bers of leucocytes accumulate in the lung during acute bacterial pneumonia, it is concluded that intercellular surface phagocytosis causes the destruction of many of the invading organisms, particularly during chemotherapy in the early stages of the disease when specific antibodies are not present to opsonize the bacteria.

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Use of 2,4-D Weed Killers on Woody Weeds in Cuba

KENNETH V. THIMANN

The Biological Laboratories, Harvard University

The problem of eradication of woody perennial weeds is much more serious in the tropics than in temperate zones. In Cuba the most serious weed is the legume *Dichrostachys nutans*, known as *Aroma marabu.* Since this plant regenerates vigorously from cut stumps, its eradication by continued cutting is almost impossible. In experiments carried out at the Atkins Garden and Research Laboratory of Harvard University, at Soledad, Cuba, several preparations and methods of spraying of 2,4-D have been tested on plots of large, well-established plants from cut stumps. Although delayed regeneration is still not entirely excluded, the following approximate figures for apparent kills in 4 weeks have been obtained:

TABLE 1

Treatment	Per cent apparently killed	Per cent probably alive
1. 2,4-D sodium salt, 0.2%....................	18	21
2. The same applied twice, 5 days apart.......	76	8
3. The same, 0.3%, applied once.............	62	8
4. The same, 0.3%, plus Carbowax 1500, 0.5%, applied once..............................	87	1
5. 2,4-D ester, 0.3%, applied once............	94	4

Since the plants die slowly, the percentage kill increases steadily with time, and a number of plants have to be classed as doubtful for a month or more after treatment. On balance, treatment No. 4 was considered the most effective, although No. 5 gave the most rapid defoliation. The volumes used were about 100 gallons/acre.

Plants in the shade were only slightly less affected than those in the sun. Spraying on the underside of the leaves did not increase the toxicity.

Another troublesome plant, *Comocladia dentata* (Guao), having a toxic action on the skin like that of poison ivy, was also studied. In this case the ester preparation ("Weedone") was definitely more effective than either the salt or the free acid, probably because of its better adherence to the vertical glossy leaves, from which aqueous sprays ran off rapidly. A concentration of 0.3 per cent gave about a 75 per cent kill as determined 6 weeks after spraying.

These experiments, which give promise of possible reclamation of land up to now considered virtually unavailable, are being continued.

Note on the Theory of Radiation-induced Lethals in *Drosophila*

U. FANO

National Bureau of Standards, Washington, D. C.

A rather complete theory of induced lethals in *Drosophila* which was proposed by Lea and Catcheside (*5*) has met with objections in private discussions. As this theory is now embodied in a comprehensive book (*4*) (reviewed in *Science*, April 25, p. 454), it may be advisable to publish some comments on the matter.

The frequency of x-ray–induced, sex-linked recessive lethals in *Drosophila* is experimentally known to be accurately proportional to the x-ray dose, at least up to about 5,000 r. The presence among these lethals of a large number which are located at points affected by chromosomal rearrangements creates a well-known difficulty for the interpretation of the dependence of frequency on dose (*2*). If it is simply assumed that this fraction of lethals is a by-product of the rearrangements, the total frequency of recessive lethals should increase faster than in proportion to the dose. Lea and Catcheside made the alternate assumption that the recessive lethals and the rearrangements result independently from a single type of primary effect. This primary lesion, the frequency of which is assumed to be proportional to the dose, may or may not, according to chance, lead to a recessive lethal and/or to a rearrangement. Such a common ancestry accounts for the observed coincidence of recessive lethals with rearrangements. It must also cause, however, a parallel frequent coincidence between the recessive lethals and those rearrangements (e.g. dicentrics) which are unviable ("dominant lethals") and thus escape detection. The latter rearrangements thus make an inroad in the observable recessive lethals, which should become increasingly important with increasing dosage; consequently, the frequency of recessives should increase slower than in proportion to the dose.

This nonlinear effect, embodied in Lea and Catcheside's detailed theory, leads to a very significant discrepancy between this theory and the experimental data. The authors merely discount the discrepancy because they reckon on having overestimated it by an undetermined amount (*5*). It is proposed here to give a minimum estimate of the importance of this discrepancy, using general arguments.

Lea and Catcheside classify the recessive lethals as class A (associated with no rearrangement), class B (associated with a minute rearrangement), and class C (associated with a viable gross rearrangement). This latter kind of rearrangement will be called VGR. We shall also consider class D lethals, *i.e.* those associated with an unviable gross rearrangement (LGR).

The various symbols will be used to indicate the corresponding frequencies, but it should be noted that the frequencies of C's and VGR's *among viable sperms* are, respectively, $C/(1 - LGR)$ and $VGR/(1 - LGR)$. The Lea-Catcheside assumption means that $A + B + C + D$ is proportional to the x-ray dose; the frequency of recessive lethals among viable sperms is $A + B + C/(1 - LGR)$. The departure of these two expressions from one another, which is a measure of the nonlinear effect, can be expressed as:

$$\frac{A + B + C + D}{A + B + C/(1 - LGR)} - 1$$
$$= \frac{D - C\,LGR/(1 - LGR)}{A + B + C/(1 - LGR)} \quad (1)$$
$$= \frac{C/(1 - LGR)}{A + B + C/(1 - LGR)}$$
$$[(D/C)(1 - LGR) - LGR].$$

The first factor in the last expression is the fraction of C's among the observable lethals. The bracketed factor can be reduced by algebraic manipulation to a form involving only the experimentally known frequency $VGR/(1 - LGR)$ and factors on which predictions can be made. These are $p = LGR/VGR$ and

$q = \frac{D}{LGR}/\frac{C}{VGR}$. The quantity (1) can then be written as

$$p\frac{q - VGR/(1 - LGR)}{1 + p\,VGR/(1 - LGR)} \quad \frac{C/(1 - LGR)}{A + B + C/(1 - LGR)}. \quad (2)$$

As stated above, $\frac{C/(1-LGR)}{A + B + C/(1-LGR)}$ and $VGR/(1 - LGR)$ are observable quantities which, at 3,000 r, amount to about 1/3 and 1/5, respectively (*4*). The factor $p = LGR/VGR$ would be 1 if every rearrangement involved only two breaks; since this is not so, p will in general be larger than 1 (*2*) and might be even as large as 2 at 3,000 r. The factor $q = \frac{D}{LGR}/\frac{C}{VGR}$ would also be 1 if VGR's and LGR's had the same chance of being associated with a sex-linked recessive lethal; actually, $q > 1$, since the LGR's are expected to have more breaks, on the average, than the VGR's. The quantity (2) is thus certainly larger than the value found by taking $p = q = 1$, which at 3,000 r would be about 2/9. For $p = 2$, $q = 1$, it would be 8/21.

Therefore, it can be stated that the nonlinear effect amounts to at least 20–25 per cent at 3,000 r. On the assumption that the C lethals are by-products of VGR's the nonlinear effect is $(A + B)/(A + B + C) - 1 = C/(A + B + C) = 1/3$—that is, possibly a somewhat larger one. The Lea-Catcheside theory may thus reduce the nonlinear effect by a factor which amounts to 1.5 at most. The remaining nonlinear effect is probably significantly at variance with the set of experimental data discussed by them. At any rate, it seems quite unlikely that an effect of such quantitative importance could have failed to be detected in all the extensive studies on this subject by so many different workers.

It may well be that the Lea-Catcheside concept of the recessive lethals, as manifestations of the same type of primary lesion which leads to the observable chromosomal breaks, is essentially correct. But the process of x-ray–induced breakage and recombination in *Drosophila* has thus far defied not only a quantitative but even any comprehensive qualitative analysis (*2, 3*). This difficulty may well prevent for the time being any satisfactory account of the relationship between recessive lethals and rearrangements and of their dose-frequency relationships. This same difficulty, incidentally, seems to put the Lea-Catcheside detailed calculation of the dose-frequency relationship for dominant lethals (*4, 5*) on a very doubtful ground, although there seems to be no difficulty with the qualitative understanding of this relationship.

A final remark may be added concerning the recessive lethals (B) associated with minute rearrangements. Lea suggests that the deficiencies involving several salivary chromosome bands are due to separate breakage processes caused by a single ionizing particle, in analogy to the mechanism which he successfully proposed for *Tradescantia*. However, the frequent occurrence of spontaneous lethals involving deficiency of several bands (*1*) suggests that such deficiencies are the outcome of a single primary, probably much more closely localized, lesion. The larger deficiencies up to about 50 bands, and the corresponding minute inversions, are generally accepted to be due to the same mechanism as the VGR's (*4*). Accordingly, a substantial fraction of the class B recessive lethals should have been transferred to class C for the purpose of the calculation carried out in this paper; this would have made the nonlinear effect appear even more important.

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Cosmic Radiocarbon and Natural Radioactivity of Living Matter

A. V. Grosse

Houdry Process Corporation of Pennsylvania, Marcus Hook

W. F. Libby

Institute for Nuclear Studies, University of Chicago

In view of the discovery of radiocarbon produced by cosmic radiation (*1*), it becomes of interest to compare its effect in living matter with that due to the older sources of activity, such as radium and its decay products, or potassium, and to the action of cosmic rays. Since data on humans are most readily available to us, we will limit ourselves here to a comparison *in man*.

This comparison can be made on various bases, such as range, ionizing power, or total energy of the particles. The range varies from the extremely small range of α-particles up to the whole length of the human body for cosmic rays. The ionizing power per unit length varies in reverse order and decreases from the higher value for α-particles to cosmic rays.

As radiochemists, it seems to us that the simplest basis of comparison would be the number of disintegrating atoms (or