is electrophoretically similar to human hemoglobin I.

Since we have not yet compared our two-component hemoglobins with those reported by Kunkel, and because of the differences in electrophoretic methods employed, it is not possible to definitively relate his findings to ours (*10*).

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Loss of Mass in Echo Satellite

We wish to make a correction to our report, "Perturbations of the orbit of the Echo balloon" [*Science* **132**, 1484 (1960)]. In preparing a detailed description of our theoretical method we discovered an error in sign in our expression for the third (and higher) harmonics of the earth's gravitational potential. (We used the coefficients provided by an astronomer, but with the physicists' definition of gravitational potential which, as we now know, is precisely the negative of that used by astronomers.)

According to our published results, the third harmonic caused a decrease in eccentricity of about -3×10^5 per day during the first 12 days after launch. The magnitude of this decrease is approximately one tenth as large as the increase due to solar radiation pressure. However, despite its being so small, it affected significantly our attempt to estimate the reflection properties of the balloon and the rate of its loss in mass due to gas escaping from puncture holes. In order to reconcile the theoretical with the observational changes in eccentricity, we had assumed that the value of KA/M (the product of a scattering constant and the area-to-mass ratio of the balloon, defined in our report) increased substantially from its nominal initial value of 102 cm^2/g.

After correcting the sign in the third (and higher) harmonics, we now find that for the first 12 days the values of KA/M which lead to reasonable agreement with the observed changes in eccentricity are quite close to 102 cm^2/g. For example, by assuming specular reflection ($K = 1$) and a decrease in mass of 0.6 lb/day, our theoretical predictions of the changes in the eccentricity from its initial value agree with changes deduced from observations to within 2 percent at all points. (The corresponding probable errors associated with the data range from 1 to 2 percent, except for the first two days after launch when the absolute changes were quite small.) On the other hand, by assuming specular reflection and no loss in mass, we find that after 12 days the predicted change in eccentricity is 4 percent below the observed change. (With respect to the argument of perigee, close agreement with the data is obtained in both cases.)

These differences between eccentricity changes estimated with an assumed loss in mass of 0.6 lb/day and changes estimated with no loss in mass do not conclusively establish that a detectable amount of gas escaped from Echo during this short period. Other physical phenomena about which little is known (such as variations in the solar constant) could also account for these differences.

Of course, since Echo was launched more than 3 months ago, many more data on its orbit have now accumulated. We find that the assumptions that K equals 1 and that loss in mass is 0 lead to changes in eccentricity which are 10 percent below those observed at the end of this extended period. Hence, it appears reasonably certain that by now Echo has lost a measurable portion of its gas. Preliminary attempts at adjusting the changes in KA/M to obtain close agreement with the data indicate that the rate of loss in mass decreased after Echo entered the earth's shadow.

The rather slow escape of gas from the balloon (slow as compared with the rate predicted by many before launch) may provide valuable information on the micrometeorite environment in the vicinity of Echo's orbit.

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Chromosomal Control of Preferential Pairing in Nicotiana

Abstract. A stock of tobacco with 23 pairs of tobacco chromosomes and one substituted pair from *Nicotiana glutinosa* was available. An amphiploid of this tobacco with *N. tomentosiformis* was synthesized in order to test whether preferential pairing is determined by the homologies of the chromosomes or whether it is under genic control. Characteristically, segregates for duplex loci in *N. tabacum* × *N. tomentosiformis* amphiploids give a gametic output of about 3:1, but for a factor on the substituted chromosome that output was found to be 59:1. The result suggests that preferential pairing in this material is not genically determined.

My co-workers and I (*1*) have used genetical segregation of synthetic amphiploids to measure differential affinity (*2*) of chromosomes. Since in any particular amphiploid the segregation ratios for independent factors were often found to be of similar magnitude, it became desirable to ascertain whether preferential pairing is determined, in our material, by individual chromosome homologies or whether it is under genic control. In the latter case, all chromosome sets of four would exhibit a similar degree of differential affinity, and would give similar genetic ratios, while under the former condition loci on different sets of chromosomes might give very different ratios.

Holmes Samsoun tobacco is an appropriate stock for such a test. In this variety Holmes (*3*) had substituted a pair of chromosomes from taxonomically distant *Nicotiana glutinosa*, which carried a dominant gene for resistance to mosaic disease, for a pair of tobacco chromosomes. The stock has been maintained over the years by selfing, and a recent test proved that it still contained 23 pairs of tobacco chromosomes and one pair from *N. glutinosa* (*4*).

The other parent for the synthetic amphiploid was *N. tomentosiformis*. This species is related to *N. tabacum* and is perhaps the closest living relative of that cultigen (*5*). Amphiploids *N. tabacum* × *N. tomentosiformis* have given consistently very small segregation ratios, indicating a close homology of the chromosomes of the two species and absence of differential affinity.

In general, an amphiploid which has obtained the recessive allele from one of its parent species and the dominant allele from the other may be symbolized as being of the genetic constitution *ZZzz*. If there is no differential affinity, the testcross of such an amphiploid will produce phenotypic ratios lying between 5:1 and 3.7:1, depending on the extent to which double reduction occurs. In *N. tabacum* × *N. tomentosiformis*

Table 1. Segregation of amphiploids *N. tabacum* × *N. tomentosiformis* for mosaic resistance in testcrosses to susceptible tobacco.

Plant No. of amphiploid	Seeds sown (No.)	Necrotic reaction	Mottled reaction	Died
		Amphiploid Holmes Samsoun × N. tomentosiformis		
C 113–4	90	58	0	1
C 113–13	90	33	2	1
C 113–15	180	98	2	1
C 113–23	90	47	0	0
Totals	450	236	4	3
		Amphiploid Burley 21 × N. tomentosiformis		
B 51–9	270	41	0	2

amphiploids, ratios ranging from 2.3:1 to 4.7:1 were obtained for six loci on five different chromosomes. These results did not suggest any differential affinity, though thus far it could not be satisfactorily explained why the ratios were all smaller than 5:1 and mostly even smaller than 3.7:1 (*5*). On the other hand, *N. tabacum* × *N. glutinosa* amphiploids gave ratios of about 80:1 for two independent loci (*6*), which were attributed to the effect of pronounced differential affinity at meiosis.

Thus, the chromosomes of *N. tabacum* and *N. tomentosiformis* appear to be closely homologous while those of *N. glutinosa* differ. The question to be asked is this: will the mosaic resistance factor of Holmes Samsoun give as small a segregation ratio as the other factors in amphiploid *N. tabacum* × *N. tomentosiformis*, or, alternatively, will the *N. glutinosa* chromosomes, in which the resistance factor is located, exhibit a behavior all their own?

To test this problem four amphiploids *N. tabacum* (Holmes Samsoun) × *N. tomentosiformis* were used. They had been produced by the treatment of germinating seedlings for 3 hours with 0.12 percent aqueous colchicine; the seeds came from a single capsule of a cross between Holmes Samsoun tobacco and *N. tomentosiformis*. A fifth amphiploid had been made in the same way with Burley 21 tobacco which carries mosaic resistance in a relatively small *N. glutinosa* segment in a chromosome of *N. tabacum* (*4*). The amphiploids were testcrossed to nonresistant tobacco. When the progeny plants had reached a diameter of approximately 2 in., their leaves were brushed with tobacco mosaic virus suspension. The inoculation was repeated one to several times at weekly intervals until each plant showed clearly either the localized necrotic lesions caused by the presence of the "resistance" factor from *N. glutinosa* or the mottling symptoms with which nonresistant tobacco responds.

The results are shown in Table 1. Out of a total of 240 scored plants, four did not contain the resistance factor—that is, the ratio was 59:1 in the backcross progenies from the Holmes Samsoun × *N. tomentosiformis* amphiploid. Unfortunately, the seed from the backcross of the amphiploid Burley 21 × *N. tomentosiformis* germinated poorly, and only 41 plants were obtained from 270 seeds. All of these had the resistance factor.

The data suggest that the low segregation ratios reported previously (*5*) for amphiploid *N. tabacum* × *N. tomentosiformis* are determined by the individual chromosomes and are not characteristic of the amphiploid per se. The *N. glutinosa* chromosome introduced into the *N. tabacum* complement behaved in a specific manner.

The result obtained from the amphiploid with Burley 21 was perhaps surprising, because here the resistance factor was carried in a chromosome which was in part *N. tabacum*; in a previous paper (*4*) it was suggested that the *N. glutinosa* sector in this interchange chromosome was less than an arm. Yet this chromosome exhibited pronounced differential affinity through the absence of segregation (Table 1, bottom). Because of the small family which was obtained the result could not be exploited quantitatively.

It may be argued that the possibility of genic control of differential affinity has not been disproved. One may propose that the particular *N. glutinosa* chromosome used could have contained a factor with such an effect. Simultaneous segregation for mosaic resistance and some independent factor could be used to test this point. Unfortunately, in the progenies of Holmes Samsoun × *N. tomentosiformis* amphiploids no other segregations could be scored. However, the Burley 21 × *N. tomentosiformis* amphiploid segregated also for the burley (white stem) character as reported elsewhere (*5*) and gave in a testcross 36 green and 16 burley plants. This result was in striking contrast with the 41:0 segregation ratio for mosaic resistance obtained from the same amphiploid but similar to other segregation ratios from *N. tabacum* × *N. tomentosiformis* amphiploids (*5*). Therefore, an association of a gene controlling differential affinity with the resistance factor is unlikely.

Recently a genetic system has been described in hexaploid wheat which effectively suppresses pairing between homeologous chromosomes (*7*). Thus there exists in wheat what amounts to genetically controlled preferential pairing which insures meiotic regularity. Since the subgenomes of *Triticum aestivum* share considerable homologies, such genic control was presumably favored early during the evolution of the species (*8*). In the evolutionary history of *Nicotiana tabacum* such mechanism was not required since amphiploids between species of the ancestral types already exhibit fairly regular bivalent pairing (*9*). The present study did not reveal the existence of genic influences upon preferential pairing; but only genes which reduce its amount could have been discovered in the present experiment—with the exception of the *N. glutinosa* segment in Burley 21 in which genes with the opposite effect could have made their influence felt (*10*).

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On Antimatter and Cosmology

Abstract. A cosmological model based on a gravitational plasma of matter and antimatter is discussed. The antigravitational interaction of matter and antimatter leads to segregation and an expansion of the plasma universe. The expansion time scale is controlled by the aggregation time scale.

There have been speculations recently about the possible large-scale existence of antimatter in the universe and the relation between such postulated existence and physical theory (*1–8*).