wish to make their life's work the sea, it is a description of what to expect. For the student the book is valuable as a preview of the compromises, adjustments, and changes of plans necessitated by the always less than desirable funding, facilities, and personnel. These complications and temporary frustrations quickly eliminate would-be expedition leaders who cannot adjust to flexible planning. The reviewer is indebted to the writer for the enjoyable hours that he spent in reading the book and recommends it to those who wish to become better acquainted with the world of a geologist who goes to sea.

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Le Coefficient de Parenté

The Mathematics of Heredity. GUSTAVE MALÉCOT. Translated from the French edition (Paris, 1948), revised, and edited by Demetrios M. Yermanos. Freeman, San Francisco, 1969. xx + 92 pp., illus. $4.

Most American biologists, myself included, have linguistic shortcomings, and an English version of Malécot's little book is most welcome.

Les Mathématiques de l'Hérédité has been far more influential than its brevity might suggest. It presented a strikingly original approach to inbreeding, relationship, random drift, and population structure. I first encountered the book in the early '50's and well remember the sheer delight that it brought. One consequence of Malécot's work is that a large part of population genetics theory, formerly reserved for advanced courses with statistical prerequisites, can now be included in elementary genetics courses.

The traditional approach to measuring relationship and inbreeding, as developed by Sewall Wright and R. A. Fisher, was by correlation analysis. Malécot, by using judicious definitions, formulated the problem in terms of elementary probability theory, with results of surprising simplicity and clarity. As so often happens in the history of science, Malécot in France and C. W. Cotterman in the United States did the same thing quite independently. They distinguish two ways in which a pair of genes can be identical—that caused by descent from a common ancestral gene and that due to the independent origin of the same allelic state. It is then clear that only the former is enhanced by inbreeding or by reduced population number. Malécot introduced the "coefficient de parenté," defined as the probability that two genes are identical *by descent*, and used this as a measure of the relationship of two individuals from which the genes were chosen. If the two genes are from the same individual this becomes Wright's inbreeding coefficient, or, in Cotterman's terminology, the probability of *autozygosity*.

This is not to say that the correlation approach is passé. It is clearly superior in some problems; for example, a negative inbreeding coefficient has an obvious meaning in terms of correlations, but not in terms of probabilities. To me, it is best to learn the probabilistic methods first and then broaden and enrich one's understanding by adding the correlation interpretation.

In addition to the discussion of inbreeding and relationship, the book gives a very simple and general derivation of the approach to gametic phase ("linkage") equilibrium under random mating. There is another characteristic Malécot innovation—an elegant probabilistic way of deriving the well-known Wright equations for inbreeding effects in a small population. Then comes a treatment of selection, mutation, and migration in a finite population as a stochastic process. Again, Malécot was a leader, this time in formulating the problem as a Markov process and making use of the mathematical theory available for such problems.

Up to this point (p. 64 in the translation) the novelty of the book is mainly in manner of derivation. But the remainder is devoted to the effects of migration and of isolation by distance on genetic relationships. Here Malécot has introduced totally new concepts. Because of their mathematical difficulty they are only beginning to be appreciated and used, but they will probably form the basis for much future work in population structure. The methods have been especially useful in the studies of N. E. Morton on human populations. Some of this work has been extended since the original publication of the book, and a few new results are included in the translation.

Other than these additions, this is a direct translation of the 1948 edition. The translation is very literal, even when the word or construction is awkward in English. One mistranslation that may cause trouble for the reader is in the heading on page 23, which should be "noninbred," rather than "unrelated."

There are a few printing errors. A serious one is on page 28, bottom line. The bracket should be after (1/2), not before; the same error is made at the top of the next page.

I have one more criticism, this time of Malécot rather than the translator. He gives the formula for correlation between two noninbred relatives as

$$r = [\frac{(\varphi + \varphi')}{2} V_g + \varphi\varphi' V_d]/V_t$$

where V_t, V_g, and V_d are the total variance and its genic (additive) and dominance components, and φ and φ' are the identity probabilities for two mutually exclusive pairs of alleles, one member of each pair from each individual. Although this is correct for most relationships likely to be encountered in human populations, it is not sufficient for some more complex relations of the type often found in animal breeding—for example, quadruple half-cousins. Four φ's are required. I prefer in this case Cotterman's formulation of the problem, which gives

$$r = [(k_1 + k_2)V_g + k_2 V_d]/V_t$$

where k_1 and k_2 are the probabilities that the two individuals have one or two genes that are identical by descent. This formula is correct for all noninbred relatives in the absence of epistasis.

I conclude by saying that this translation is most welcome, in fact long overdue. It is a testimony to the influence of the book that many readers will already be familiar with the earlier parts; much of it has gotten into textbooks.

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