The Principles of Humane Experimental Technique

W.M.S. Russell and R.L. Burch

CHAPTER 6

REDUCTION

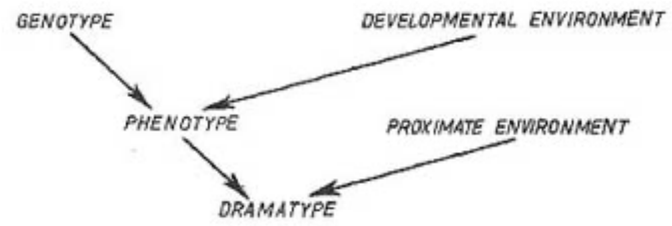
Many laws regulate variation, some few of which can be dimly seen, and will... be briefly discussed.

The Sources of Physiological Variance

Quantitative study of the variation of individual organisms within a species may be said to have begun in earnest with the work of the Danish botanist Johannsen, who gave us the term "gene", "genotype", and "phenotype". His work at the turn of the century on self-fertilized beans showed clearly that much of the variation within any one generation of genetically homogeneous material was not inheritable. By the thirties, the relations between nature and nurture were reasonably well understood in principle (Hogben, 1933). Phenotypic (i.e. directly observable) variation between members of one species results from the interaction of the genotype, or heritable blueprint instructions (Kalmus, 1950), with the environment in which the organism is grown, starting in mammals with the intrauterine environment. Differences in genotype and developmental environment jointly and interactively determine differences in the phenotype.

Most of the early work on intraspecific variation was concerned with stable morphological structures, and it is to these that the phenotype concept chiefly applies. In bioassay, however, we are normally concerned with physiological *response* of relatively brief duration. When examining variation in these, it is convenient to introduce a third concept, the *dramatype.*[1] Variation in the dramatype, or response action pattern, may be said to be determined as shown in Figure 6 (where conventional arrows are used to express the pathways of contribution to variance--Sewall Wright, 1923; cf. Russell *et al,* 1954).

Figure 6. The Determination of the Dramatype



The diagram shows the relations between certain variables. It is a "path diagram." That is, the arrows represent causal relations. Variation in the system at the back end of an arrow contributes to the variance of the system at the front end.

Differences in genotype combine interactively with differences in early, developmental environment to determine phenotypic variation between individual animals. In homely terms, when two animals differ phenotypically, the difference is a joint product of their differential nature and nurture.

By phenotypic variation, we now mean variation in respect of "the end-products of cellular activity, as expressed in relatively stable anatomical structures" (Chance, 1956). As a result of differential nature and nurture, animals vary in such properties as the shape of their skulls, the color of their coats, or the more permanent properties of their physiological mechanisms.

By the dramatype we mean the pattern of performance in a single physiological *response* of short duration relative to the animal's lifetime; for instance, the reaction to a hormone of its target organ, or the reaction of the whole organism to a poison. Variation in such responses is, in its turn, the joint product of two factors. One is the phenotype itself. The other is the *proximate* or immediate environment in which the response is elicited. Dramatypic variation thus depends on the animal's more stable properties, phenotypically determined, and on the environmental conditions in which these are expressed in action.

If we wish fully to control the variance of physiological responses, we must therefore proceed as follows. First, we must control the phenotype, and this in turn may be done by *breeding methods* together with influence on the environmental conditions *in which the animals are reared.* Second, we must control the environmental conditions *in which the animals are tested.*

The distinction between proximate and developmental environment must not be overdrawn, but it provides a useful broad division of subject-matter. For simplification, we may say that the phenotype is established at sexual maturity. Or (with Chance, 1956b) we may contrast variation in "the end-products of cellular activity, as expressed in relatively stable anatomical structures" (the phenotype) on one hand, with variation in potentialities of organs or tissues and the rate of cellular activity on the other (dramatype, to which the proximate environment will also contribute). There are certainly overlaps; we may usefully study all three determining factors at work on sexual immature animals, and even such solid processes as bone growth may be influenced by environmental factors acting long after sexual maturity. But in principle we may distinguish the developmental environment as that which directly interacts with genetic factors, while the proximate environment plays upon the combined system, as shown in the diagram (cf. here Hahn, 1956).

A further distinction can be made among environmental factors. We can distinguish those acting via transmission of messages to the central nervous system on one hand, and all others (e.g. diet and infections) on the other. The latter are sometimes misleadingly called "physical" factors--all factors are of course physical. Nor can we distinguish simply between information and energy flow, for a vitamin or a poison is primarily a carrier of information in the technical sense. But the use of the term "physical" in the restricted sense is so common that we may reasonably retain it, and distinguish in this sense between physical and *behavioral* factors. The importance of the latter for dramatypic variation will be obvious enough from Chapter 1. Among behavioral factors, we may further distinguish social and nonsocial ones.

We shall begin our survey with the phenotype. As Chance indicates, this refers to relatively stable structures, whose variation contributes part of the variance to physiological responses. Rapid developments have occurred recently in this field. They are of considerable general historical interest, and they are seen by most workers to have profound implications for laboratory practice.

[1]Strictly, this should be called "dramatotype", but consistency and euphony may sometimes be allowed to prevail over etymological good manners.