microchemical methods at present available and also of the evolution of these methods during the last twenty years. Iodine values obtained during this period have in general progressively decreased as the methods have improved. Yet in these chapters older data are incorporated with the new. Thus the normal blood iodine is stated to be "rarely less than 5 micrograms per cent. or more than 20 micrograms per cent." Judged by the concentrations of other normal constituents of the blood, fasting normal blood iodine is probably more constant than present data indicate. The question always arises, Are we measuring only iodine? and the answer at present is that we are not. Such a question does not arise in the older work where only direct measurements of iodine were made, using material containing more than 100 micrograms of iodine per gram.

Chapter 10 on radioactive iodine is the outstanding chapter. It is an excellent summary of the work to date in this very recent and accurate application of a product of the cyclotron-"tagged" iodine, to the problem of the endocrine function of iodine. As work progresses, and it certainly will progress rapidly with "labeled" iodine, the bizarre normal values reported for iodine in the various tissues, using microchemical methods, will be checked by the more accurate microphysical methods and one may then expect that "normal" tissue iodine will be defined within narrower limits. At that time one may, perhaps, determine the iodine balance with the accuracy of a Ca, P or N balance. The recent discovery by Hamilton and Soley that another product of the cyclotron-element 85 or "eka-iodine" is selectively taken up by the thyroid gland is properly emphasized. As the author points out, radioactive iodine gives investigators a fascinating new tool which should greatly improve the accuracy of future iodine determinations and thereby further extend our knowledge of the biological importance of iodine.

Chapter 8 is the poorest. There is no convincing evidence that the rich extrinsic nerve connections, both sympathetic and parasympathetic, play an important role (other than vasomotor) in thyroid activity; while against this there is an easily proven humoral factor, first demonstrated by thyroid transplantation, which the author does not mention, by cold and by *in vitro* tissue cultures. There are some minor clerical mistakes—as that Coindet reported on the treatment of goiter with iodine in 1811 and some confusing ones caused merely by the omission of "per cent." in the expression "mgm. per cent." (p. 100).

An appendix giving four methods in detail for estimating varying amounts of organic iodine, together with some of the general properties of iodine, materially increases the practical usefulness of the book. The sequential arrangement of the subject-matter has been well considered. A bibliography of 588 complete references and a good subject index complete the volume.

DAVID MARINE

# SOCIETIES AND MEETINGS

## INDIANA ACADEMY OF SCIENCE

THE fifty-sixth annual meeting of the Indiana Academy of Science was held on Thursday, Friday and Saturday, November 14, 15 and 16, 1940, at Muncie, Indina, with Ball State Teachers College as the host institution. Over 400 scientists were in attendance.

The general meetings were presided over by Frank N. Wallace, state entomologist, and the principal papers on the general program were given by Glenn A. Black, Indiana State Historical Society, on "Archeology at the Angel Mounds Site," and T. G. Yuncker, DePauw University, on "Life and Customs Among the Samoans." The necrology was read by Will E. Edington, DePauw University. The academy lost 18 members by death during the past year.

At the nine divisional meetings on Friday afternoon 104 papers were read.

The annual banquet was held on Friday evening, following which President Wallace spoke on "Fighting the Japanese Beetle in Indiana." This meeting closed with the election of the following officers: *President,* Paul Weatherwax, Indiana University; *Vice-president,* Edward Degering, Purdue University; *Secretary,* Winona Welch, DePauw University; *Treasurer,* William P. Morgan, Indiana Central College; *Editor of the Proceedings,* P. D. Edwards, Ball State Teachers College; *Press Secretary,* Will E. Edington, DePauw University; *Divisional Chairmen:* Anthropology, Thomas B. Noble, Indianapolis; Bacteriology, C. G. Culbertson, State Board of Health, Indianapolis; Botany, R. E. Cleland, Indiana University; Chemistry, J. L. Riebsomer, DePauw University; Geology and Geography, Robert Karpinski, Indiana State Teachers College; Mathematics, Will E. Edington, DePauw University; Physics, R. E. Martin, Hanover College; Psychology, Harry N. Fitch, Ball State Teachers College; Zoology, W. E. Martin, DePauw University. R. E. Cleland, Indiana University, and Carl Means, Butler University, were elected fellows. The 1941 annual meeting will be held in Greencastle, Indiana, with DePauw University as the host institution.

The state societies of entomologists and taxonomists held their meetings on Saturday.

The Junior Academy, composed of 38 high-school science clubs, met on Saturday with 250 young scientists present. Addresses were given by Walter C. Geisler, Shortridge High School, Indianapolis, on "A New Technique in Gem Cutting," and L. S. Shively, Ball State Teachers College, on "Astronomy." Eleven papers were given by members of the Junior Academy. The following officers were chosen for 1941: *President,* Patricia Anderson, Edison High School, Hammond; *Vice-president,* Mary Hybarger, Lew Wallace High School, Gary; *Secretary,* Mary Lou Sweet, Marion High School. Honorary memberships in the American Association for the Advancement of Science were awarded to Frances Scott, Arsenal Technical High School, Indianapolis, and Robert Gericke, Lew Wallace High School, Gary. Dean Howard E. Enders, Purdue University, senior academy sponsor of the Junior Academy, closed the meeting with a report on the progress of the Indiana Junior Academy through the state.

WILL E. EDINGTON,
*Press Secretary*

# SPECIAL ARTICLES

## APPLICATION OF $N^{15}$ TO THE STUDY OF BIOLOGICAL NITROGEN FIXATION

STUDY of the mechanism of biological nitrogen fixation should be greatly aided if isotopic nitrogen could be used for tracing the path of nitrogen from its molecular to its fixed state in the cell. Inaccuracies of the Kjeldahl method have frequently suggested fixation of nitrogen by germinating seeds, Rhizobium independent of its host, non-leguminous plants and other biological agents whose ability to fix nitrogen is questionable. It would be possible to detect nitrogen fixation unequivocally, however, by the appearance of excess $N^{15}$ in a biological agent under an atmosphere containing excess $N^{15}$, provided no direct exchange of $N^{14}$ and $N^{15}$ occurred between the fixed and the gaseous nitrogen in the system.

A culture of the free-living, nitrogen-fixing organism *Azotobacter vinelandii* was used to test for exchange. Nitrogen gas containing 35 per cent. $N^{15}$ excess was mixed with air to produce a non-equilibrium condition of the molecular species of $N_2$. This gas mixture was introduced into an evacuated culture vessel containing 30 ml of a three-day culture of *Azotobacter vinelandii* which had grown in air and fixed 117.7 micromols $N_2$ (as shown by Kjeldahl analysis). In four more days the culture fixed 150.2 micromols additional $N_2$ under the $N^{15}$-excess atmosphere. Samples of gas and culture were taken at the time the culture was first supplied with the $N^{15}$-excess atmosphere and at the termination of the experiment.

By assuming non-selective fixation and no exchange, it was possible to calculate (from the composition of the two atmospheres supplied to the culture and the Kjeldahl analyses) the final $N^{15}$ content of the culture as follows:

| | | Micromols $N^{15}$ |
|---|---|---|
| 117.7 micromols $N_2$ fixed in air (0.37% $N^{15}$) | | 0.43 |
| 150.2 micromols $N_2$ fixed in $N^{15}$-excess atmosphere (9.12% $N^{15}$) | | 13.70 |
| 267.9 Total | Total | 14.13 |

$$\frac{14.13 \text{ micromols } N^{15}}{267.9 \text{ micromols } N_2 \text{ fixed}} = 5.27\% \ N^{15}$$

Mass spectrographic analysis indicated a final concentration of 5.23 per cent. $N^{15}$ in the culture.

The close agreement between the calculated and observed values indicates that there was no selective action in the fixation of $N^{15}$ and $N^{14}$ atoms from the molecules of mass 28, 29 and 30, and that there is no apparent exchange reaction between molecular nitrogen and fixed nitrogen in the culture. Schoenheimer and Rittenberg[1] have presented convincing evidence that the animal body exerts no selection between $N^{14}$ and $N^{15}$ in combined forms, but our study seems to provide the first direct extension of that observation to a biological process involving molecular nitrogen.

Analysis with the mass spectrometer indicated that initially the $N^{15}$-excess atmosphere contained 9.12 per cent. $N^{15}$ and finally contained 9.11 per cent. $N^{15}$. The analysis showed the distribution of molecular species as in Table I.

TABLE I

| Molecule | | Concentration as percentage of total | |
|---|---|---|---|
| Composition | Mass | Initial | Final |
| $N^{15}_2$ | 30 | 2.99 | 3.01 |
| $N^{15}\,N^{14}$ | 29 | 12.24 | 12.20 |
| $N^{14}_2$ | 28 | 84.77 | 84.79 |

Calculations show that at equilibrium between the molecular species the distribution would have been as in Table II.

TABLE II

| Molecule | | Concentration as percentage of total | |
|---|---|---|---|
| Composition | Mass | Initial (9.12% $N^{15}$) | Final (9.11% $N^{15}$) |
| $N^{15}_2$ | 30 | 0.83 | 0.83 |
| $N^{14}\,N^{15}$ | 29 | 16.58 | 16.56 |
| $N^{14}_2$ | 28 | 82.59 | 82.61 |

Of the $N^{15}$-excess atmosphere supplied, 6.4 per cent. was fixed by the organism. If an equilibration (in-

[1] R. Schoenheimer and D. Rittenberg, *Physiol. Rev.*, 20: 218, 1940.