the closed system, and at $r = 0$ for the open system; we see that the values obtained are in agreement.

Note added in proof. Dr. Hl. de Vries, Groningen, suggests an improvement of the optical arrangement. Our formula (3) applies only to a plane perpendicular to the capillary axis; in a vertical plane through the axis, the correction reads simply

$$r = r_0 - n_w m.$$

Our method will therefore suffer from a certain astigmatism, causing an inaccuracy in the determination of the height of the particles in the lower parts of the capillary. The obvious remedy is the use of a slit (perpendicular or parallel to the capillary axis) as a source of light.

[1] *J. Chim. phys.*, **23**, 209, 226 (1926).
[2] de Kadt, *Koll. Chem.*, Beihefte **32**, 294 (1931).
[3] *J. Phys. Chem.*, **40**, 399 (1936).

QUANTITATIVE INHERITANCE

A COLLOQUIUM on quantitative inheritance was held under the auspices of the Agricultural Research Council in the Institute of Animal Genetics, Edinburgh, during April 4–6. The meeting was designed to elicit critical discussion of the approach to problems of multifactorial inheritance, and the variety of papers and vigorous discussion amply fulfilled its purpose.

Prof. Sewall Wright opened the meeting with a wide-ranging historical account of the growth of the concepts used in the study of quantitative inheritance, and outlined the various levels—from primary gene action to organised patterns—at which experimental work could be carried out. He emphasized the vast gap between speculation and certainty in these complex genetic situations. The familiar assumption of additive gene action may be less applicable than is currently supposed. He presented statistical methods of estimating numbers of effective factors from crosses between extreme strains on various assumptions about the magnitude of their individual effect. In a second paper he illustrated many of these concepts from his extensive data derived from guinea pigs. In particular, he stressed the need for suitable scale transformation where possible, although many cases of untransformable interaction have arisen in his work—particularly with coat colour.

Considering the subject from the embryological point of view, Prof. C. H. Waddington emphasized the self-regulating properties of the organism and the need for linking the purely genetic concepts of gene segregation with the functional activity of genes in producing a highly differentiated animal or plant. It is helpful to consider the gene-controlled processes as canalized in development; barriers to organic change can be thought of in terms of sharpness of the canalization, and it might be possible to alter this experimentally by introducing striking mutants or altering the environment. Provided the developmental process concerned is thereby influenced, selection might be made more effective.

Dr. Cecil Gordon presented an analysis of a series of mutant lines inbred by Timofeeff-Ressovsky. The lines differ characteristically in the variability of exhibition of the mutants and raise the question of how to treat this variability in crosses. It may be necessary to develop new statistical methods to cope with differing sensitivity of genotypes to the same range of environmental conditions, in place of the current manner of estimating the portion of the observed variance due to environmental conditions. In a second paper, he described the types of allele, extremely sensitive to both genetic and environmental conditions, revealed by inbreeding wild populations, and suggested that the importance of such 'bad' genes has been grossly underrated.

The next speaker, Prof. K. Mather, described the detailed analysis of a replicated experiment with *Nicotiana rustica*, designed to analyse the observed variance in height and flowering time, from F_2, F_3 and backcross data derived from a wide cross. He presented data for two consecutive seasons with widely differing weather conditions and showed there was a considerable genotype-environment interaction —a factor of importance in practical plant-breeding work.

Prof. J. B. S. Haldane described types of genetic variation likely to be found in natural populations. These can be considered under such headings as: genes that are more or less neutral with respect to selection; transient genes, that is, alleles on their way to fixation or elimination; clinal genes, originating via migration from centres differing in gene frequency; mutation; selection of heterozygotes, due to their greater fitness; opposite effects of genes on the two sexes; cases where the selective value of a genotype depends on the genetic constitution of the rest of the population, as in some of the blood groups; and, finally, equilibrium due to differences in direction of selection in zygote and gamete. He quoted various examples and emphasized the need for experimental work designed to assess the relative importance of these possibilities.

Data relating to human characters were presented by Prof. L. Penrose, which suggest that there is a tendency for the variability of parents to be less than that of their progeny. It is conceivable that parents tend to come from the central region of the total distribution. He suggested several genetic models which might account for stability of such a phenomenon.

Dr. B. Woolf thought that under-estimation of the importance of the environment largely accounts for the discrepancy between response to selection and observed heritability in animal breeding. He quoted examples, in illustration, and warned against the danger of misinterpretation of statistical analysis.

In referring to his work with the inheritance of seed weight in the castor-oil plant, Dr. S. C. Harland said that variation in such characters can be roughly assigned to three categories: cases where clearly identifiable genes with relatively big effects are responsible; those where modifiers are relatively much more important; and, finally, those where it is quite impossible to identify particular genes. The work referred to comes into the last-mentioned group.

Mr. A. Robertson derived an expression for the rate of genetic improvement in an animal-breeding programme in terms of the possible selection and the heritability of the character concerned. He applied this method to the results of selection actually practised by dairy cattle breeders and showed that the probable rate of genetic improvement is of the order of three gallons a year.

An analysis of the variation in milk yield, both within and between herds, was presented by Dr. J. M. Rendel. From a sample drawn from the highest-yielding herds available, he concluded that only thirty per cent of the variation within herds is genetic in origin. The variation between herds is more difficult to assess, but, from cases where the same bulls have been used in herds at greatly different levels of yield, it seems likely that the greater part of the differences have been due to management.

In reports by Dr. E. C. R. Reeve and Dr. F. W. Robertson on different aspects of their work on the inheritance of body size in *Drosophila*, the former dealt with the study of a strain selected for large size, and the latter with the estimation of differences between chromosomes from different selected strains. One strain which had long failed to respond to selection, in spite of retaining a very high heritability, has been subjected to a detailed biometrical analysis. Different genetic models were discussed to explain the results of selection on size and on the genetic correlation between wing and thorax length. Apparent lethals in the third chromosome were very sensitive to genetic background. A chromosome assay technique was used for comparing the effects on size of individual chromosomes from a number of selected lines against different genetic backgrounds. Use of such independent estimates to forecast the size of various genotypes revealed some striking non-additive interactions between chromosomes, particularly when more than one chromosome set was heterozygous.

Dr. Cavalli gave a description of experiments designed to estimate components of variation attributable to linkage in crosses between strains of *Drosophila* selected for high and low bristle number. These demonstrated the comparative inefficiency of second-degree statistics based on F_2 and F_3 data. He presented a theoretical treatment of the contribution of linkage of varying degree.

The effects of selecting mice on an unrestricted and a restricted diet for large size at six weeks were then described by Dr. D. Falconer. Size increased in both lines. When both lines were tested on the same diet, the low-plane mice grew almost as big as the high-plane mice on the good diet, and bigger than high-plane mice on the poor diet. It was suggested that different physiological characters had been selected in the two lines.

In summing up, Prof. Haldane expressed the thanks of the guests for such a stimulating meeting. He commented that a number of workers in the Institute of Animal Genetics are engaged on both fundamental studies and practical animal-breeding research—an excellent way of linking theory and practice. He directed attention to the urgent need for more detailed experimental work and touched on the gap between biochemical research in genetics and studies of quantitative inheritance. He concluded that new statistical methods may have to be fashioned as experimental work grows.

SCIENTIFIC DEVELOPMENT AND INDUSTRY

A SERIES of articles by the scientific correspondent of the *Financial Times*, published in June 1948, entitled "The Neglect of Science", are worth recalling in connexion with the current debate on technological education. The first of these, dealing with science and industry, reviews the causes of the technological backwardness of much of British industry, due to the belief of industry that there was no urgent need of new developments, and the consequent exclusion of the scientific workers from executive or administrative responsibility and the neglect of research. The functions of an industrial research laboratory are discussed in the second article, where the importance of scientific representation at the highest level is stressed. The shortage of scientific workers makes it difficult to expand research; and it is stated that a contributing factor is the loss to other countries such as the United States of first-class technologists to take up, for example, high industrial positions. On the whole, the kind of education offered to potential scientific workers by the universities is regarded as satisfactory. The real shortcomings are in the field of technical education, and, discussing this question, the third article urges the building of at least two institutions like the institutes of technology at Zurich and Massachusetts, of full university status and demanding high standards. This is suggested as a very worthy object for Marshall Aid; but it is recognized that in some subjects it would be necessary to obtain teachers from abroad. The view is taken that attempts to patch the present system of technological education in Britain would be fatal.

In a subsequent series of articles entitled "A Scientist Looks at America", published in the *Financial Times* last January, reference is made to the concern of scientific men in the United States about the secrecy regulations imposed in connexion with atomic energy work, and about the high proportion of the money spent on research which is drawn from military sources. The article quotes from a statement issued by the American Chemical Society urging a revised approach not only towards secrecy but also towards other questions of policy, and maintains that the false notion that secrecy means security may lead to possible destruction. Scientific opinion is against the view that government funds for science in general should be distributed by the military, even if at present the distribution is very fair. A second article, dealing with the relations between science and industry, comments on the growing strength of American industry and the advantage the United States has reaped, particularly in theoretical physics, from the absorption of large numbers of the scientific men and engineers expelled from Central Europe, and especially Germany, since 1933. The main weakness in the scientific side of American life is in fundamental science, and it is suggested that conditions of life in the United States may conduce in future, as in the past, to American dependence on European workers for fundamental ideas; it is thus a serious matter for Europe as well as for the United States that European scientific workers seem increasingly to desire to settle in America. Americans themselves, like Dr. K. T. Compton, are anxious to see European science restored to its pre-war vigour; but apart from the much smaller economic units in Europe there are other factors to be considered. In spite of brilliant individualists, the French, for example, have fallen back in most technical fields where a scientific background and team-work are essential; and reviewing the significant lessons for Britain in the light of American experience, the concluding article reiterates the plea put forward in 1948 that the most important step required to make British industry competitive is reform of technological education. For this the full support of industry is essential. An improvement in the position of scientific workers is also required if full efficiency is to be achieved and migration to America checked.