FIGURE 1.—Each line represents for a given value of x (indicated at the lower end of each line) the various values of y for the relevant range of Z_1 and Z_2 .

If $Z_1 < Z_2$, the table is read directly to give the appropriate value for x and y .

If $Z_2 > Z_1$, the values of Z_1 and Z_2 are interchanged, x and y are determined directly but the sign of x is reversed.

A RAPID METHOD FOR ANALYSING UNDERLYING VARIATION OF THRESHOLD CHARACTERS INVOLVING ASYMMETRY

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IN a recent article (WHITTEN 1966) I proposed a method for partitioning phenotypic variation into its genetic, environmental, and developmental noise components. The method is restricted to organisms with asymmetrical development but which are normally bilaterally symmetrical. Each side (or organ) is classified on a yes/no basis whether it be presence/absence or normal/abnormal etc. The model, an alternative to probits, permits a fuller analysis of the factors causing phenotypic variation by introducing a component which has been called "developmental noise" (WADDINGTON 1957) "errors in development" (MATHER 1953) or "statistical energy levels" (DE MARINIS 1959). The analysis, unlike probit analysis (SANG 1963) allows comparisons between populations with differing genetic variability.

The rationale of the method has already been outlined (WHITTEN 1966). Since the method may have general application to examples of asymmetrical development, the purpose of this communication is to present a graph which facilitates greatly the estimation of the statistics of the underlying variation.

To illustrate the technique, I will refer to the *witty eye* mutant of *Drosophila melanogaster*. Three phenotypic classes are distinguishable:

(L+) or (+R) = flies with only one eye abnormal

(LR) = flies with both eyes abnormal

(++) = flies with both eyes normal

Let Z_1 = proportion of (++) flies

Z_2 = proportion of (L+) + (+R) flies

Z_3 = proportion of (LR) flies.

It was shown earlier (WHITTEN 1966) that each triplet Z_1 , Z_2 and Z_3 uniquely determines the mean, x , and standard deviation, y , of a variable, ξ , which is related to the probability of an eye developing abnormally. The mean and SD of ξ are determined by genetic and environmental factors (WHITTEN 1967 and in press). A fuller definition of ξ together with reasons for preferring its use, can be found in the previous paper.

Previously it was necessary to determine Z_1 , Z_2 and Z_3 and then refer to a bulky set of tables calculated on a computer to find the appropriate x and y . Figure 1 depicts a family of curves plotted from the set of tables which permits the estimation of x and y quickly and accurately. The rules for using Figure 1 are contained in the legend. The irregularities in the curves for values of y greater

than 4.2 are probably not real. They may represent errors of approximation due to the change from integrals to summations in the computer programme (WHITTEN 1966 Appendix I). These irregularities militate against use of the figure for large values of y . By interpolation one can find the values of x and y for any likely range of Z_1 and Z_2 (since $Z_1 + Z_2 + Z_3 = 1$ it suffices to know the value of Z_1 and Z_2 to determine x and y). If the analysis requires an answer in terms of morphogenetic substance it is necessary to remember that the mean value of morphogenetic substance for a population = x and the standard deviation = $(1 + y^2)^{1/2}$ (WHITTEN 1966).

I am indebted to DR. L. VAN VALEN who suggested representing the tables for measuring the penetrance parameter in graphical form.

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