Sciences, which was held jointly with the Geological Society of Washington.

DR. F. C. BISHOPP, assistant chief of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture, addressed a joint meeting in New York of the New York University Medical Society and the New York University Chapter of Sigma Xi on November 11. He spoke on "Insect Control—War and Post-War Developments."

DR. K. LINDERSTRØM-LANG, of the Carlsberg Laboratories in Copenhagen, and Dr. Ernst Bergmann, of the Sieff Institute in Jerusalem, spoke before the Organic Chemistry Seminar of Fordham University on November 2 and 14, respectively. Dr. Linderstrøm-Lang reported on "Recent Advances in Microbiological Methods," and Dr. Bergmann discussed "Walden Inversion and Racemization Reactions."

PROFESSOR WILBUR M. WILSON, of the department of civil engineering of the University of Illinois, spoke at Iowa State College, Ames, at a Sigma Xi dinner and initiation on November 27. His lecture was entitled "Notes from the Diary of a Research Engineer."

THE third annual D. J. Davis Lecture on medical history of the College of Medicine of the University of Illinois at Chicago was delivered on November 21 by Dr. Carl E. Black. He spoke on "Medical Practice Before the Hard Roads."

AT the fall dinner on November 13 of the Smith College chapter of the Society of the Sigma Xi, Dr. Henry Allen Moe, secretary-general of the Guggenheim Memorial Foundation, was the guest speaker. His subject was "Proposed Government Plans for the Discovery and Development of Scientific Talent." Dr. Marjorie Williams, of the department of astronomy, is president of the chapter for the coming year.

THE four hundred and thirteenth meeting of the American Mathematical Society was held at the California Institute of Technology on November 24. By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, Professor Hans Lewy, of the University of California, Berkeley, delivered an address entitled "Water Waves on Sloping Beaches."

THE Federation of American Societies for Experimental Biology will meet in Atlantic City beginning on Monday, March 11, 1946. The federation is composed of the American Physiological Society, the American Society of Biological Chemists, the American Society for Pharmacology and Experimental Therapeutics, the American Society for Experimental Pathology, the American Institute of Nutrition and the American Association of Immunologists.

A STATEMENT setting forth their position on the international control of atomic energy has been made public by five hundred and fifteen physicists, chemists and engineers who were engaged in war research at Harvard University and the Massachusetts Institute of Technology. A summary of this statement reads: "Specifically our conclusions are: (1) Other nations will be able to produce atomic bombs; (2) no effective defense is possible in atomic warfare; (3) safety can not be obtained by superiority in atomic armament; (4) henceforth, war will mean the destruction of a large fraction of civilization; (5) international co-operation of an unprecedented kind is necessary for our survival."

THE French Press and Information Service reports that a new ordinance, appearing in the *Journal Officiel,* establishes a committee for atomic energy. It is stated in the preamble: "Urgent national and international necessities have obliged the taking of the requisite measures, so that France may hold her place in the field of research in atomic energy." This organization will include a small committee which will act as a board of management and at the same time act as a working group in scientific research. Scientific and technical work will be directed by a high commissioner. A general manager representing the Government will be placed at the head of the administrative and financial management of the commission. Three investigators in atomic research and the president of the coordinating committee of national defense research work will be appointed members of the commission, which will be presided over by the president of the Provisional Government. The commission's freedom of action is guaranteed by the fact that its creation is regulated by civil and commercial law.

# SPECIAL ARTICLES

## THE ROLE OF AMINO ACIDS AND AMIDES IN THE METABOLISM OF AMMONIUM ABSORBED BY ZEA MAYS L.[1]

ONE or the other, and sometimes both, of the acid amides, asparagine and glutamine, have been known for many years to accumulate in plants when ammonium is absorbed from the substrate or when the

[1] Published with the approval of the director of the South Dakota Agricultural Experiment Station as Journal Paper No. 198.

environment is unfavorable so that protein hydrolysis occurs and the amino acids are deaminized to produce ammonia. The latter condition occurs when seedlings or excised leaves are cultured in the dark. Boussingault[2] and later Prianischnikow[3] considered this amide formation to be a detoxicating mechanism for ammonia, but recently Chibnall[4] and Vickery and Pucher[5] considered it to be a regular phase in the respiratory mechanism of the plant.

Other methods of utilizing excess ammonia have been suggested: (1) the storage of ammonium as the cation of organic acids by Ruhland and Wetzel[6] in plants with acid saps, (2) formation of arginine in the conifers as suggested by Susuki[7] but later questioned by several investigators, and (3) the formation of urea by certain higher plants and the fungi.

In connection with studies on the nitrogen metabolism of corn, more information was needed on the nature of the compounds formed in response to the absorption of ammonium or its release by catabolic processes in the tissues. Boussingault[2] noted the presence of asparagine in corn when he compared the formation of this amide to the detoxication of ammonia as urea in animals. Prianischnikow[8] demonstrated that the presence of carbohydrate was essential for the formation of asparagine in corn. Asparagine was crystallized from etiolated corn seedlings by Jodidi,[9] but he did not report the presence of glutamine. According to Klein and Taubock,[10] urea does not occur in corn and the writer has been unable to demonstrate its presence in mature plants.

## EXPERIMENTAL

The plan was to produce plants low in soluble nitrogen compounds and high in sugars by limiting the supply of nitrogen during the preliminary growth period; and then to force them to absorb ammonium until toxicity symptoms appeared, measuring the changes in certain constituents during this period of enforced ammonium absorption.

South Dakota hybrid 105 × 107 seeds were planted in sand, and when the plants were about 10 cm high, they were transplanted to crocks (3 per crock) each containing 7 liters of one-half strength Hoagland solution supplemented with the essential microelements. $FeSO_4$ was added in solution semiweekly throughout the entire investigation. On January 2, when the plants were 18 inches high, the solution was replaced by a similar solution except that nitrogen was omitted, the Ca and K being added as the sulfates. At the end of 7 days, the lower leaves were showing definite nitrogen deficiency symptoms along the midrib, and the soluble nitrogen constituents of the expressed sap had been reduced to a low level as shown by subsequent analyses (0 days, Table 1) of 6 plants calculated to a 12-plant basis.

TABLE 1

INFLUENCE OF AMMONIUM ABSORPTION ON VARIOUS CONSTITUENTS OF TOPS OF 12 CORN PLANTS

| Days | 0 | 3 | 6 | 13 |
|---|---|---|---|---|
| meq/l $(NH_4)_2SO_4$ in solution for preceding interval .... | 0 | 30 | 60 | 120 |
| Dry wt. (g) .............. | 27.4 | 27.7 | 38.8 | 44.5 |
| Total N (mg/g) .......... | 26.5 | 28.4 | 30.3 | 34.8 |
| Total sugar (per cent. dry wt.) | 5.00 | 6.12 | 6.46 | 5.62 |
| "True protein" (mg N/g) .... | 18.8 | 21.2 | 18.8 | 18.8 |
| pH of sap ................ | 6.6 | 6.7 | 6.9 | 6.9 |
| $NH_3$ and $NH_4^+$ (mg N/1) .... | 15.2 | 14.6 | 18.9 | 100 |
| Glutamine " .... | 27.2 | 43.8 | 99.0 | 328 |
| Asparagine " .... | 37.2 | 107 | 249 | 588 |
| α-amino " .... | 155 | 161 | 201 | 380 |
| Undetermined " .... | ... | 515 | 904 | 1,592 |
| Total soluble " .... | ... | 842 | 1,472 | 2,988 |

Thirty meq/l of $(NH_4)_2SO_4$ were added to the remaining solutions, and after 3 days, 12 more plants were harvested. The $(NH_4)_2SO_4$ concentration of the remaining solutions was then increased to 60 meq/l, as indicated in Table 1. This procedure was continued until the final set of plants was in 120 meq/l of $(NH_4)_2SO_4$. On the 13th day the remaining plants began to wilt, the leaves rolled and the tips began to die. During this period of rapid ammonium absorption, the solution pH remained at $6.5 \pm 0.1$.

At harvest the plants were separated into roots and tops, and the roots were washed in distilled water. Fresh weights were taken, the material cut into one-inch lengths, thoroughly mixed, one third dried for moisture, sugar, total N and "true protein" determinations, and the remaining portion wrapped in cheesecloth, frozen, slowly thawed, and the sap expressed in a hydraulic press at 2,600 lbs./sq. in.

## ANALYTICAL METHODS

*Dry material*: total sugars were determined by the procedure of Hassid.[11] Total N and "true protein N" were determined by the Kjeldahl method, the latter after extracting the dried material with 80 per cent. ethanol for 6 hours followed by boiling water.

*Sap constituents*: ammonia, glutamine, and as-

[2] J. B. Boussingault, *Agronomie, chemie agr. et physiol.*, 4: 245, 1868.

[3] D. Prianischnikow, *Ber. bot. Ges.*, 40: 242; *ibid.*, *Biochem. Z.*, 150: 407, 1924.

[4] A. C. Chibnall, "Protein Metabolism in the Plant." New Haven, 1939.

[5] H. B. Vickery and G. W. Pucher, *Jour. Biol. Chem.*, 128: 703, 1939.

[6] W. Ruhland and K. Wetzel, *Planta*, 1: 558, 1926; *ibid.*, 3: 765, 1927; *ibid.*, 7: 503, 1929.

[7] U. Susuki, *Bull. Coll. Agric. Tokyo*, 4: 1, 25, 1900–1902.

[8] D. Prianischnikow, *Landw. Vers. Sta.*, 99: 267, 1922.

[9] S. L. Jodidi, *Jour. Agr. Res.*, 34: 649, 1927.

[10] G. Klein and K. Taubock, *Biochem. Z.*, 255: 278, 1932.

[11] W. Z. Hassid, *Ind. Eng. Chem., Anal. Ed.*, 9: 228, 1937.

paragine were determined by the procedure of Vickery *et al.*[12] Total soluble N was determined on 3 per cent. trichloroacetic acid filtrates. Van Slyke $\alpha$-amino N was determined on the deproteinized filtrates after the amides were hydrolyzed for 2 hours with 2N HCl at 100° C. followed by the liberation of the ammonia on the steam bath at pH 7.5.[13] The $\alpha$-amino N associated with the amides was subtracted from this value to give the $\alpha$-amino N reported in Table 1.

Since the data from the roots are similar, they will not be given here, except to note that the roots gained only 10 per cent. in dry weight during the experimental period, whereas the tops gained over 60 per cent. during the same period. This experiment has been repeated in the spring season with substantially similar results.

## DISCUSSION

The data of Table 1 indicate that the plants absorbed large quantities of ammonium N and made substantial growth. There was no significant trend in "true protein" N, but the nitrogen absorbed in excess of the plant's requirements went into the formation of glutamine, asparagine and one or more amino acids. There was also a great increase of undetermined forms of soluble N. Ammonia does not accumulate in the neutral sap until the amides and other soluble nitrogen constituents have reached a relatively high level. The factor or factors preventing further utilization of this absorbed ammonia are not known, but carbohydrate would not appear to be the limiting factor. It is appropriate to recall Prianischnikow's[14] speculation that ammonia may not always be the toxic agent, but the accumulation of some product arising from the utilization of the ammonia.

That the increase in $\alpha$-amino N observed here is a net increase and does not come from the degradation of protein is inferred from the stable values for "true protein" N. This role of amino nitrogen has apparently not been appreciated in the past, since in the usual type of experiment with etiolated seedlings or excised leaves the amino acids arise from protein hydrolysis and, hence, their role in metabolizing ammonia can not be appraised. This function of amino N may not be universal, however; for Vickery, Pucher and Clark[15] found that all the ammonia absorbed by the beet was transformed into glutamine.

This rapid synthesis of one or perhaps more $\alpha$-amino acids offers the possibility of a new approach to the study of amino acid synthesis and protein regulation in the plant.

## SUMMARY

When corn seedlings, previously depleted in soluble nitrogen constituents, are forced to absorb large quantities of ammonium nitrogen, soluble compounds accumulate in the sap. Asparagine, glutamine, one or more amino acids and undetermined compounds are synthesized. Ammonia does not accumulate until these constituents have reached a relatively high level.

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12 H. B. Vickery, G. W. Pucher, H. E. Clark, A. C. Chibnall and R. G. Westall, *Biochem. Jour.*, 39: 2710, 1935.

13 Personal communication from T. C. Broyer and D. R. Hoagland, University of California.

14 D. Prianischnikow, *Z. Pflanzenernahr. Dungung*, 4A: 242, 1925; *ibid.*, *Jour. Russian Botan. Congress*, 1: 65, 1921. (Abstracted in *Chem. Abs.*, 19: 3288, 1925.)

15 H. B. Vickery, G. W. Pucher and H. E. Clark, *Plant Physiol.*, 11: 413, 1936.

# THE EFFECT OF TRANSFUSIONS OF RED BLOOD CELLS ON THE HYPOXIA TOLERANCE OF NORMAL MEN[1, 2]

ONE of the most striking physiologic changes during acclimatization to high altitudes is the development of polycythemia.[3, 4] An artificial polycythemia has been produced in experimental animals by means of cobalt administration and has apparently increased their tolerance to hypoxia.[5] It appeared of interest to learn whether polycythemia induced in normal men by the transfusion of red blood cells would increase their tolerance to altitude hypoxia.

## EXPERIMENTAL PROCEDURE

A group of ten normal young men was divided into two groups of five each so that the mean ages and body weights were comparable. During the first two weeks of the experiment, control observations were made on both groups. These consisted of determinations of oxygen capacity of the blood; arterial oxygen (using arterialized venous blood[6]) and carbon dioxide content and pH of the serum at sea level and at a simulated altitude of 15,500 feet in a low pressure chamber; oxygen and carbon dioxide content of alveolar air; total urinary pigments; reticulocyte per-

1 From the Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland.

2 The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

3 D. B. Dill, "Life, Heat and Altitude." Cambridge: Harvard University Press, 1938.

4 A. Hurtado, C. Merino and E. Delgado, *Arch. Int. Med.*, 75: 284, 1945.

5 S. S. Dorrance, G. W. Thorn, M. Clinton, H. W. Edmonds and S. Farber, *Am. Jour. Physiol.*, 139: 399, 1943.

6 S. Goldschmidt and A. B. Light, *Jour. Biol. Chem.*, 64: 53, 1925.