trodes mounted at 30° intervals all over the inside wall, so that the heart vector could also be calculated by integration of the surface potentials (*10*). The simplified method was not as accurate, but gave a good approximation to the correct values (*11*). The data on the rabbit and turtle hearts are presented only to illustrate the nature of the results that can be obtained by the method described. The results suggested that there is a correlation between the weight of the heart and the magnitude of the peak vector (*12*).

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11. The "resultant dipole moment" denotes a vector, the magnitude, direction, and location of which are functions of time during the cardiac cycle. The simple bipolar method neglects changes in location of the vector, but a central location is not necessary for the integration method.
12. Further experiments are in progress to study this relation and to obtain better statistical averages. This project was supported by grants from the U.S. Public Health Service (H-2590) and the Maine Heart Association.

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Indole-like Urinary Stress Reactant in Man

Abstract. Paper chromatograms on extracts from serial 6-hr urine samples from humans of both sexes on indole-controlled diets revealed either the appearance of or marked increment in "spot 32" (*1*) after ACTH gel injections. This corresponds in time and duration with the rise in 17-hydroxycorticoid excretion. 5-Hydroxyindoleacetic acid and 28 other urinary indoles failed to show this rise predictably.

There have been several conflicting reports in recent years concerning abnormalities in indole excretion in schizophrenic patients compared with neurotic, "normal," or other control groups (*2, 3*). Kety, in his recent articles in *Science* (*4*), has speculated extensively concerning various systematic experimental errors which may account for these differences. It has been our general purpose to explore some of these "extraneous" factors in an effort to explain with documentation some of the findings reported in the area of indole research on schizophrenic patients. We are currently engaged in an evaluation of the effect of nonspecific stress factors on urinary indole excretion. This report presents a heretofore unreported phenomenon associated with activation of part of the physiologic stress mechanisms by ACTH injection—that of a predictable change in the excretion of indole-like compound.

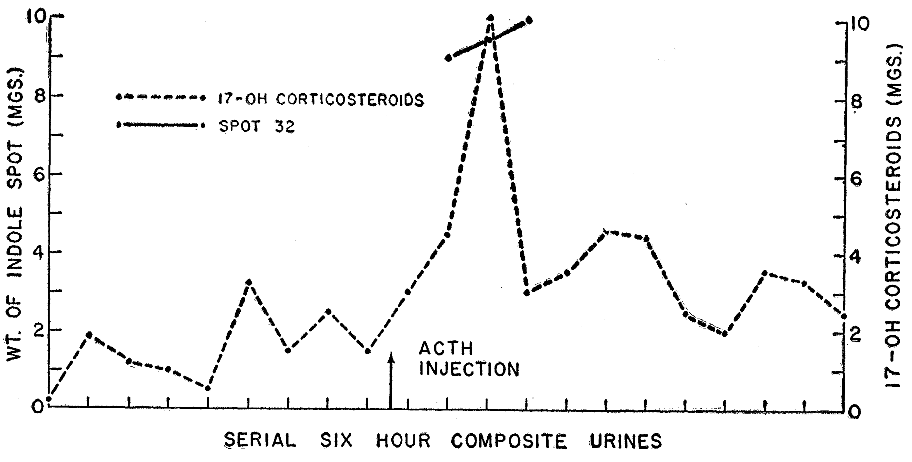

Fig. 1. A typical response of the indole-like "spot 32" and 17-hydroxycorticosteroids to ACTH gel injections. Spot 32 is visible down to a size corresponding to 6 mg weight. Spot 32 was not present except where indicated.

Hospitalized neurotic, psychotic, and psychopathic patients who had not been on drugs were placed on a standardized, high-calorie, high-protein diet that was free of indoles except for the tryptophan contained in the protein (*5*). Twelve 6-hr urine specimens were collected before and nine after the intramuscular injection of 40 units of ACTH gel. Urinary extracts were made and chromatographed according to the method of Armstrong *et al.* (*1*) with the exception of the application of extract equivalent to 2 mg of creatinine for chromatography. The bidimensional solvent systems were isopropanol-ammonia-water (8:1:1) and benzene-proprionic acid-water (10:7:5). 17-Hydroxycorticosteroids were determined by the method of Silber and Porter (*6*). The chromatograms were analyzed semiquantitatively by cutting out and weighing the spots. Using known indoles, we found, as did Masuda *et al.* (*3*), that there was a linear relationship between the amount of indole present and the size of the spot as indicated by its weight in the quantity range being measured.

Exogenous indoles from dietary sources due to previous uncontrolled food intake disappeared in 24 to 36 hr, resulting in relatively stable indole chromatograms from period to period except for the consistent diurnal variation (*7*). After the injection of 40 units of ACTH gel, there was no predictable change in any of the 30 or more indole spots manifested by most patients with the exception of spot number 32. This spot was absent in pooled urines from the psychiatric staff and in most of the patients studied during the control period. It appeared usually between 6 and 12 hr after the injections and peaked in density and size during the period of maximum 17-hydroxycorticosteroid excretion (Fig. 1). It disappeared most commonly in 18 to 24 hr. Spot 32 failed to appear in those patients who, for some reason, did not respond to ACTH with a rise in excretion of 17-hydroxycorticosteroids. The appearance of this spot appeared to be unrelated to the diet, bowel status, or urinary volume and specific gravity. The response of this spot is probably unrelated to changes in the creatinine referent, because creatinine excretion did not change significantly with ACTH injection. The determinations of the 29 other indoles which likewise used creatinine equivalents of urine did not evidence this change predictably. In addition, its appearance was independent of age, sex, or diagnostic category of the subjects. Its R_f (0.07, 0.01), ultraviolet sensitivity, relative position, and development characteristics with *p*-dimethylaminobenzaldehyde suggest strongly that it is an indole or indole-like compound and is identical with spot 32 of Armstrong *et al.* (*1*). We are currently engaged in characterizing this response further by using corticoids, epinephrine, and psychological stress. Efforts are likewise being made to characterize this compound chemically.

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7. The individual indoles appear to manifest the same diurnal variation reported for 17-hydroxycorticoids and creatinine; they reach their peak in the morning hours and decline throughout the day and evening.

30 January 1961

Standard for Reporting Concentrations of Deuterium and Oxygen-18 in Natural Waters

Abstract. A standard, based on the set of ocean water samples used by Epstein and Mayeda to obtain a reference standard for oxygen-18 data, but defined relative to the National Bureau of Standards isotopic reference water sample, is proposed for reporting both deuterium and oxygen-18 variations in natural waters relative to the same water. The range of absolute concentrations of both isotopes in meteoric waters is discussed.

In a previous report (*1*) the relationship between deuterium and oxygen-18 variations in meteoric waters throughout the world was shown. Many laboratories are measuring one or the other of these isotopes in various types of natural waters, and those workers studying O^{18} variations have more or less adopted, as a reference level for reporting enrichments, the "average ocean water" found by Epstein and Mayeda in the first precise work on O^{18}/O^{16} ratios in natural waters (*2*).

Deuterium analyses, however, occur in the literature relative to at least six different "working tap water" standards. In the previous report (*1*) the data presented for both isotopes showed how important it is to obtain data on both D and O^{18} variations in the same water samples, and it therefore seems that a common deuterium standard, preferably the same water as the O^{18} standard, should be adopted for consistency. The data shown previously (*1*) indicate that tap waters from various countries could easily differ by as much as 15 percent in the D/H ratio, and for many reasons it appears to be desirable to have an ocean water standard for reporting geochemical data.

For this purpose, the same set of ocean waters chosen by Epstein and Mayeda to give their "average ocean water" for O^{18} data was analyzed for the D/H ratio along with the samples described previously (*1*). These waters, taken from depths of 500 to 2000 m in open ocean areas where no direct dilution by continental runoff or glacial melt water could occur, were grouped by Atlantic, Pacific, and Indian Ocean samples, and equal volume composites were made from each set and analyzed relative to the laboratory working standard.

No single sample of "average ocean water" which could be circulated widely for analysis actually exists. Oxygen-18 data have generally been tied to the Epstein-Mayeda scale by analysis of various carbonate samples, requiring special techniques for preparation of 100 percent H_3PO_4, and so on. However, in the course of the present work it was found that both the D and O^{18} data on the set of ocean waters analyzed could be very simply specified in terms of the National Bureau of Standards isotopic reference sample No. 1, a distilled water sample of large volume intended for cross-check circulation to mass spectrometric laboratories (*3*). After consultation with various laboratories it was decided to define a "standard mean ocean water" (SMOW) in terms of the National Bureau of Standards reference sample 1, such that

$$\mathrm{D/H\ (SMOW)} \equiv 1.050\ \mathrm{D/H\ (NBS\text{-}1)}$$
$$\mathrm{O^{18}/O^{16}\ (SMOW)} \equiv 1.008\ \mathrm{O^{18}/O^{16}\ (NBS\text{-}1)}$$

and to report isotopic data for both isotopes as per mil enrichments relative to the defined SMOW (*4*), thus tying the standard to a sample readily available for world-wide distribution.

The isotopic analyses of the composite ocean water sets made from the samples used by Epstein and Mayeda are shown in Table 1, in which the O^{18} data are averages for each set taken from their paper (*2*) with slight corrections later found necessary (*5*). The deuterium analyses are those I made, and all data have been calculated relative to SMOW, so that

$$\delta = [(R_{\mathrm{sample}}/R_{\mathrm{SMOW}}) - 1] \times 1000$$

is the per millage enrichment in either isotopic ratio *R*, relative to SMOW. The analytical precision has been described (*1*).

These data indicate that, within the limits of analytical precision and geographical variation, SMOW as defined above provides a consistent and convenient zero reference level for reporting isotopic enrichments and is an adequate average for the Epstein-Mayeda O^{18} data on "average ocean water." Clearly it will be a long time before the actual mean ocean composition is known; the designation "standard" indicates that SMOW is an arbitrary mean value based on the Epstein-Mayeda oxygen scale but defined in terms of an actual water reference standard, the NBS-1. The δO^{18} value of the Chicago PDB-1 carbonate standard (CO_2 from reaction with 100 percent H_3PO_4 at 25°C) is +0.22 per mil on the SMOW scale (*6*).

Table 1. D/H and O^{18}/O^{16} enrichments of the Epstein-Mayeda "average ocean water" set and other samples, in per millage relative to SMOW. Numbers in parentheses after ocean names indicate number of samples in each set.

Sample	δD (per mil)	δO^{18} (per mil)
Atlantic (6)	− 0.7	+ 0.14
Pacific (11)	+ 0.9	+ 0.04
Indian (2)	+ 0.1	− 0.07
NBS-1	− 47.60	− 7.94
NBS-1A	−183.3	−24.33

Table 1 also shows the NBS-1 data as defined versus SMOW, and the value obtained for the NBS-1A secondary water standard. The D/H enrichment of NBS-1A relative to NBS-1 is found to be −142.5 ± 2.5 per mil (*3*). Horibe and Kobayakawa found a value of −141.3 ± 2.3 per mil (*3, 7*) in good agreement. Their data yield an absolute D concentration for SMOW of 157 ± 1 atomic parts per million (ppma), based on direct calibration with enriched standards. I analyzed five water samples which had been measured previously for absolute D content by Kirshenbaum (*8*); this comparison gives a D concentration of 159 ± 2 ppma for SMOW. We may therefore take the absolute D content of SMOW as 158 ± 2 ppma, corresponding to a D/H ratio of 1/6328.

Absolute O^{18} concentrations, based on data obtained by Nier and me, have been given for standards including the NBS-1 water (*5*). From these data the O^{18} concentration in SMOW is found to be 1989.5 ± 2.5 ppma, corresponding to an O^{18}/O^{16} ratio of $(1993.4 \pm 2.5) \times 10^{-6}$.

In the previous paper (*1*) the relation between δD and δO^{18}, expressed as per millage enrichments relative to SMOW, was found to be linear in the majority of meteoric waters, obeying the equation

$$\delta D = 8\ \delta O^{18} + 10$$

By using the absolute concentrations for SMOW as given above, the atom fractions of D and O^{18} are found to be related in meteoric waters by the expression

$$X_{\mathrm{D}} = 0.6359\ X_{\mathrm{O}} - 1105.6$$

when the atom fractions are given in atomic parts per million. This relation is approximately obeyed by ocean waters also, but does not hold for lakes having high ratios of evaporation to outflow.

The total variations in meteoric waters are about 360 per mil for deuterium and about 48 per mil for oxygen-18, relative to the concentrations in SMOW. This variation in D content corresponds to a variation of about 6 ppm in density, while the O^{18} variation