loosely held by the crystal lattice after reduction. In the presence of concentrated ammonium ion, on the other hand, the manganous ions continuously leave the surface of the oxide, exposing a fresh surface to attack by the quinol. This argument in its turn suggests that in estimating the manganese in soil that is available to plants the reducing agent should be removed before an extraction with electrolyte. Preliminary work along these lines has given results that are correlated with the health of oats, as observed in pot tests. The earlier method of extracting with ammonium acetate accompanying quinol has failed to distinguish some of these soils.

The "cure" referred to in these tables was obtained in the first year after application. Some oxides revert in some soils to a less active form in later years; the results of work on the conditions of this reversion are being prepared for publication elsewhere.

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The Distribution of S^{34} in Nature and the Sulfur Cycle[1]

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Relatively large variations in the abundances of the sulfur isotopes in natural sources have been reported from this laboratory (*1*, *2*). Also, A. Trafimov (*3*) reported some indication of these variations. In our work, sulfates in general were found to be enriched in the heavy isotopes of sulfur as compared to hydrogen sulfide and other sources of sulfur (see Fig. 1). The results suggested that sea water sulfate, the source of many sulfate deposits, would also be enriched and that the large reservoir of sulfur in the sea might provide a base level from which the isotopic content of other sulfur sources might be reckoned. The results of four sea water sulfate samples investigated to date are given in Table 1. From Fig. 1 it can be seen that the sea water sulfates are enriched in these heavy isotopes in comparison to other sources of sulfur and that the isotopic ratios obtained are remarkably constant for the three different oceans. The high precision abundance data does show, however, some significant difference between Pacific and Atlantic.

Previous results reported from this laboratory showed that sulfate and hydrogen sulfide present together in ground water samples, contained markedly different isotopic abundances. The sulfate samples were in every case enriched in S^{34} as compared to H_2S. This result and the fact that sea water sulfate samples are also enriched by about the same factor suggest isotope fractionation in the conversion of sulfate to hydrogen sulfide in nature.

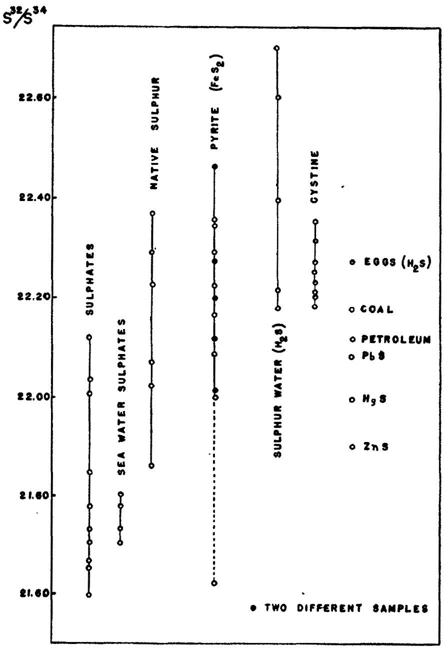

Fig. 1. Distribution of S^{34} in nature.

The partition function ratios for isotopic substances involving sulfur have been calculated by the well-known methods of statistical mechanics. For example:

$\frac{QS^{34}O_4^-}{QS^{32}O_4^-}$ and $\frac{QH_2S^{34}}{QH_2S^{32}}$ turn out to be 1.088 and 1.015 respectively where Q is the partition function of the isotopic molecule in question. These calculations indicate that in the conversion of SO_4^- to H_2S, perhaps by action of sulfur bacteria, the isotopes of sulfur will be fractionated, favoring S^{34} and S^{36} in the sulfate ion by a factor of the

TABLE 1

Isotopic Constitution of Sulfur from Sulfate in Sea Water

Sample No.	Location	180° Mass spectrometer* S^{32}/S^{34} ratio
1	Halifax Harbor (Atlantic Ocean)	21.70 ± 0.02
2	Resolute Bay Cornwallis Island (Arctic Ocean)	21.73 ± 0.02
3	Straits of Juan de Fuca Victoria, B.C. (Pacific Ocean)	21.78 ± 0.02
4	Pacific Naval Laboratory #27 Depth 200 yd	21.80 ± 0.01
	Average	21.75 ± 0.02

* Each sample is ratioed to Park City, Utah, having S^{32}/S^{34} equal to 22.12.

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same order of magnitude as that indicated by our results. If sulfate is converted to hydrogen sulfide under equilibrium conditions, then the calculated enrichment factor for S^{34} would be $1.088/1.015 = 1.072$. However, if it is a unidirectional process, then the enrichment factor will depend largely on the 1.088 factor above.

Controlled laboratory experiments are being carried out in collaboration with H. Kleerekoper of our Zoology Department to determine the extent of sulfur isotope fractionation that occurs when anaerobic sulfur bacteria attack and reduce sulfate to hydrogen sulfide. This process occurs at the bottom of the sea and in swamps under anaerobic conditions and is part of the natural sulfur cycle. On the other hand, certain aerobic sulfur bacteria act on organic matter and H_2S to produce free sulfur and sulfate. Sulfur isotope fractionation may occur in these processes as well. It is known from our previous results that free sulfur from the Gulf of Mexico, which is considered to be of bacterial origin, is low in S^{34} as compared to free sulfur from Italy and Sicily, which are of volcanic origin. These bacterial processes are being investigated in this laboratory also.

TABLE 2

ISOTOPIC CONSTITUTION OF SULPHUR FROM CYSTINE

Sample No.	Source	180° Mass spectrometer* S^{32}/S^{34} ratio
1	Commercial cystine (Eastman Kodak)	22.32 ± 0.01
2	Human hair†	22.35 ± 0.01
3	"	22.27 ± 0.01
4	"	22.18 ± 0.02
5	"	22.21 ± 0.01
6	"	22.20 ± 0.01
7	"	22.23 ± 0.01
	Average	22.25 ± 0.02
8	H_2S from eggs	22.27 ± 0.02

* Each sample ratioed to pyrite from Park City, Utah, having an S^{32}/S^{34} ratio equal to 22.12.

† Each sample of hair was taken from a different individual.

Sulfur samples from cystine, obtained from human hair, have also been investigated. The S^{32}/S^{34} ratios obtained are given in Table 2. Fig. 1 shows that these isotopic ratios for organic material, and for cystine in particular, fall between the values obtained for sulfates and hydrogen sulfides, although for the most part the organic sulfur is low in S^{34} content.

Since amino acid and protein sulfur are synthesized by plants which utilize sulfates in the soil (a part of the sulfur cycle), it is possible that some fractionation of the sulfur isotopes occurs in photosynthesis. Experiments are in progress using *Chlorella* to investigate this possibility.

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Weight and Body Temperature[1]

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Although it is generally stated that the normal body temperature of birds is higher than that of mammals, examination of the literature shows the temperature of some birds to be as low as 39° C (*10*), whereas many mammals have temperatures as high as 39.5° C (*3*). An analysis of available data (*2, 3, 10–12*) shows that the body temperature of large birds is approximately of the same order as that of mammals of the same size.

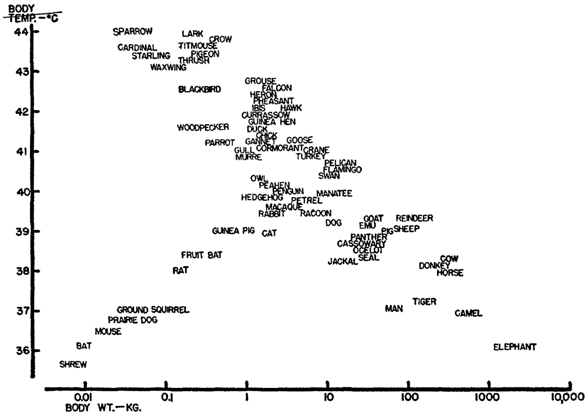

FIG. 1.

A plot of the body temperatures of birds against the logarithm of the average weight of the adult of the species gives a linear relationship (Fig. 1). Birds of 1 kg have a body temperature of about 41.5° C. For each tenfold decrease in weight, the body temperature increases about 1.5° C. A similar plot of data on large mammals gives approximately the same slope with perhaps a slightly lower intercept. However, for the small mammals weighing less than 1 kg, a line of different slope is obtained. In these, each tenfold decrease in weight is accompanied by a decrease in body temperature of about 1.5° C.

Since body temperature varies somewhat with the diurnal and reproductive cycles, age, exercise, excitement, depth of insertion of the thermometer, and environmental temperatures, the plotted data are considered as so many areas having a range of ± 0.5° C, rather than as points. The weight of mature animals of a species also varies within a range, as indicated. Because of the extreme variability of data on the body temperature of mammals with poor temperature regulation, such as monotremes and edentates, these are not included in the present analysis.

In small animals, the small amount of metabolizing

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