Comments and Communications

Weight and Body Temperature in Mammals

THE recent statement (*1*) that a previously described relationship between weight and body temperature (*2*) was "not valid," and that "the apparent correlation resulted from an inadequate representation of data," deserves comment.

The paucity of data in the literature makes it difficult to correlate comparative body temperatures with other factors in a thorough and completely satisfying manner. This deficiency has been due in part to the fact that many reports on metabolic rates of various species neglect to record necessary data on body temperature of the animals under study (*3, 4*). Nevertheless, a large number of well-controlled studies on laboratory and domestic animals, and the sporadic data on exotic species make it apparent that the described relationship between weight and body temperature *is* valid. This becomes clear in a brief review of some of the literature reporting the body temperature of smaller mammals, listed below in order of increasing weight.

In a painstaking study Kendleigh (*5*) has shown the *basal* body temperature of shrews (*Blarina brevicauda talpoides*) (10 g) to approximate 34.7° C, and that of the white-footed mouse (*Peromyscus maniculatus gracilis*) (20 g) is averaged at 36° C. The careful work of Herrington (*6*) gives the average basal temperature of mice (20–30 g) as 36.5° C. Bats (30 g) are reported as also showing this temperature (*7*). The chipmunk (*Tamias striatus*) (150 g) has a basal temperature of 36.5° C (*5*). Ground squirrels (150–250 g) are reported as averaging 37° C (*8, 9*). The rat (300–400 g) is generally agreed to have an average body temperature about 37.5° C (*6, 8, 10–13*). The average temperature for the guinea pig (400–750 g) is given as ranging from 38° to 39° C (*6, 8, 12, 14, 15*). For the rabbit, cat, and dog the average is 39° C or slightly higher (*8, 12, 16–23*). Data on body temperatures of nondomestic animals are necessarily limited and are commonly influenced by exertion and anxiety on the part of the animal, and often of the observer.

The average temperatures of mammals in the 5–100-kg range show considerable variation, as indicated in our original figure (*2*), but all are 37.5° C or more. The very large mammals have temperatures below this value. Thus the elephant seal, with a weight of about 1400 kg, has a temperature of 35° C (*24*). Elephants are reported consistently to have body temperatures of 35.5°–36.5° C (*8, 12, 25, 26*). All these data fit well with the postulated relationship. Inspection of Morrison and Ryser's Fig. 1 reveals a satisfactory relationship for weight and body temperature for carnivores and primates. Computation of statistical trends for other single orders, such as Morrison and Ryser have attempted, must await the accumulation of considerably more data than they present.

The great variability of body temperature, particularly under conditions of disease and exertion, makes it necessary to use judgment in the utilization of data. Publication of all available data obtained under these nonbasal conditions, calculation of averages, and even statistical handling with determination of the standard deviation of the means and the t values, do not assure an adequate approximation to the resting temperature level. Thus, as Wislocki (*8*) has pointed out, "the temperature readings [on whales] are all from stranded individuals and in all likelihood do not represent the normal temperature of these animals." Just why Morrison and Ryser selected two values from the 40 listed by Zenkovich (*27*) on dead whales, rather than the five values on living but moribund whales is difficult to fathom. These values obviously cannot be accepted as evidence against the weight-temperature relationship. Similarly, Morrison and Ryser (*1*) have selected a single datum on the shrew from the four listed by Kendleigh (*5*) and have neglected to note that this was a struggling animal that died immediately afterward. Kendleigh (*5*) recorded that in the course of a few minutes of struggling, the body temperature of small mammals may rise from a resting level slightly over 35° C to as high as 39.5° C. Since no statement concerning the conditions of measurement of the body temperature of their small mammals was made by Morrison and Ryser (*1*), the validity and significance of their data must be held *sub judice*.

Attention is called to an error in the weight, and probably in the temperature, given for the manatee (*2*). These sea cows may weigh as much as 1000 kg. Only two reports (38.9° and 40.0° C) were found on these species, both apparently taken at the time of death (*28*). The difficulty in obtaining resting temperatures of these animals, as well as of other animals being driven to slaughter, has been pointed out by Hanna (*29*).

It must be borne in mind that our knowledge of basal mammalian temperatures is so fragmentary that scientific evidence damaging to the weight-temperature assumption may yet accumulate on further inquiry.

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Book Reviews

The Exact Sciences in Antiquity. **O. Neugebauer. Princeton, N. J.: Princeton Univ. Press, 1952. 191 pp. and 14 plates. $5.00.**

Despite all the lip service given nowadays to general education, rarely is science assigned more than a minor technical role of "information, please." Any integration of science with culture is supposedly the responsibility of self-styled humanists, who rely primarily upon the scholarship of other humanists. It is not surprising, therefore, that the historical interrelationships between science and civilization are somewhat distorted. What is needed as a basis for any generalizations are researches by scientifically trained historians and/or by historically trained scientists. Otto Neugebauer belongs to this class. As he gratefully remarks in the preface, with respect to its dedication to Richard Courant: "I owe him the experience of being introduced to modern mathematics and physics as a part of intellectual endeavor, never isolated from each other nor from any other field of civilization."

The present book, a modified form of the author's 1949 Cornell University "Messenger Lectures on the Evolution of Civilization," is a semipopular, scholarly account of mathematics and astronomy in Babylonia and Egypt in their relationship to Hellenistic science. It is based upon the author's belief that "The investigation of the transmission of mathematics and astronomy is one of the most powerful tools for the establishment of relations between different civilizations." The author modestly concludes his account with the remark: "Perhaps it is vain to hope for anything more than a picture which is pleasing to the constructive mind when we try to restore the past."

After a review of the early history of number symbols, the author discusses the characteristic features of mathematics in the Old Babylonian period of the Hammurabi dynasty. To an amateur, such as myself, nurtured upon classical tradition, it is startling to learn of the highly developed numerical skills utilized at this time. Tables still exist containing squares and square roots, cubes and cube roots, and sums of squares and cubes. Special types of cubic equations were solved; particular exponential functions (for the computation of compound interest) were used; arithmetical progression was known. From a Seleucid text one finds "the correct application of the 'quadratic' formula for the solution of quadratic equations."[1] Their computed value of 1.414213 (actually 1.414214) for the square root of 2 was still used by Ptolemy. In connection with such numerical work, "The determination of the diagonal of the square from its side is sufficient proof that the Pythagorean theorem was known more than a thousand years before Pythagoras." Even the "fundamental formulas for the construction of triples of Pythagorean numbers were known. . . . Geometrical concepts play a very secondary part in Babylonian algebra."

After this fascinating revelation of "a level of mathematical development which can in many aspects be compared with the mathematics, say, of the early Renaissance," it is somewhat of a letdown to read about the status of early Egyptian mathematics and astronomy. For example, "Egyptian mathematics did not contribute positively to the development of mathematics." One of the major results, however, was a "deeper insight into the development of computation with fractions." The whole process was entirely additive. In the case of astronomy there is apparently only one very beneficial influence—namely, a calendar with a fixed time scale and no intercalations, which became the standard astronomical system of reference through the Middle Ages. "This calendar, indeed, is the only intelligent calendar which ever existed in human history." Incidentally, one "Egyptian contribution to astronomy is the twelve divisions of daytime and of night." Noteworthy by its omission in the text proper is any reference to the astronomical or mathematical significance of the Pyramids. The author con-

[1] "One of the tablets from Susa implies even a special problem of the eighth degree."