was exhausted in tests with other antisera.

Of the mosquitoes studied, *A. communis, A. punctor,* and *A. trichurus* are morphologically closely similar and all lack bands of white scales on the tarsi. Edwards (*8*), in a classification of the subgenus *Ochlerotatus*, placed *A. communis* and *A. punctor* in the same group (Group "G") and *A. trichurus* in an adjacent group (Group "H"). *Aedes excrucians*, although in the same subgenus, has bands of white scales on the tarsi and is readily separated from the other species.

The relationships shown by serological methods are in general agreement with those indicated by comparative morphology. The ease with which the species were distinguished by precipitin tests suggests that there is a wider separation between species than morphological comparisons would indicate. There can be little doubt that certain biochemical or physiological characters are more sensitive indicators of divergence than are morphological structures. Observations on the physiological and behavioral variations in other closely-related groups of mosquitoes support this view (*1*). Serological techniques should prove of value in assessing the interrelationships among various species-complexes in the Culicidae. Studies on groups comprised of autogenous and anautogenous forms would be particularly useful (*9*).

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References and Notes

1. L. E. Rozeboom, and J. B. Kitzmiller, *Ann. Rev. Entomol.* **3**, 231 (1958).
2. C. A. Leone, *Ann. Entomol. Soc. Amer.* **40**, 417 (1947); W. K. Lawlor, thesis, Johns Hopkins University, Baltimore, Md. (1949); A. S. West, R. H. Horwood, T. K. R. Bourns, Anne Hudson, *Ann. Rept. Entomol. Soc. Ontario* **89**, 59 (1959).
3. A. E. R. Downe, and A. S. West, *Can. Entomologist* **86**, 181 (1954).
4. A "Spinco model CP" (Beckman Instruments Inc.) electrophoresis apparatus was used; separations on Schleicher and Schuell No. 470 filter paper.
5. A. E. R. Downe, in preparation.
6. R. L. Libby, *J. Immunol.* **34**, 71 (1938).
7. A. A. Boyden, and R. J. DeFalco, *Physiol. Zool.* **16**, 229 (1943).
8. F. W. Edwards, *Genera Insectorum. Family Culicidae.* Fasc. 194 (P. Wystman, Brussels, 1932).
9. From Ph. D. thesis submitted to the Faculty of Arts and Science, Queen's University, Kingston, Ontario (1961). Supported by half-salary grant from the Entomology Research Institute, Canada Department of Agriculture, Ottawa. The work was also supported by a grant to Professor A. S. West, Queen's University from the U.S. Public Health Service (grant No. AI-01155). I thank Professor West for advice and assistance.

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Yttrium-88 on High-Activity Zirconium-95 Fallout Particles

Abstract. *Yttrium 88 has been identified, by gamma spectroscopy, in residues of grass samples gathered in the neighborhood of the Euratom Research Center, Ispra, Italy. The yttrium-88 is associated with zirconium-95.*

The gamma spectra of samples of grass from the neighborhood of the Euratom Nuclear Center at Ispra showed a photopeak at 1.85 Mev. This peak was observed for the first time when samples were collected for examination during the last week of July and the first week of August 1962.

Because this peak was associated with another at 0.90 Mev, the radiation could be attributed to yttrium-88. This hypothesis was fully confirmed when yttrium (Y) was isolated by chemical methods.

The activity accompanied the yttrium carrier during the various steps of the analysis, which included oxalate precipitations of the rare earths and solvent extraction with tributyl phosphate. The spectrum, measured on 24 August 1962, of hay and the spectrum of the separated Y^{88} are shown in Figs. 1 and 2 respectively.

Because of the difficulties encountered in dissolving the active component, we believed that the activity was concentrated on single particles, the bulk of which might be zirconium oxide. Fusion in mixtures of potassium and sodium carbonate were unsuccessful. The active component was dissolved finally with hydrofluoric and nitric acid.

Other samples were fractionated before chemical treatment with the hope of isolating a single particle that contained all the activity.

With the aid of the gamma spectrometer we separated such a residue, of which the dimensions were less than 0.1 by 0.5 mm, from each of the samples treated. Our work was greatly facilitated by the presence of a combined activity of $(Zr^{95} + Nb^{95})$ which was 10 to 20 times greater than the usual Y^{88} activity encountered.

Figure 3 shows a spectrum obtained with a particle. Other gamma emitters commonly found in fission products are absent. On one occasion only, there was some activity at 0.14 Mev, probably attributable to the isotopes cerium-141 and 144.

The ratio of the activities of $(Zr^{95} + Nb^{95})$ to Y^{88} varies in the rather narrow range of (1 : 10 to 1 : 20). On 1 October the activity of the "hottest" particle was 2000 pc $(Zr^{95} + Nb^{95})$, whereas the other particles all showed half this activity. Although we were not able to identify the particles by microscopy, we succeeded in isolating an active fragment of inorganic material, the diameter of which did not exceed 10 μ.

That local contamination is the source of Y^{88} is not likely for several reasons. There is no experimental work on Y^{88} here, nor does any work at the Center result in production of Y^{88}; none of the devices run for routine control of environmental radioactivity (air monitors, pot samples for fallout and so forth) showed Y^{88} activity; two samples taken at a distance of 75 km from here and in a direction where fallout of airborne

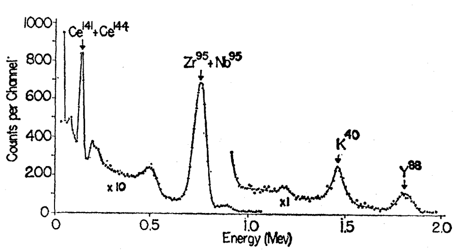

Fig. 1. Spectrum of hay sample, 24 August 1962.

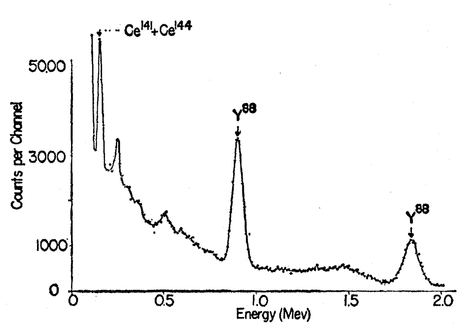

Fig. 2. Spectrum of Y^{88}, separated from hay.

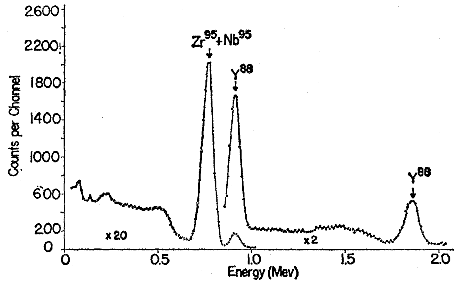

Fig. 3. Spectrum of a particle separated mechanically.

contamination from work at the Center is highly improbable, were contaminated with Y^{88}.

The high specific activity of these particles makes them of interest to the health physicist even if he does not know whether they originated in some new material incorporated in nuclear bombs or in an uncontrolled release from a nuclear establishment.

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Origin of Tektites

Abstract. *A comet of the size recently postulated by H. C. Urey would leave a large crater. It is shown, from aerodynamic theory, from observations of distribution around terrestrial impact craters, and from experimental nuclear explosions, that the observed distribution of tektites cannot be the result of impact on the earth, whether cometary or meteoritic. It is further shown, from aerodynamic theory, from observation of a meteor shower, and from study of the breakup of artificial satellites, that the distribution of tektites can be accounted for as a result of fusion stripping of a satellite, as originally suggested by Suess.*

Urey (*1*) has recently rediscussed the problem of the origin of tektites in the light of new evidence. He shows that it is not reasonable to think of tektites as formed individually by impact at the moon's surface, since in this case the tektites would undoubtedly be scattered more or less uniformly over the surface of the earth, and through at least the Cenozoic strata, which is not observed. We agree with this argument, and we further agree with his opinion that the whole Far Eastern strewnfield, from China to Tasmania, is to be regarded as a single event.

Unfortunately, it appears that his hypothesis of the origin of tektites by cometary impact on the earth contains contradictory elements. On the one hand, it is asserted that the atmosphere arrests the cometary head as it descends, so that the primary effects are not a shock-produced crater in the solid ground, but a mass of heated gas. On the other hand, it is supposed that the tektites produced on the ground by this heated air are not arrested, but rise to the top of the atmosphere with ballistic velocity sufficient to carry them thousands of kilometers.

The laws of aerodynamics do not work this way. It is the small bodies which are stopped by the atmosphere, and the big bodies which get through. The drag pressure is given by

$$p = C_d \, \tfrac{1}{2} \, \rho \, V^2$$

where ρ is the density of the air, V the velocity of the body relative to the air, and C_d the drag coefficient. The drag coefficient is of the order of 1, and will be omitted from the rest of the discussion, since we are aiming at the order of magnitude. If the area of the body is A, and the increment of distance traversed is ds, then the increment of work, dW, is

$$dW = p \, A \, ds = \tfrac{1}{2} \, \rho \, A \, V^2 \, ds$$

When the work done becomes of the order of magnitude of the initial kinetic energy, $\tfrac{1}{2} \, M \, V^2$, (M being the mass of the body), then the body is essentially stopped. Neglecting the variation in velocity, this means

$$\tfrac{1}{2} \, M \, V^2 = \int_{S_1}^{S_2} dW = \tfrac{1}{2} \int_{S_1}^{S_2} \rho \, A \, V^2 \, ds$$

that is,

$$M = A \int_{S_1}^{S_2} \rho \, ds$$

that is, when the mass of the air encountered is equal to the mass of the body. This principle, though not this derivation, was stated to us by F. L. Whipple.

Since a vertical atmospheric column has about 1 kg of mass per square centimeter, it is to be expected that bodies with less than this mass per square centimeter of frontal area will be arrested. In practice, this means that bodies with a diameter less than something like 5 m will be stopped by the atmosphere, and will reach the ground with terminal velocity. Larger bodies will penetrate and will make craters. This expectation is approximately satisfied by the facts about the largest meteorites and the smallest craters.

The general principle at work here can also be derived from Newton's Third Law of the conservation of momentum. Alternatively, from purely dimensional considerations, it is clear that the total drag must increase with the square of the linear dimensions, while the mass, and hence the energy, increase with the cube; hence once more we see that the larger bodies must be the ones which will penetrate, while the smaller bodies will be stopped.

Even if the density of the cometary head is as little as 0.01 g/cm^3, and the diameter is 10 km, as Urey (*2*) has previously suggested, the mass per square centimeter of frontal area will be much greater than that of the atmosphere, and the body will be stopped, not by the atmosphere, but by the earth. The comet postulated by Urey would have an energy of 5×10^{28} ergs.

On the other hand, Shoemaker finds (*3*) that an energy only a little more than the above, namely, 7.5×10^{28} ergs, was required for the formation of the lunar crater Copernicus, 80 km in diameter, with walls 4 km above the floor. Hence we would expect that a conspicuous terrestrial crater would have been formed by the impact which, on Urey's theory, produced the Far Eastern strewnfield. The crater would presumably be nearer the northern end of the field, since the tektites are much more numerous there. It would be marked by a large circular lake. No such lake can be found, however, either in Laos, or in Thailand, or Burma, or Yunnan Province, China. It happens that Yunnan Province is covered by a 1 : 50,000 map series which one of us personally examined during World War II and compared with Army Air Forces astronomical positions. The series is adequate to show a lake of this size, which would, in fact, cover a dozen sheets of the map. The lake is not there.

Urey also considered a comet 70 kilometers in diameter, which would produce a lake 7 times wider. This is excluded a fortiori.

In any case, why a comet? There are nickel-iron spherules in tektites, but no volatiles; hence, one's first guess would be a meteorite. The spherules make it reasonably sure that the impacting body did mix physically with the ground which it struck; then why the mechanism of compressed hot gases to keep the two apart?

Consider next the second postulate of the cometary theory, which it shares with all theories of terrestrial origin, namely, that tektites were melted by impact and then ejected through the atmosphere. The very small mass per square centimeter of frontal area, which