is not just another text in social psychology. For the most part it leaves the concepts and problems of sociology to the sociologists, especially the problems of acculturation and human interaction. Its most distinctive contribution is in the emphasis placed upon the social significance of individual differences in abilities, character, wants and satisfactions, and upon the genetic causes of such differences. Thorndike does not deny the importance of good environment, but he never forgets that genes set the limits to its effects. With sly humor he notes that "the perfectibility of human nature is wisely put by religions in a heaven with not only optimal environment but also infinite time." Numerous passages could be cited in which he pays his respects to the biological ignorance that underlies egalitarian social philosophies. Certainly very few writers have so boldly expressed the implications (as he sees them) of the doctrine of individual differences for economic and political theory.

Not every one will agree with Thorndike on what the true implications are. Some who agree with him completely about the potency of genes will be unable to accept all the conclusions he deduces from that premise. For Thorndike the fact that the ability of the gifted far transcends that of the masses, together with the fact that there is a positive correlation between ability and character, calls for a political system in which power would be largely concentrated in the hands of a benevolent aristocracy composed of the able and the good and in which equal suffrage would be replaced by some scheme of weighted ballots. The author believes that our present "aversion to government by experts is on a level with aversion to medical treatment or sanitation by experts." One may question whether he has given due consideration to the dangers inherent in even the best aristocracies and whether he is not banking too heavily on the practical consequences of a slight positive correlation between intelligence and character. It may well be, however, that a vigorous presentation of this point of view will serve as a useful antidote to the sentimental political and social philosophies that ignore or deny heredity differences and attribute magic influences to factors of environment.

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SPECIAL ARTICLES

FAILURE OF BARLEY TO FIX MOLECULAR N^{15}

THE testimony of centuries of experience in practical agriculture has established the respective nitrogen depleting and nitrogen replenishing natures of non-leguminous and leguminous crops. Despite the weight of practical and experimental evidence against the conclusion, periodic reports reassert that non-leguminous plants can fix atmospheric nitrogen.

Results were presented in this journal by Ruben, Hassid and Kamen[1] indicating the fixation of radioactive N^{13} gas by the fresh tops of barley plants and the lack of fixation by tops boiled in water before exposure to N^{13}. As N^{13} has a half life of but 10.5 minutes, these experiments were necessarily of very short duration, the barley tops having been exposed to N^{13} for only 20 minutes.

The stable nitrogen isotope, N^{15}, offered us a means of tracing nitrogen fixation without the time limitation imposed by the radioactive isotope. Barley seeds were dehulled and then rendered bacteria-free by treatment with 70 per cent. ethyl alcohol followed by calcium hypochlorite solution carrying 3 per cent. available chlorine. The seeds were germinated aseptically and transferred to culture tubes containing thoroughly washed quartz sand to which a nitrogen-free nutrient salts solution had been added prior to sterilization. Tubes containing bacteria-free red clover plants and red clover plants with added root nodule bacteria (*Rhizobium trifolii*) were prepared in the same manner. Cresol red[2] in side bulbs on the tubes indicated when CO_2 was needed, and this gas was added to the atmosphere as required during the experiment. The plant culture tubes were sealed to a common manifold, evacuated and supplied with a gas mixture of 20 per cent. oxygen and 80 per cent. nitrogen. The nitrogen gas had 13.5 atom per cent. N^{15} excess (*i.e.*, 13.87 per cent. N^{15}, the normal abundance of N^{15} being 0.37 per cent.) and was freed of combined nitrogen compounds by passage through alkaline $KMnO_4$ and H_2SO_4.

Each group of plants, bacteria-free barley, bacteria-free clover and inoculated clover, received the same gas mixture, and the gas during the entire experiment was free to diffuse among the tubes through their cotton plugs. Air controls were grown in the same manner. The plants of experiment 1 were harvested after 42 days, subjected to Kjeldahl digestion, the NH_3 distilled and then converted to N_2 with alkaline hypobromite.[3] The N_2 was analyzed for the N^{15} isotope with a mass spectrometer.

In a second experiment, which did not include the bacteria-free clover culture, 8.1 atom per cent. excess

[1] S. Ruben, W. Z. Hassid and M. D. Kamen, SCIENCE, 91: 578, 1940.

[2] Elizabeth M. Smyth, SCIENCE, 80: 294, 1934.

[3] D. Rittenberg, A. S. Keston, F. Rosebury and R. Schoenheimer, *Jour. Biol. Chem.*, 127: 291, 1939.

N^{15} nitrogen gas was used. The plants were harvested after 56 days and analyzed. The experimental results are given in Table 1 as atom per cent. N^{15} excess of plants over the average values of air control plants.

TABLE 1

	Atom per cent. N^{15} excess of plants over average of air controls	
	Exp. 1	Exp. 2
Bacteria-free barley	-0.010 ± 0.005*	-0.006 ± 0.005
Bacteria-free clover	-0.004 ± 0.005	
Inoculated clover	2.469 ± 0.061	0.689 ± 0.052

* 0.005 per cent. represents the standard deviation of spectrometer readings for all determinations on the bacteria-free plants; the standard deviations of readings for the inoculated clover (calculated for individual samples) are higher, since the error of measurement is greater at higher N^{15} concentrations. The regular occurrence of negative values for bacteria-free plants is merely fortuitous.

These data show that if either barley or bacteria-free clover fixed any nitrogen, the amount fixed was within experimental error, whereas fixation by inoculated clover resulted in the accumulation of large quantities of N^{15}.

By calculation from the data of Ruben *et al.*,[1] we can find if their success and our failure to observe fixation arises from a difference in the sensitivity of the stable and radioactive tracer methods. These investigators used 30 grams wet weight of barley tops which, assuming 75 per cent. moisture and 3 per cent. nitrogen on a dry weight basis, would contain about 225 mg of nitrogen. The authors stated that during the experiment the plants assimilated an amount of N_2 which "corresponds roughly to 0.01 cc of N_2"; 0.01 cc of N_2 (0.0125 mg N_2) constitutes 0.00556 per cent. of the total nitrogen of the plants. We can calculate what the final N^{15} content of our barley plants should be if we assume that the rate of fixation reported by Ruben *et al.*[1] occurred uniformly during the period of our experiment 1. Since 42 days' exposure is 3,024 times the 20-minute treatment of Ruben *et al.*,[1] 16.8 per cent. (*i.e.*, 0.00556 per cent. $\times$ 3,024) of the total nitrogen of the plants would be fixed during the experimental period. But as 13.5 atom per cent. excess N^{15} was used, the observed N^{15} value would be 2.27 atom per cent. N^{15} excess (*i.e.*, 16.8 per cent. $\times$ 0.135).

The value 2.27 atom per cent. N^{15} excess, which we would have found had our barley plants fixed nitrogen at the same rate as Ruben *et al.*[1] report for N^{13} fixation, is 454 times the standard deviation of our measurements with the mass spectrometer. It is about the same value as we actually observed with inoculated clover plants.

Since the fixation experiments with barley were completely negative, one can but speculate as to the reason that the twenty-minute exposure of excised barley tops in the experiments of Ruben *et al.*[1] resulted in an uptake of N^{13}. These workers extracted the barley plants with boiling 80 per cent. ethyl alcohol, boiled the extract in a stream of air in an effort to drive off N_2, and then detected radioactivity in the boiled extract. It hardly seems likely that the observed N^{13} uptake can be attributed to fixation by the small number of bacteria carried by the plant tops or, in view of our results, to a true nitrogen fixation by the plant tops themselves. Ruben *et al.*[1] state, "These experiments with N^{13} do not necessarily prove that a net uptake of N_2 has occurred, since the existence of reversible (interchange) reactions involving N_2 is possible." However, Burris and Miller[4] demonstrated the absence of any interchange reaction in *Azotobacter vinelandii*, which was vigorously fixing N_2 in a non-equilibrium N^{15}-excess atmosphere. The possibility remains that a non-specific surface adsorption of N_2 by fresh barley tops and a failure to completely remove this N_2 containing N^{13} accounts for the radioactivity detected by Ruben *et al.*[1] In our experiments it is obvious that the Kjeldahl treatment would eliminate all adsorbed N_2.

The complete lack of fixation of the stable N^{15} isotope by bacteria-free barley and bacteria-free red clover plants under conditions identical with those supporting active fixation of N^{15} by red clover inoculated with *R. trifolii* supports the generally accepted conclusion that non-leguminous plants and leguminous plants in the absence of the root-nodule bacteria are unable to fix molecular nitrogen.

In addition to the question of nitrogen fixation by non-leguminous plants, positive and negative reports in the literature present controversies concerning the nitrogen fixing ability of germinating pea seeds, excised root nodules with added oxalacetic acid, and root nodule bacteria in the absence of the host plant. Thus far we have been unable to demonstrate fixation of N^{15} by any of these biological agents, whereas azotobacter and leguminous plants with root nodule bacteria fix N^{15} readily.

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CROWN GALL PRODUCTION BY BACTERIA-FREE TUMOR TISSUES

CROWN gall has in the past been produced only by inoculation of a host plant with *Phytomonas tumefaciens* (Smith and Town.) Bergey *et al.* either as a pure culture or in the form of a preparation of tissues infected therewith. Although crown-gall tissues have not always yielded cultures of the organism, it has been presumed that the bacteria were present or at least had been present at some stage in the development of the tumor. The production of tumors with-

[4] R. H. Burris and C. E. Miller, SCIENCE, 93: 114, 1941.
[5] National Research Council fellow.