of marsh vegetation into the lake, but the concomitant rise of *Pinus* (dated as 1662 ± 80 years ago, Y-1155) (*8*) may record a southward advance of pine from its major area of distribution in northeastern Minnesota. The sediment of the main core is truncated at the top, but a supplemental core from elsewhere in the marsh shows an abrupt rise in *Ambrosia*-type and in Chenopodiaceae-Amaranthaceae which is probably attributable to the disturbance caused by forest clearance and agriculture in the region.

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22 August 1962

Inhibition of Antigen-Antibody Reactions by Aminocarboxylic Acids

Abstract. Aliphatic aminocarboxylic acids inhibit at least two different antigen-antibody reactions. The degree of inhibition depends upon carbon chain length and the position of the amino group in relation to the carboxyl group.

The solubility in saline solution of macromolecular complexes of deoxyribonucleoprotein is increased when certain aliphatic aminocarboxylic acids are present (*1*). Activity of the compounds which were studied was maximal when the chain contained six carbon atoms and when the amino group was in the terminal (omega) position rather than in the alpha position. We have studied the effects of these compounds on another group of macromolecular complexes, namely those arising from reactions of antigen and antibody.

The first group of experiments was based on a precipitin reaction between crystalline bovine serum albumin and specific rabbit antiserum (*2*). The reaction was carried out at *p*H 7.4 by double diffusion in agar (*3*). The test compounds were added to the reaction

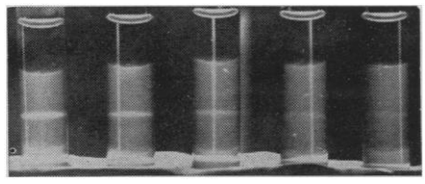

Fig. 1. Influence of ε-aminocaproic acid (0, 0.1, 0.25, 0.5, 1.0*M* concentration) on the precipitin reaction between bovine serum albumin and specific antiserum.

tubes in varying amounts prior to immunodiffusion, and any effect on the final amount of precipitate was noted. Figure 1, a photograph taken on the 8th day of one such experiment, shows that increasing amounts of the aminocarboxylic acid ε-aminocaproic acid caused a progressive inhibition of the antigen-antibody reaction. This is seen as a decrease in the amount of precipitate.

A comparative study was then made of the inhibition of the precipitin reaction by different aminocarboxylic acids. At a final concentration for the amino acid of 1*M*, the relative ability to inhibit was as follows: ε-aminocaproic acid, γ-aminobutyric acid, β-alanine. Glycine and the control, which contained no amino acid, showed no inhibition. ω-Aminocaprylic acid was less inhibitory than ε-aminocaproic acid; α-aminobutyric acid was the same as the control. Maximum inhibition was thus provided by a compound with a six carbon chain where the amino group was in the terminal position.

The second group of experiments was designed to avoid the necessity for a secondary expression, such as precipitation, of the primary union of antigen and antibody. Leucocyte nuclei

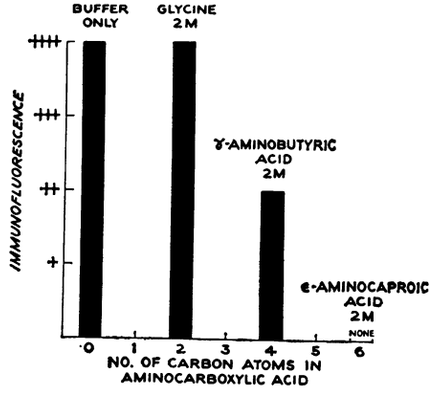

Fig. 2. Influence of certain aminocarboxylic acids on the binding of anti-globulin serum to globulin-coated nuclei.

from normal human blood, which was smeared onto glass slides, were coated with gamma globulin from serum which was drawn from a patient with lupus erythematosus and which was known to contain antibodies to nuclei. The globulin-coated nuclei were then treated with rabbit antihuman globulin which had been conjugated with fluorescein isothiocyanate and examined with a fluorescence microscope (*4*, *5*). The effect of aminocarboxylic acids was studied by incorporating at *p*H 7.4, prior to treatment of the nuclei with the conjugate, varying amounts of these compounds into the fluorescent conjugate and by noting any change in the brilliance of the immunofluorescence. A decrease in fluorescence was interpreted as an inhibition of the fixation of antiglobulin to the globulin-coated nuclei. The fluorescence of the conjugate itself was not lessened by the presence of the test compounds.

A preliminary experiment showed that increasing amounts of ε-aminocaproic acid inhibited the test reaction. At a concentration of 2*M* the reaction was totally inhibited, and this concentration was then used to study the effect of chain length of the aminocarboxylic acids (Fig. 2). Further studies with this method have shown that arginine and lysine are both considerably more inhibitory than ε-aminocaproic acid.

Our studies of nucleoproteins showed that the effect of the aminocarboxylic acids was not related to their activity as salts or chelating agents, and this is also true for the phenomena here reported. The high dielectric activity of the more inhibitory aminocarboxylic acids suggests one possible explanation for their action, but a complete correlation is not yet available (*6*, *7*).

Note added in proof. Since this report was submitted for publication, the work of Gill *et al.* (*7*) has come to our attention. Their studies of synthetic polypeptides suggest that certain amino acids are important as antigenic determinants and that inhibition of reactions between antigen and antibody by amino acids may be due to specific complementary relationships between those amino acids and the antibody or antigen.

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6 July 1962

Fallout Radionuclides in Euphausiids

Abstract. Radioanalyses by gamma-ray spectrometry have been carried out on 37 samples of *Euphausia pacifica* obtained from a network of stations off the Oregon coast. Data on euphausiids taken from this area in November 1961 and in March and April 1962 are compared to show the variation in concentration of zirconium-95 and niobium-95, ruthenium-103, and cerium-141, with time and location. A mixture of zirconium-95 and niobium-95 was the most abundant fission product noted.

A large portion of the radioactive debris from the testing of nuclear devices falls into the ocean. The fission products Zr^{95}, Nb^{95}, Ru^{103}, and Ce^{141} occur in particulate form in sea water (*1*). They are produced in considerable quantity, and result in percentages of 14.6, 12.9, 12.5, and 10.6, respectively, of the total radioactivity from a nuclear detonation 45 days after the blast (*2*). These radionuclides were the principal fallout gamma emitters found in the samples examined in my study. Zinc-65, though ubiquitous in this part of the ocean, is introduced mainly by the Columbia River where it is contained in the effluent from the Hanford, Washington, nuclear reactors (*3*). In general, the gamma-ray spectra of organisms taken near the mouth of the Columbia River showed strong Zn^{65} peaks (*4*), but my research indicates there is no correlation between Zn^{65} and fallout peaks. No additional gamma emitters, other than relatively weak natural potassium-40, were observed in the spectra which extended out to about 3.0 Mev.

Particulate radionuclides tend to be concentrated at the second trophic level (*5*). The euphausiid, *Euphausia pacifica,* is a filter feeder of this level (*6*) and appears to be a good indicator of radioactive fallout in the ocean because it is an effective concentrator of most radionuclides. Euphausiids are the shrimp-like crustaceans (known as "krill" by Norwegian whalers) which comprise the food of certain whales in polar regions. *Euphausia pacifica* is a species found in more temperate waters. Because of its great abundance, its use as forage by many predators, and its extensive diurnal vertical migrations, it is an important vehicle for the transport of radioactivity in the ocean.

The euphausiids were collected at depths ranging from 200 meters to the surface during 30-minute tows with a 6-foot midwater trawl (Isaacs-Kidd). The specimens were preserved in formalin and freeze-dried. After freeze-drying, which gave a weight reduction factor of about 7, gamma spectra were made with the low background anticoincidence instrument (*7*) at General Electric's Hanford Laboratories. Counting time was 30 minutes per sample.

Figure 1 shows the distribution of the three fission products in euphausiids in early November 1961, about 2 months after the beginning of the Russian nuclear tests. The highest concentration occurred 45 miles off Astoria, Oregon. This radioactivity must have crossed the Pacific Ocean in the atmosphere, because the North Pacific Current is too slow to account for its presence at this time. The mixture of Zr^{95} and Nb^{95} in the sample taken 45 miles from the mouth of the river is more than two orders of magnitude greater than that of the sample taken 15 miles from the mouth. Figure 2 shows the virtual disappearance of the "hot spot" by April 1962 and a general lessening of radioactivity. A similar series of measurements made in January 1962 indicates that this change occurred gradually.

Table 1. Results of analyses of two euphausiid samples collected in mid-March 1962. Samples No. 1 and No. 2 were located at 34°19′N, 120°48′W and 32°49′N, 123°54′W, respectively. The lower radioactivity is probably caused by a latitudinal effect in the fallout pattern.

Fission product	Content of sample No. 1 (pc)	Content of sample No. 2 (pc)
Zr^{95}-Nb^{95}	10.6 ± 1.4	8.8 ± 1.3
Ru^{103}	0.2 ± 1.2	0.2 ± 1.2
Ce^{141}	2.3 ± 1.4	3.6 ± 1.4

In general, the amount of Ce^{141} varied directly with the Zr^{95}-Nb^{95}, but Ru^{103} did not show any great fluctuations during the 5-month period covered by these observations.

Two samples of euphausiids taken in California waters in mid-March 1962 were also examined (Table 1). The lower radioactivity which they displayed is probably caused by a latitudinal effect in the fallout pattern.

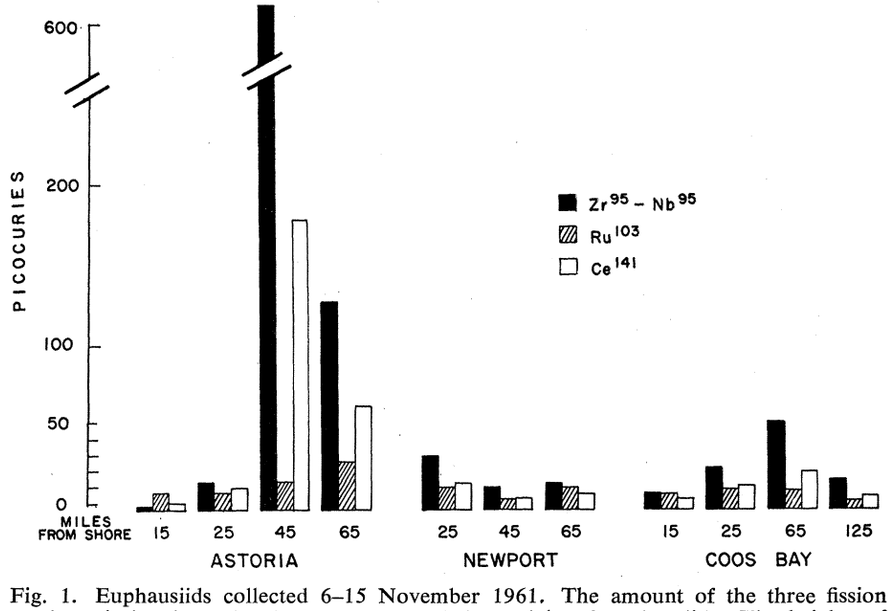

Fig. 1. Euphausiids collected 6–15 November 1961. The amount of the three fission products is in picocuries (pc) per gram of dry weight of euphausiids. The heights of the bars are proportional to the radioactivity, which varies from 2.5 to 618 pc. A wet weight of about 30 g of the sample was the minimum required. The distance from shore is in nautical miles due west from Astoria, Newport, and Coos Bay, Oregon.