six) were corrected for decay to the day of slaughter and averaged.

Nuclear weapon tests were conducted in the atmosphere by the U.S.S.R. during September and October 1961. Samplings of thyroids of Reno cattle were made approximately twice weekly during this time and on a slightly less frequent schedule until 30 January 1962. These data are presented in Fig. 1. A noticeable rise in concentration occurred on 12 September (day 255), 11 days after the first announced atmospheric detonation. The thyroid I^{131} level continued to rise until 3 November (day 307), after which it decreased rapidly, and reached the pre-testing level around the end of January 1962. A large variation in thyroid I^{131} concentration of animals sampled the same day has been reported (*1*). In the present study, on 8 of 24 sampling dates the maximum concentration in an individual gland was more than 10 times the minimum concentration. Greater uniformity was observed as the concentration was increasing rather than decreasing. No correlation was found between the day of the week and the I^{131} concentration, indicating that the management practices of the slaughter establishment did not influence the data.

The data appear reasonably linear as a semilogarithmic plot. This type of graphical representation has been used previously for similar data (*1*). A regression (log of concentration versus time) equation was fitted separately to the rising and falling portions of the curve. The rise to the maximum is characterized by a doubling time of 5.7 days. The decline shows a half-period of 6.6 days which is very similar to that previously reported for sheep (*6*). The rate of rise would be primarily a function of the test schedule (time and fission yield) and atmospheric conditions whereas the rate of decline would reflect primarily the rate of deposition (fallout), physical decay of I^{131}, and turnover of I^{131} by cattle.

It has been demonstrated in several mammalian species that I^{131} is absorbed only through the gastrointestinal tract (*6, 7*). Thus the thyroid I^{131} levels in cattle reflect only the I^{131} content of their feed and water modified by the rather slow turnover of I^{131} in cattle. The level of I^{131} in cattle thyroids should, therefore, be a very sensitive indicator of the maximum fallout of I^{131} available in the biosphere.

The radiation dose occurring in the thyroid gland of cattle from this test series was computed by the method of Dunning (*8*). The maximum and average doses were, respectively, 1.1 and 0.55 rads per gram of fresh thyroid tissue. Assuming a mean thyroid weight of 34 g (*8*), the mean dose to cattle in Reno from the test series was estimated to be 19 rads and the estimated maximum was 37 rads. These dosages are considerably greater than those reported for cattle during the 1955–56 nuclear tests (*1*). Although no radiation protection standards have been promulgated for cattle, certain comparisons may be made with protection standards for humans. The weights of human and cattle thyroid glands are similar (*9, 10*). The "Radiation Protection Guide" for human thyroids is 1.5 rem per year for individuals and 0.5 rem per year for the population (*11*). The doses computed for Reno cattle resulting from the U.S.S.R. test series were 25 to 40 times greater than these guide figures. Human thyroid I^{131} concentrations have been reported to be only 1/500 as great as those found in cattle (*12*).

The data presented here serve to re-emphasize the suggestion (*13*) that continuous monitoring of thyroid glands from slaughter cattle provides a good index of the biological concentration of airborne radioactive fallout (*14*).

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Genetic Differences among White Leghorn Chicks in Requirements of Arginine

Abstract. Among three strains of the one breed, and among sire families within each strain, there were highly significant differences in ability of chicks to tolerate a deficiency of arginine at ages up to 4 weeks. One of these strains required about 25 percent more arginine than another for maximum growth to that age.

Extreme variability in growth rate of chicks fed diets deficient in arginine has been reported by several investigators (*1, 2*). Hegsted (*3*) found that White Leghorn chicks differ from Barred Plymouth Rocks in quantitative requirement of arginine. The study reported in this paper shows that there are significant differences in the requirement of that amino acid between strains of White Leghorn chickens and among sire families within those strains.

Pedigreed, wing-banded, male chicks from three strains of White Leghorns were grown to 4 weeks of age on diets deficient in arginine. At the end of the experiment, chicks were weighed individually, and average weights were determined for the three strains and for sire families.

The arginine-deficient diet consisted of the following ingredients (in grams per 100 g): casein, 25.00; glucose, 59.75; cellulose, 3.00; corn oil, 4.00; glycine, 1.00; DL-methionine, 0.40; vitamin mixture, 1.22; mineral mixture, 5.63. The vitamin and mineral mixtures were the same as those used by Nesheim *et al.* (*4*).

Twenty unpedigreed male chicks from each strain were placed on a control diet identical to the one just given except that it contained 0.81 percent L-arginine added as L-arginine•HCl to the 0.9 percent already in the casein.

Differences among the three strains at 4 weeks of age were remarkable (Table 1). Chicks of strains A and C did not differ significantly in weights of controls, in reduction of weight on the deficient diet, or in mortality. In striking contrast, among chicks on the deficient diet, mortality was higher and growth poorer in strain B than in both the other strains.

An analysis of variance showed that the differences among the strains in weights at 4 weeks on the deficient diet were highly significant ($P = <.01$). Similarly, comparisons of the number that died in strain B with those dying in strains A and C (using actual numbers in contingency tables rather than the percentages given in Table 1) showed

Table 1. Weights at 4 weeks and mortality to that age in three strains of White Leghorns on a diet deficient in arginine.

Strain	Chicks started (No.)	Av. wt. (g)	Mortality (%)
	Deficient diet		
A	309	147	2.2
B	107	75	18.7
C	172	132	5.2
	Controls		
A	20	293	0
B	20	250	0
C	20	328	0

the mortality in strain B to be significantly higher than in the other two strains at the level: $P = <.001$.

Among the controls, none of which died, it is evident that chicks of strain B grew very slowly in comparison with those of strains A and C. This does not mean that birds of strain B are normally smaller than the others. On the contrary, at 1 year of age, average weights for females are almost 100 g heavier in strain B than in the other two strains. A subsequent experiment (see below) showed that, while the diet for the controls contained ample arginine (1.7 percent) for growth of chicks of strain A, that same amount was below the level needed for normal growth by chicks of strain B.

Apart from the difference between strains in ability to tolerate a deficiency of arginine, additional evidence of genetic variation in that respect was provided by the remarkable differences among sire families, within strains, in ability to grow on the deficient diet. In strain B (the most susceptible), average weights of chicks at 4 weeks ranged in eight sire families from 63 to 92 g. In strain A, average weight was 197 g for one sire family (eight chicks only), 163 for another (36 chicks), and in eight others ranged down to 109 g for one family of 27 chicks. Similar differences occurred in strain C, but the range in eight sire families of that strain was somewhat smaller than in strain A. Analyses of variance showed that within each strain these differences among sire families in weights of surviving chicks were highly significant ($P = <.01$).

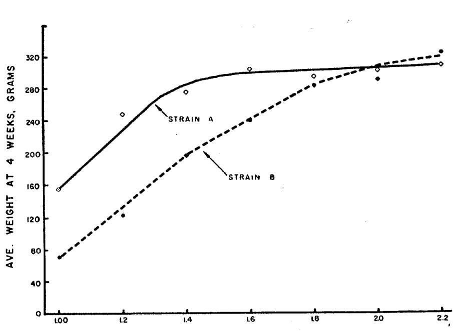

Fig. 1. Average weights of chicks from strains A and B when fed increasing dietary levels of arginine. Each point represents average weight at 4 weeks of three groups of eight chicks each.

An additional experiment was conducted to obtain information on possible differences between two of the strains in quantitative requirements of arginine. Male chicks from strains A and B were fed diets containing varying levels of added L-arginine•HCl. The basal diet used in this experiment was similar to that for the previous one except that casein was increased to 27 percent. The sodium and chlorine contents of all the diets were kept constant by adjustment of NaCl and $NaHCO_3$ as the L-arginine•HCl was increased. Chicks from strains A and B, when fed this experimental diet, differed markedly in their response to added levels of arginine (Fig. 1).

Inspection of the data indicates that about 1.6 percent total dietary arginine allows maximum growth for chicks of strain A, but that probably 2.0 percent or more is necessary for strain B. Based on values published by Block and Bolling (*5*) for casein, the basal diet in this experiment would contain about 1.0 percent arginine. Chicks of strain B thus require approximately 25 percent more dietary arginine (to 4 weeks of age, at least) than chicks of strain A. Snyder *et al.* (*2*) suggested that the requirement for arginine on a diet similar to the one used in this study was about 1.7 percent of the diet.

Strains A, B, and C have all been maintained as closed flocks (that is, without introduction of new blood) for over 26 years. Among the several objectives for which they have been bred, none is directly concerned with rate of growth, and each year (generation) chicks in all three strains have been intermingled and raised on the same diet. No selection for ability to tolerate deficient diets was ever knowingly practised. On the contrary, every effort was made to ensure that the diet was adequate, so that genetic differences in other respects could be fully manifested.

The difference between breeds in requirement of arginine found by Hegsted *et al.* (*3*) was attributed by them to the fact that their White Leghorn chicks grew feathers very rapidly, while their Barred Plymouth Rocks feathered out more slowly. That difference, in turn, results from the action of the sex-linked genes *k* (in Leghorns) and *K* (in the Barred Rocks). As feather proteins have a comparatively high content of arginine (8.0 percent), their interpretation seems valid. In that case, however, the difference between the two breeds in requirement of arginine would be a secondary effect of the *K–k* alleles.

It must be made clear that the chicks in our studies all had the rapid feathering that is characteristic of Leghorns, and all were of the genotype *kk*. No visible differences in rate of feathering have been evident among the three strains. Accordingly, the genetic differences in requirement of arginine found in these studies were independent of rate of feathering, and hence more likely attributable to genes directly concerned with the utilization of arginine.

The facts that there can be such significant differences between strains in requirement of one amino acid, that they can arise without deliberate selection therefor, and remain undetected until revealed by specific tests, all suggest that unsuspected genetic differences in experimental animals may be a fundamental reason for the diverse results sometimes obtained by investigators in different laboratories.

The differences between strain B and the other two strains in requirement of arginine, and the variation among sire families within strains, suggest that by appropriate selection even greater genetic differences might be established in requirement of that amino acid. Evidence that fowls differ genetically in several other nutritional requirements was recently reviewed elsewhere (*6*). Altogether, such variation suggests that it may be possible to breed animals specially adapted for specific nutritional regimens. Exploration of that possibility might permit better use of animal feedstuffs which may not be completely balanced nutritionally for most currently available breeds, strains and individuals among domestic animals.

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