not in equilibrium with the intracellular metabolite pool.

Free asparagine has been demonstrated in mammalian tissues (5) and plasma (6), and it appears to be a regular constituent of proteins (7). Ohno has recently shown (8) that lysozyme has 12 asparaginyl residues and only one aspartyl residue. Despite the wide occurrence of asparagine, little is known of its biosynthesis. Mardashev and Lestrovaya (9), on the basis of experiments with rat liver slices, proposed a transamidation between glutamine and aspartic acid yielding asparagine and glutamic acid, but there is as yet no unequivocal evidence for the proposed reaction. It should be emphasized that the results described in this report offer no clue to the mechanism of transfer of the amide group or to the nature of possible intermediates. They do, however, render it unlikely that asparagine is formed in this system by the direct amidation of aspartic acid by ammonia (10).

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Acquisition of Resistance to Osteolathyrism during Adaptation to Cold

"Crossed resistance" is a condition in which exposure to one agent induces resistance to another agent (1). Analysis has shown that, in most instances, this phenomenon is due to the fact that the stress of exposure to a noxious agent results in a discharge of glucocorticoids which, in their turn, inhibit responsiveness to other agents. It has been shown, for example, that through this mechanism, exposure to stressors (cold, muscular exercise, trauma, and infections) can inhibit the lung edema normally produced by adrenaline, the anaphylactoid reaction usually elicited by egg white or dextran, and many other types of inflammatory responses (2).

Since the thyroid also participates in certain systemic adaptive reactions, it seemed of interest to determine whether an increased endogenous secretion of thyroid hormone could likewise produce a phenomenon of "crossed resistance."

Experimental osteolathyrism is a disease characterized by excessive proliferation and degeneration of bone and junction-cartilage tissue (not to be confused with the clinical lathyrism, which affects the nervous tissue selectively). This skeletal disease, which is usually induced in the rat by treatment with *Lathyrus odoratus* or aminoacetonitrile (AAN), can readily be prevented by thyroxin (3). It is well known, furthermore, that exposure to cold augments the secretion of thyroid hormone. Could this stimulation of the thyroid during adaptation to a low temperature afford protection against intoxication with aminoacetonitrile?

Thirty female Sprague-Dawley rats with a mean initial body weight of 97 g (range 90 to 107 g) were subdivided into three equal groups. Group I was kept at room temperature throughout the experiment. Group II was kept at 0°C during treatment with aminoacetonitrile and group III was kept at 0°C for 10 days before and during aminoacetonitrile treatment. Aminoacetonitrile hydrosulfate was administered to all three groups, by stomach tube, at the daily dose level of 12 mg (6 mg in 0.2 ml of water twice daily). The experiment was terminated after 16 days of aminoacetonitrile treatment. At autopsy the skeleton was examined macroscopically, and one femur of each animal was fixed and simultaneously decalcified in Susa solution for the subsequent histologic examination of paraffin-imbedded sections stained with hematoxylin-eosin.

Mere macroscopic inspection of the bones sufficed to show that all the control animals (group I) had developed severe osteolathyrism, with multiple exostoses at tendon-insertion sites and excessive periosteal bone formation. Only traces of such changes were seen in group II, and none were seen in group III (Fig. 1). Histologic examination of the bones merely confirmed the macroscopic findings.

The histologic structure of the thyroid was essentially normal in group I, while in the two groups exposed to cold, the thyroid showed cellular hypertrophy and hyperplasia.

Since thyroidectomized rats do not withstand exposure to cold, it was impossible to verify the importance of the thyroid gland in the development of this kind of "crossed resistance" by control experiments on thyroidectomized animals. However, we know that small doses of thyroxin can inhibit osteolathyrism, and exposure to cold did, in fact, cause thyroid stimulation under our experimental conditions. Therefore, it appears justifiable to conclude that the resistance to osteolathyrism, which develops during adaptation to cold, is probably the result of an increased secretion of thyroid hormone.

Fig. 1. Femur of AAN-treated rat kept at room temperature (group I) (left) and femur of a rat which had been kept in a refrigerated room during AAN administration (group II) (right). There is intense bone proliferation (especially in the upper two-thirds of the femur) and widening of the junction-cartilage line (in the distal extremity of the bone) under the influence of AAN at room temperature. These changes are inhibited in the rat that had been kept in the cold.

These experiments furnish us with still another example of an experimental disease whose development is decisively influenced by a hormone. They show, furthermore, that the amount and type of hormone normally secreted by the thyroid during adaptation to cold suffices to induce resistance against a severe experimental malady (4).

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10 July 1957

Thorium Content of Stone Meteorites

The abundance and distribution of thorium in many terrestrial rocks and in meteorites have not been well defined, owing to the difficulty of detecting the small amounts of thorium involved, compounded with the problem of contamination by extraneous thorium at such low concentrations. Recent measurements of uranium in meteorites (*1*) have shown lower concentrations than have been generally accepted previously. This has served to renew interest in the companion problem of the concentration of thorium in meteorites, since in dispersed phases in terrestrial rocks, at least, the limited evidence available indicates that thorium and uranium occur in a fixed ratio of about 3 to 4 parts of thorium to 1 part of uranium.

Measurements of thorium in meteorites were undertaken independently at about the same time by one of us (H.A.P.), at the request of H. C. Urey, and by the other two of us (G.L.B. and J.R.H.), using the common technique of neutron activation. It is the purpose of this article to report jointly the collective data now at hand.

Jenkins (*2*) has summarized the analytical difficulties encountered in thorium analysis by means of conventional techniques and has demonstrated the two major advantages of the method of neutron activation—namely, high sensitivity and freedom from effects of reagent contamination during chemical processing after irradiation. However, Jenkins' method is based on radiochemical assay of thorium-233, whose 23-minute half-life requires rapid chemical processing.

The analyses reported here have been based on radiochemical assay of protactinium-233, the 27.4-day daughter of Th^{233}. Ease of chemical processing is greatly enhanced with the longer-lived Pa^{233}. Although the use of Pa^{233} diminishes the sensitivity of the method, owing to the lower specific activity relative to Th^{233}, a further advantage is gained in that the samples may be permitted a cooling-off period of several days, with a substantial reduction of the extraneous activity from short-lived emitters.

Table 1 summarizes the analyses of meteorites completed to date. Samples marked *a* were analyzed by Potratz, using the gross β^- activity of Pa^{233} following irradiation in the boiling-water reactor at Los Alamos; samples designated *b* were analyzed by Bate and Huizenga, using the associated 310-kev γ-activity of Pa^{233} following irradiation in the Argonne CP-5 heavy-water reactor. The methods differed further in the chemical processing techniques followed (*3*). In all cases the thorium concentrations were determined by comparison with the activity of a flux monitor of known thorium content, irradiated simultaneously with the samples.

The data reported generally represent the averages of at least two analyses in each case and are believed to be accurate within 10 percent, including uncertainties attributable to counting statistics. With the exception of Holbrook, the chondrites exhibit a fairly uniform thorium concentration. Although there is no reason to suspect the Holbrook datum on analytical grounds, it should be pointed out that the Holbrook sample consisted of small pebbles and could therefore be more susceptible to thorium contamination before irradiation because of the large surface area involved. The two achondrites show a wide variation of thorium content, which may not be unexpected, since the concentrations of other elements are known to vary widely in achondrites.

Table 1. Thorium in stone meteorites. (*a*) Analysis by Potratz, samples supplied by H. C. Urey. (*b*) Analysis by Bate and Huizenga, samples supplied through cooperation of B. H. Mason, American Museum of Natural History, New York, and of H. H. Nininger, American Meteorite Museum, Sedona, Ariz. (*c*) Uranium concentrations reported by Hamaguchi, Reed, and Turkevich (*1*). (*d*) Patterson (*4*). (*e*) Reasbeck and Mayne (*6*). (*f*) Davis (*5*).

Sample	Thorium concn. (10^{-8} g Th/g sample)		Uranium concn. (10^{-8} g U/g sample)
Chondrites			
Beardsley	4.3 (*b*)		
Forest City	4.0 (*a*)	20 (*d*)	1.0 (*c*)
Forest City	4.7 (*b*)	20 (*d*)	1.0 (*c*)
Holbrook	9.0 (*b*)		1.3 (*c*)
Modoc	4.5 (*a*)	50 (*d*)	1.1 (*c*)
Achondrites			
Johnstown, Colo.	.55 (*b*)		
Nuevo Laredo	54 (*a*)	70 (*d*)	13 (*c*)
Olivine phase of pallasite			
Brenham, Kan.	1.1 (*b*)	5.3 (*e*)	0.69 (*e*) < 0.09 (*f*)

The only meteorite analyzed in common by the two methods is Forest City. The sample portions involved were not identical, and their relationship is not known; hence, a rigorous comparison of the two results is not possible. It may be noted that the thorium contents of Forest City, Modoc, and Nuevo Laredo are considerably smaller than are those computed by Patterson (*4*) to account for measured lead isotopic compositions, as is indicated for comparison in the table. In general, the results shown in Table 1 compare favorably with those for uranium in the same meteorites reported by Hamaguchi, Reed, and Turkevich (*1*), if a thorium-to-uranium ratio of about 4 to 1 is an acceptable criterion for comparison. By the same criterion, our thorium content for Brenham olivine is at least 3 times the value expected from the uranium content found by Davis (*5*) and is about one-fifth of the thorium value (Table 1) reported by Reasbeck and Mayne (*6*).

In contrast with the essentially uniform thorium content of chondrites previously noted, the value of $(39 \pm 8) \times 10^{-8}$ g of thorium per gram of sample, reported by Chackett and coworkers (*7*) for a portion of the chondritic Beddgelert meteorite, is discordant by nearly an order of magnitude. Although the data thus far enumerated are insufficient for extensive generalizations, they indicate that the neutron activation technique gives generally lower thorium values than do conventional nonactivation methods (used for all previous thorium analyses cited in the references). The spread of the data may, of course, be real, attributable to random variations from meteorite to meteorite of the same type or to variations within a given sample caused by statistical distribution of high thorium-bearing inclusions (an effect becoming increasingly pronounced with lower thorium concentrations and with reduced sample size).

If, however, these discrepancies are to be attributed to differences in methods of analysis, then it would appear that either reagent contamination is not yet completely accounted for in conventional nonactivation methods or neutron activation is sensitive to the matrix in which thorium occurs (primarily with reference to differences between the flux monitor and the sample). The latter factor is regarded as a possibility, but it is difficult to conceive of a mechanism to account for a discrimination factor approaching an order of magnitude. In the work at both Argonne and Los Alamos, flux monitors were prepared by introducing a known amount of thorium into a meteorite matrix, which should constitute an ideal flux monitor. This problem is receiving continued study, and as the validity of the method of thorium determination by neutron activation is further established, additional samples will be analyzed thereby (*8*).

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Effects of Gamma Radiation on Collembola Population Growth

Relatively little work has been done on the effects of ionizing radiations on populations, in contrast to the considerable body of work devoted to their effects, physiological and genetic, on individuals. Because of the interest of this laboratory in the disposal of low-level radioactive wastes into the soil, some research emphasis is being placed on radiation effects on populations of different soil arthropods. The Collembola, which are small, primitive, ametabolous, wingless insects, were chosen because they are abundant in soil, where they play a role in the breakdown of organic materials in the biological cycle of soil formation. Also, they are easily reared in the laboratory, have a short life-cycle, and will multiply rapidly. The species used in these studies was *Proisotoma minuta* Tull. (*1*), which is a ubiquitous form, known from North America, Europe, and Australia.

The effects of radiation on population growth rate were examined in these experiments. Increase in population size was measured by bidaily counts of individuals at food points and by counts of total numbers at the termination of the experiment. If the magnitude of the doses used reduced the numbers, this reduction could be construed to be an effect on the future potential of the population. Since certain important internal population parameters, such as age distribution, longevity, and sex ratios, were not known, and since these experiments were carried through only about three generations, only a crude index of the effect on the intrinsic rate of increase can be obtained.

The experiments were started with 61 reproducing population units of ten individuals each. Three doses of gamma radiation from a cobalt-60 source totaling 3000 r, 5000 r, and 7000 r were given in single exposures (at a dose rate of 19 r/sec) to these units. Sixteen replicates were used for each dose level; the remaining 13 were not irradiated. The experiments were terminated after 16 to 30 days, at which time the individuals were sacrificed and counted. At the end of the experiments 42,504 individuals were present.

There was a significant difference ($P = 0.001$) in the total numbers between the control and irradiated populations. The means of the treatments appeared to be linearly related to dose. A negative linear regression was significant at greater than 0.001 probability, while the deviations from linearity were not significant. Means of the bidaily sample counts, with their standard errors, are given in Table 1. Grand means (not shown) were as follows: control, 65.6 ± 6.9; 3000 r, 58.6 ± 5.6; 5000 r, 43.2 ± 3.7; 7000 r, 33.5 ± 2.4. An analysis of variance shows the difference between treatments to be significant; this significance appears to be the result of differences between extremes (controls versus 5000 r and 7000 r; 3000 r versus 7000 r) rather than of differences between adjacent means.

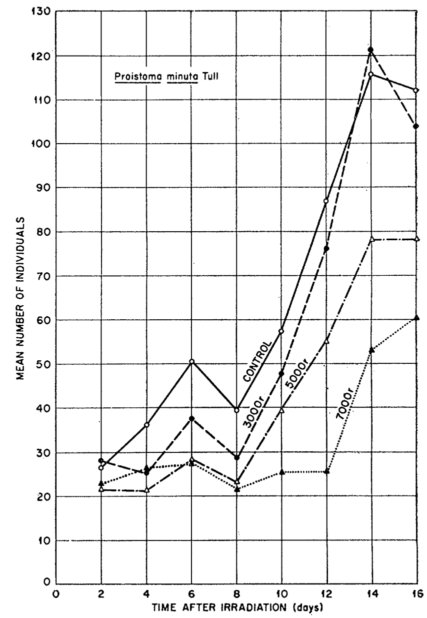

Fig. 1. The effect of acute gamma radiation on growth of Collembola population units as shown by bidaily counts of individuals at feeding points.

The bidaily counts at food points show that all the population units had an initial threshold period followed by the typical phase of exponential growth (Fig. 1). The effect of radiation seems to be chiefly one of lengthening the threshold period. When this lag phase has been passed, the population (with the possible exception of those units given 7000 r) then proceeds to multiply at the control rate. Until asymptotic levels are approached by all experimental cultures, the totals at any sampling point in time prior to reaching plateau reflect the lag effect.

Table 1. Means of sample counts taken every 2 days after irradiation. Shown are means for 2, 4, 6, 8, 10, 12, 14, and 16 days post-irradiation, reading from top to bottom.

Control mean ($N_i = 13$)	3000 r mean ($N_i = 16$)	5000 r mean ($N_i = 16$)	7000 r mean ($N_i = 16$)
26.7 ± 9.7	28.0 ± 7.4	21.5 ± 5.3	23.0 ± 5.0
36.0 ± 7.7	25.2 ± 5.6	21.1 ± 4.5	26.6 ± 5.9
50.6 ± 14.4	37.5 ± 9.5	28.1 ± 5.9	27.5 ± 6.3
39.2 ± 9.9	28.7 ± 5.3	23.1 ± 3.5	21.6 ± 3.2
57.5 ± 12.5	47.8 ± 10.2	39.6 ± 9.4	25.2 ± 4.3
87.0 ± 24.6	76.2 ± 15.6	55.0 ± 11.7	25.8 ± 4.1
115.8 ± 26.4	121.3 ± 23.8	78.1 ± 13.4	53.0 ± 8.5
111.8 ± 25.2	103.8 ± 19.3	78.6 ± 12.9	60.2 ± 8.2

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Note

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