The report by Anderson and Langham begins with an excellent historical survey of whole-body counter methodology. No one can deny the importance of the contribution which they and their co-workers have made in this field. As a result of their studies there are now available more data on the potassium content of man than for any other body constituent. But such a detailed exposé was clearly beyond the scope of our brief report in *Science* (*1*), nor is it germane to the substance of that report.

We considered the *technique* of potassium measurement to have been clearly established. Our intent was to develop an *application* of that technique, and this is what we did.

Apparently Anderson and Langham are not content with the references which we made (references 5, 6, 10) to their work (*2*). We have searched the writings of the Los Alamos group without finding more than oblique and vague references to fat determination in man by this technique. Mention is made (which we quoted) of lean body mass, and much emphasis is placed on the concept of bone mineral-free, water-free, and fat-free solids. It is surprising indeed that they could have been working on a method for fat determination since 1953 without once having published a value for actual fat content for any of their subjects. There was nothing to hinder them from doing so, and one can only conclude that they were not particularly interested in this aspect of body composition. Indeed, we ourselves have made such calculations from their data, which they have so generously made available to us, often in advance of publication.

In all fairness to history, it should be stated that the concept of the constancy of adult tissue composition when calculated on a fat-free basis long antedated the establishment of the Los Alamos group (*3*). In recent years a number of workers have applied this general principle to fat determination in living man by the total body water and densitometric techniques. Our intent was merely to suggest an extension of this principle to include potassium.

Our interest in this problem dates from some analyses of human carcasses made in 1954 and published in 1956 (*4*). Upon completion of the Rochester whole-body counter, measurements were made in 1959 and first reported at the May 1960 meetings of the American Pediatric Society. The calculations are based, not upon indirect estimates of fat content, but upon actual chemical analyses, and despite the protestations of Anderson and Langham, our work is the first to be published in which emphasis is placed on the estimation of fat content by means of the potassium technique in living man.

We are quite aware of the importance of the issue raised in the next to the last paragraph of their report. The question of the composition of the "lean body mass" in living man is one that can be approached only by indirect and inferential means, and inevitably involves assumptions based on the many animal and the all too few human analyses which have been done. As Anderson and Langham have indicated [and the recent data of Talso *et al.* (*5*) would bear them out], the potassium content of lean body mass calculated from simultaneous water measurement differs by a few percent from that derived from chemical analysis of carcasses. It is impossible to decide whether this discrepancy is due to a systematic error in the total body water method, or to the possibility that the analyzed specimens were not representative of the normal state.

At any rate, we were encouraged to proceed with our work by the report from the Los Alamos group—and we quote from our report (*1*)—of "a good correspondence between K^{40} content and lean body mass as determined by tritium dilution in man."

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23 February 1961

Sound Production in Scorpions

The fact that some species of scorpions produce sound has been known for a long time. It was suggested by Landois and Wood-Mason in 1877 (from Werner, *1*) and recorded for the first time by Pocock (from Alexander, *2*). Several observations on the behavior of scorpions, morphological studies, and attempts to draw sound from preserved specimens led to the suggestion that various body parts might be involved in sound production by scorpions (summarized by Werner, *1*).

The subject was investigated in detail only recently, by Alexander (*2*), in *Opisthophthalamus latimanus* Koch., *O. nitidiceps* Poc. (Scorpionidae), and *Parabuthus planicauda* Poc. (Buthidae). The two species of the genus *Opisthophthalamus* were found to produce a hissing sound by rubbing the chelicerae against the ventral side of the carapace; whereas *Parabuthus planicauda* produced a shrill grating sound by scraping the tip of the tail across the first caudal tergite and the last mesosomal one. Vachon *et al.* (*3*) registered in 1958 the specters and oscillograms of the sound produced by *Opisthophthalamus latimanus*.

So far all mechanisms of sound production in scorpions, either suggested or actually investigated, have been based on stridulation—that is, friction between two body parts which may, or may not, bear special adaptations for sound production.

During studies on *Scorpio maurus* L. (Scorpionidae), we found that this scorpion produces sound by a mechanism which is basically different from the mechanisms mentioned above.

At least two subspecies of *S. maurus* occur in Israel: *S. maurus fuscus* H. et E., which varies in color from light to dark brown, and *S. maurus palmatus* H. et E., which is yellow (*4*). Both these subspecies produce sound by rapidly striking the posterior half of the mesosoma against the ground. While they are doing so, their pedipalps are flexed, the tail is brought over the mesosoma until it is almost touching it, and the body vibrates rapidly in a forward-upward, backward-downward direction. No other part of the body, such as the chelicerae, pectines, or aculeus, is involved in this reaction. In *S. maurus palmatus* each strike is accompanied by a few very rapid vibrations of the body which are performed without hitting the ground, so that the effect produced is that of a series of very rapid, successive, clearly audible thuds. *Scorpio maurus fuscus* was observed to hit the ground at a higher frequency; the motion is so rapid that it is difficult to ascertain whether each jerk actually hits the ground or not. In this case the successive thuds merge into a rattle.

Unlike the hissing of *Opisthophthalamus*, which may precede an encounter between two specimens, but will not occur after the two have come into actual contact, as stated by Alexander (*2*), *Scorpio maurus* may produce sound after a fight with another specimen. This response was witnessed also when a scorpion was following a locust which it failed to catch.

Among *S. maurus fuscus* a smaller form (possibly another subspecies) occurs, the adults of which do not surpass 5 cm in length. In this case similar vibrations were also observed in the male (once after the escape of a female with which the male was trying to mate), but no audible sound could be detected.

It is extremely difficult to induce *S. maurus* to produce sound, but we succeeded in eliciting this response several times by the use of irritating stimuli. Once a scorpion has begun to respond in this manner, after either a natural or an artificial stimulus, it will often repeat the response a few times, running around and stopping every now and then in order to produce the sound. So far only males have been observed to perform this type of reaction, but the possibility that females too may be able to do so has not been excluded.

Stridulation is a very common method for sound production among insects (*5*) and crustaceans (crabs) (*6*), but cases of sounds produced by rapidly tapping any part of the body on the substrate (or "drumming," as the mechanism is often termed) also occur in both these classes. Thus Imms (*5*) lists cases among Anobiidae, pupae of Hesperiidae and Lycaenidae, termite soldiers, and Psocotera. Drumming in *Pimelia striata* is mentioned by Darwin (*7*) and in some Acrididae by McE-Kevan (*8*) and Pierce (*9*). Crane (*10*) describes drumming in some crabs of the genus *Uca* (Brachyura). However, to the best of our knowledge, drumming in scorpions has never been recorded before.

The body vibrations of *Scorpio maurus* during sound production recall in their tetanic nature the juddering of males of *Opisthophthalamus latimanus* (Scorpionidae) (*11*) and *N. hierochonticus* (Diplocentridae) (*12*) during courtship, except that in the latter case the pedipalps are outstretched and the motion is performed horizontally, so that the body does not hit the ground. The juddering of scorpions is not limited to sexual behavior and may occasionally be performed in the presence of other males, specimens of another species, and sometimes even in the presence of prey. However, emission of sound in *Scorpio maurus* does not constitute a part of the normal courtship behavior.

Scorpio maurus exhibits various types of threatening behavior and also repeated forward and backward jerks of the body with outstretched pedipalps and arched tail. This reaction is very common in both sexes. (An identical, or at least a very similar, reaction is almost invariably performed by the male at the beginning of courtship.) There may be some relation between this threatening behavior and sound production, since scorpions were observed several times to change such a threatening reaction into the sound-producing one. The body jerks were quickened, the pedipalps were gradually flexed, and the tail was lowered over the body; the sound was at first very feeble, but soon acquired full volume.

It is not yet known whether the difference observed in the frequency of the sound by the two subspecies *S. maurus palmatus* and *S. maurus fuscus* is innate.

No response of one scorpion to the sound produced by another was noted. Alexander (*2*), who found no such response in the cases she investigated (stridulatory type), suggested after making a few experiments that the sound may have a defensive value against predators. The presence of a sense of hearing in scorpions is still doubtful, but considering that their sensitivity to vibrations of the substrate is apparent (*13*), the possibility that, in the case of *S. maurus*, sound may have also an interspecific role is not to be dismissed without further careful investigation.

Variations in the loudness of the sound, due to changes in intensity of reaction of one and the same specimen, were mentioned above. We realize, however, that the loudness of the sound may also depend, at least partially, on the hardness of the substrate against which the body hits, although slightly pressed soil suffices for the production of a clearly audible sound. It should also be noted that scorpions do not usually inhabit terrains of soft loose sand (*14*).

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27 December 1960

Theory of Oxygen Transport through Hemoglobin Solutions

Abstract. A combination of equations describing diffusion, gas solubility, and mass conservation yields a general relation for oxygen transport in hemoglobin solutions. Total oxygen flux is shown to be the sum of the flux in the plasma and the flux due to transport by hemoglobin. The total flux depends not only on oxygen concentration gradient but also on absolute oxygen concentration.

Because of the recent interest in the transport of oxygen in hemoglobin solutions (*1, 2*), it seems desirable to attempt to understand this transport phenomenon in terms of simple physical-chemical principles.

The theory that one generally applies to transport phenomena is embodied in the statement of Fick's law (*3*). This law states that the mass transport per unit time per unit area, $\partial m/\partial t$, is directly proportional to the concentration gradient, $\partial c/\partial x$, where the constant of proportionality, D, is called the diffusion coefficient. That is

$$\frac{\partial m}{\partial t} = -D\frac{\partial c}{\partial x} \qquad (1)$$

For the problem at hand we must consider the diffusion of three species, namely, oxygen dissolved in plasma or water, oxygenated hemoglobin, and hemoglobin. We choose a geometry of plane parallel boundaries so that the problem is one dimensional. Let A be the concentration of dissolved oxygen, B the concentration of hemoglobin, and E the concentration of oxygenated hemoglobin.

We may now write three simultaneous diffusion equations:

$$\begin{aligned} J_A &= \frac{\partial m_A}{\partial t} = -D_A\frac{\partial A}{\partial x} \\ J_B &= \frac{\partial m_B}{\partial t} = -D_B\frac{\partial B}{\partial x} \qquad (2) \\ J_E &= \frac{\partial m_E}{\partial t} = -D_E\frac{\partial E}{\partial x} \end{aligned}$$

These equations are not independent and must satisfy certain boundary conditions. Since hemoglobin and oxygenated hemoglobin cannot spill over the boundary of the diffusion cell, we must require that

$$J_B + J_E = 0 = -D_B\frac{\partial B}{\partial x} - D_E\frac{\partial E}{\partial x} \qquad (3)$$

A further constraint on the system is imposed by conserving the total amount of A and B and remembering that $A + B \rightleftharpoons E$. The material balance for oxygen (A) implies that

$$D_A\frac{d^2A}{dx^2} + D_E\frac{d^2E}{dx^2} = 0 \qquad (4)$$