter. Finally, as pointed out by Robinson (*17*), such descent does not imply that all representatives of *Australopithecus* were older than *Homo* or that all representatives of *Homo erectus* were older than *Homo sapiens*. Partial coexistence is probable.

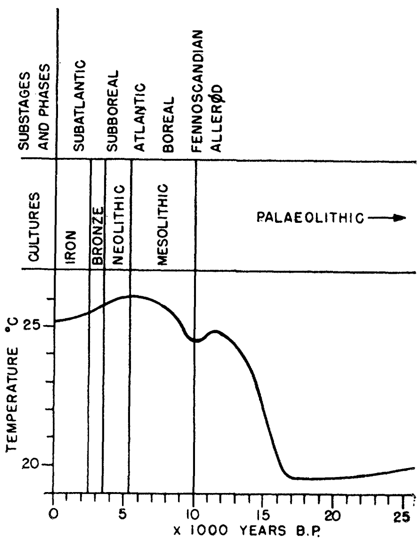

Fig. 2. Temperature variations since the beginning of the last deglaciation and correlation with geologic and cultural stratigraphy.

Table 1. Approximate durations of the cultures shown in Figs. 1 and 2.

Culture	Approximate duration (years)
Iron	2,500
Bronze	1,000
Neolithic	2,000
Mesolithic	4,500
Magdalenian	5,000
Solutrean	5,000
Aurignacian	35,000
Mousterian	45,000
Acheulian	75,000(?)
Abbevillian	100,000(?)

Many "missing links" have now been found, and absolute dating of these Lower and Middle Pleistocene fossils is important if a clearer picture of human evolution is desired. Such dating for many if not most of the fossil hominids now appears feasible if the following steps are taken: (i) oxygen isotopic analysis of Caribbean or equatorial Atlantic cores that are stratigraphically longer than those now available and that reach into the Pliocene; (ii) oxygen isotopic analysis of equally long Mediterranean cores (an attempt to raise such cores will be made by the Lamont Geological Observatory in the summer of 1956); (iii) correlation of the paleotemperature curves of the two sets of cores in order to establish a general deep-sea stratigraphic record covering the whole Pleistocene epoch and to connect the marginal Mediterranean record with the more representative Caribbean and equatorial Atlantic records; (iv) pollen analysis of Mediterranean cores and correlation of pollen profiles with paleotemperature curves (pollen is present in Tyrrhenian cores, as shown by Larsson, *18*) and as mentioned by Tongiorgi, *19*); (v) pollen analysis of a large number of continental sections, especially the Villafranchian of Italy and the African and Asian sections that are related to hominid localities; (vi) correlation of these continental pollen profiles with the Mediterranean profiles and, thus, with the general deep-sea record.

When this is done, it may be possible to determine absolute dates for the fossil hominids and also for the associated faunas, and to view from safer grounds the evolution of vertebrates during the Pleistocene and the emergence of man.

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Original thinkers and investigators do not therefore represent the only type of university professor. They will always be the distinguished figures; theirs will usually be the most profound and far-reaching influence. But even universities, modern universities, need and use men of different stamp—teachers whose own contributions to learning are of less importance than their influence in stimulating students or their resourcefulness in bringing together the researches of others.—ABRAHAM FLEXNER, *Universities—American, English, German* (Oxford University Press, New York, 1930), p. 6.