In addition to defining some of the common denominators of economic development many corollary benefits were derived from the conference. The world's leaders in resource development became better acquainted. Frank and open discussion was possible. Time was not wasted in quibbling over words but was put to use in weighing ideas. The proceedings of the conference, to be published in a number of languages, will become a lasting source of technical information and practical ideas for applying scientific techniques toward world-wide resource conservation and use.

Although this conference was called long before President Truman's inaugural address, in which he proposed "a bold new program" for the development of the world's resources, especially in underdeveloped countries, it came at a particularly advantageous time —when the nations of the world are considering how to carry out such a program.

Age Determinations by Radiocarbon Content: Checks with Samples of Known Age

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FURTHER TESTS of the radiocarbon method of age determination (*1–3, 6, 8, 10*) for archaeological and geological samples have been completed. All the samples used were wood dated quite accurately by accepted methods. The measurement technique consisted in the combustion of about 1 ounce of wood, the collection of the carbon dioxide, its reduction to elementary carbon with hot magnesium metal, and the measurement of 8 grams of this carbon spread uniformly over the 400-square-centimeter surface of the sample cylinder in a screen wall counter (*7, 9*). The background count was reduced during the latter part of the work to 7.5 counts per minute (cpm), which is some 2 percent of the unshielded background, by the use of 4 inches of iron inside 2 inches of lead shielding, plus 11 anticoincidence counters 2 inches in diameter and 18 inches long, placed symmetrically around the working screen wall counter inside the shielding. The screen wall counter had a sensitive portion 8 inches in length, so the long anticoincidence shielding counters afforded considerable protection on the ends. No end counters were used. The data obtained are presented in Table 1 and Fig. 1.

The youngest sample used was furnished by Terah L. Smiley, of the University of Arizona Laboratory of Tree-Ring Research. It was a sample of Douglas fir excavated by Morris in the Red Rock Valley in 1931, the exact location being Room 6 of the Broken Flute Cave. The inner ring date is 530 A.D. and the cutting date is 623 A.D.

The next sample was furnished by John Wilson, of the Oriental Institute at the University of Chicago, and was a piece of wood from a mummiform coffin

TABLE 1

AGE DETERMINATIONS ON SAMPLES OF KNOWN AGE

Sample	Specific activity (cpm/g of carbon) Found	Expected	Age (years) Found	Expected
Tree Ring	11.10 ± 0.31 11.52 ± 0.35 11.34 ± 0.25 10.15 ± 0.44 11.08 ± 0.31 Average: 10.99 ± 0.15	10.65	1100 ± 150	1372 ± 50 (577 ± 50 A.D.)
Ptolemy	9.5 ± 0.45	9.67	2300 ± 450	2149 ± 150 (200 ± 150 B.C.)
Tayinat	8.97 ± 0.31 9.03 ± 0.30 9.53 ± 0.32 Average: 9.18 ± 0.18	9.10	2600 ± 150	2624 ± 50 (675 ± 50 B.C.)
Redwood	8.81 ± 0.26 8.56 ± 0.22 Average: 8.68 ± 0.17	8.78	3005 ± 165	2928 ± 52 (979 ± 52 B.C.)
Sesostris	7.73 ± 0.36 8.21 ± 0.50 Average: 7.97 ± 0.30	7.90	3700 ± 400	3792 ± 50 (1843 ± 50 B.C.)
Zoser: Sneferu		7.15	4750 ± 250	
Zoser	7.88 ± 0.74 7.36 ± 0.53			4650 ± 75 (2700 ± 75 B.C.)
Sneferu	6.95 ± 0.40 7.42 ± 0.38 6.26 ± 0.41 Average: 7.04 ± 0.20			4575 ± 75 (2625 ± 75 B.C.) Average: 4600 ± 75 (2650 ± 75 B.C.)

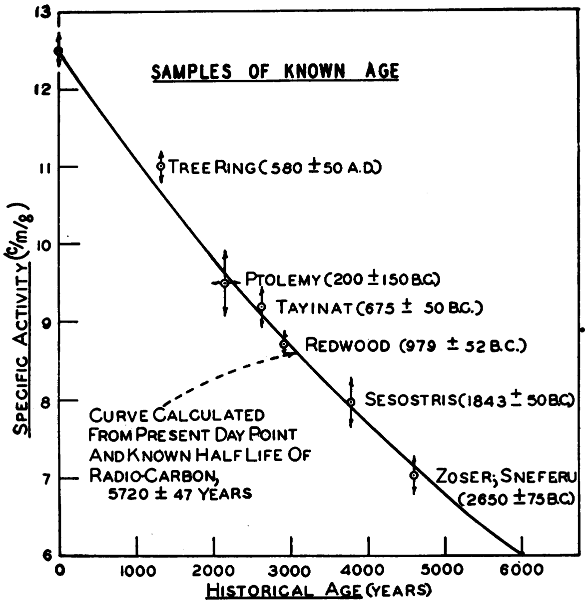

FIG. 1. Specific activities for samples of known age.

from Egypt, dated on stylistic grounds in the Ptolemaic period 332–30 B.C. It was measured quite early in our research, when the sensitivity of the instrument was somewhat less, and so the error is larger and only one measurement was made.

The next sample was furnished by Robert Braidwood, of the Oriental Institute, and consisted of two fragments of wood (*Pinus halepensis*) from the floor of a central room in a large *hilani* (palace) of the Syro-Hittite period in northwestern Syria. Prof. Braidwood dated the material between 725 and 625 B.C. from an imported Corinthian alabastron fragment, together with a great deal of historical evidence. This sample was measured with considerable care and with our most sensitive instrument. The agreement seems to be satisfactory.

The redwood sample was furnished by Edmund Schulman, of the Laboratory of Tree-Ring Research at the University of Arizona. It was a fragment of the inner part of a *Sequoia gigantea* tree felled in 1874 A.D. It is known as the Centennial Stump and has been described by A. E. Douglass (*4*). The sample furnished carried a sequence of rings from 1031 to 928 B.C.

The fifth sample was a piece of deck board from the funerary boat of the Egyptian Sesostris III, which is displayed in the Chicago Natural History Museum. The wood probably is cedar of Lebanon. The sample was kindly furnished to us by the museum through the good offices of C. C. Gregg and Alex Spoehr. John Wilson dated the material as 1843 ± 50 B.C.

The last sample, really being two samples, was described, with measurements, in an earlier publication (*10*). One of the two was from the tomb of Sneferu of Meydum (furnished by Froelich Rainey, of the University of Pennsylvania Museum in Philadelphia), which was 4575 ± 75 years old. The other was from the tomb of Zoser at Sakkara (furnished by Ambrose Lansing, of the Metropolitan Museum in New York City), which was 4650 ± 75 years old. The former sample was cypress wood and the latter acacia. The dates were given by John Wilson.

The agreement between prediction and observation is seen to be satisfactory. The errors quoted for the specific activity measurements are standard deviations as computed from the Poisson statistics of counting random events. One of the six average values, and seven of the 17 individual runs, differ by more than one standard deviation unit from the predicted value. Since in a long series of measurements 32 percent may be expected to fall outside this limit, we may conclude that the statistical error is the major source of scatter. Thus the deviation in the Douglas fir tree-ring sample should not be considered significant.

The errors quoted in the column "Age (years)" of Table 1 include also the uncertainties in the (relative) value of the present-day specific activity, and in the value of the half-life of C^{14}.

At intervals throughout the work, samples of anthracite coal were measured and no significant radioactivity was ever found. This served as a check on possible sources of contamination in the course of the measurement, such as chemicals used in processing, and the necessary exposure to air during the handling of the material.

These results indicate that the two basic assumptions of the radiocarbon age determination method—namely, the constancy of the cosmic radiation intensity and the possibility of obtaining unaltered samples—are probably justified for wood up to 4600 years. The fact that the most ancient samples agree with the predicted value shows that the cosmic ray intensity has been constant to within about 10 percent for periods up to 20,000 years ago. This refers to variations over intervals comparable with the half-life of radiocarbon, 5720 ± 47 years (*5*); it is obvious that shorter time variations would average out and would not affect the measurements.

The *Sequoia gigantea* sample has an additional interest of its own in that the wood spent most of its time at the heart of a live tree, and if any chemical processes had occurred involving the inner heartwood the specific radioactivity would have been elevated above the value found. In other words, this check apparently shows that the redwood heartwood is truly dead and does not partake in any of the metabolic processes of the tree. This finding is not surprising to most botanists.

These results seem sufficiently encouraging to warrant further investigation and application of the method. We have been assisted in this work from the beginning by a committee of the American Anthropological Association and the Geological Society of America, consisting of Frederick Johnson, chairman, Donald Collier, Richard Foster Flint, and Froelich Rainey. This committee advised us what samples of known age to use for testing and greatly assisted us in procuring them. The attempt to establish the method for the great unknown periods of prehistory has involved further work with this committee and the majority of our decisions and efforts to date on unknown samples have been directly connected with their efforts. It was decided that the proof of the method in periods older than 5000 years, for which there are no generally accepted dates for testing, would have to be obtained by checks of internal consistency from a wide variety of samples and in a wide variety of problems. Eleven different major dating questions were selected for this purpose and prominent investigators in each case were invited to collaborate in the research. The problems selected were: Early Man, with Frank H. H. Roberts, Jr.; California–Oregon, with Robert Heizer; Hopewell–Adena, with James Griffin; Mankato, with Richard Foster Flint; Mesopotamia and Western Asia, with Robert Braidwood; Peru, with Junius Bird; Scandinavia and Western Europe, with Hallam Movius; the Southeast, with William S. Webb; the Yukon, with Frederick Johnson; the Valley of Mexico and Tepexpan Man, with Helmut de Terra; and Pollen Chronology, with Edward Deevey.

It is hoped that investigators who have samples fitting into these general problems will write to the collaborators named, to the committee, or to the authors, so that the best materials available can be used for the research. The samples may consist of wood, charcoal, peat, cloth, flesh, and possibly antler, teeth, and shell. Since ten grams of carbon is needed for a single measurement and at least two independent measurements should be made on each sample, some two ounces of wood or charcoal and correspondingly larger quantities of the other materials, according to their carbon content, are needed. In important cases, where only smaller amounts can be furnished, measurements can be made at some sacrifice of accuracy.

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