The second objective consists in a device for adequate indexing and abstracting of all publications in order to lighten the burden upon the investigator who is finding the literature problem an overwhelming one. For many persons the difficulty in acquiring a working knowledge of what has already been done in the field is so great as to occupy his whole time to the exclusion of opportunity for original effort. There is no really sound reason why the duplication of effort in searching out all relevant material in the literature should be imposed upon every investigator in the field. I trust the time will never arrive when indexing and cataloging will be so perfect that an investigator will have to do no foraging on his own account; but there could be an enormous improvement in our existing workaday routine methods without danger of losing the opportunity for individual ingenuity in literary searches.

The third objective is to provide a mechanism whereby a library may, with a reasonable budget, maintain itself as an adequate working tool for investigators using it. Two changes seem to be indicated in order to bring about needed improvement in this line. The cost of publishing scientific material must be reduced. The expensive methods of printing and illustration must, it seems, give way to less expensive, yet entirely adequate, methods of reproduction. Scientific literature has a very limited distribution and the expense of type setting and engraving is not warranted, either from the point of view of the necessity for perfection and permanence, or from the economic angle. With the perfection of such methods as photolithography which lend themselves to the problem of inexpensive reproduction in limited editions, there seems no longer any necessity for the continuance of the time-honored methods.

Furthermore, the journal method itself is open to serious criticism as the most desirable means for publishing scientific results. A volume of a journal may contain anywhere from a single to two hundred separate and distinct publications. There are many so-called border line journals which contain infrequently very important contributions to investigators in a particular field. A working library can not afford to be without those contributions, neither can it afford to pay for the printing and distribution of all the irrelevant matter in order to provide itself with the small part which is really necessary. There are some journals whose entire content is useful in particular libraries. There seems to be no question but that a larger number of libraries could be completely stocked with substantially all relevant publications in particular fields if those publications were available as separata instead of being available only in connection with large quantities of irrelevant material.

In order to bring about these desired ends, it is suggested that an organization such as the National Academy of Sciences undertake the problem of supervising the publication of all scientific material in this country. Similar bodies might function in other countries. The academy would serve as a clearing house and depository for original documents. Once every two weeks a list of all titles, including a condensed abstract of each manuscript, would be sent to every contributing library, carefully and completely indexed as to the content of each paper. Each library would then indicate which papers it desired for its files in the form of separata. A lithoprinting would be made, the cost of each publication being determined by the number of requests received for it. The cost of reproduction would be low, and sale of copies after the first issue could probably be counted upon to provide most of the funds necessary for the abstracting and indexing service. It is estimated that several million dollars a year are spent for the purchase of strictly scientific periodicals in the United States. It is not hard to imagine a system whereby this project could be successfully handled with an expenditure considerably less than is necessary at present.

Difficulties arise in the fact that there would be handicaps during the establishment of any system so radically different from the existing one. A duplication of effort in attempting to keep two systems working would be uneconomical and prohibitive from that angle unless some endowed organization or governmental agency could undertake to carry such a project through the first few difficult years.

It is suggested that the American scientific societies consider these problems in their annual meetings, or appoint committees to work jointly in considering a general scheme.

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BIOLOGICAL VARIATION vs. ERRORS IN MEASUREMENT

MEASUREMENTS are made with instruments which differ greatly in precision. On the one hand, there are relatively accurate determinations, like weight and length. On the other, there are elusive estimates of color and quality, together with the difficult kinds of laboratory measurements typified by the settling method for estimating the sizes of particles in the soil. The investigator is under the unfortunate necessity of including the variation in his measurements with the variation of the entity measured. Frequently the former is trivial in comparison with the latter. However, in new experimental practises and new laboratory techniques the relative magnitudes of the two kinds of variation may well be subjected to a critical test. If there are taken at least two independent observations on each individual, the method of analysis of variance[1] furnishes a convenient mode of testing the relation. Two examples are presented below.

Stark[2] investigated the relation between hardiness of apple varieties and the percentage of unfrozen water in shoots of one season's growth. The data were secured from fifteen varieties during each of eleven months. In each month the shoots from one variety were mixed and subjected to a temperature of $-20°$ C. From the composite sample two determinations of unfrozen water were made by the heat-of-fusion method. How much of the observed variation may be attributed to the heat-of-fusion technique of measurement, and how much to the biological differences in the samples? The analysis of variance is as given in Table 1.

TABLE 1

Source of variation	Degrees of freedom	Mean square
Within composite samples	165	70
Between means of months	10	40,463
Between means of varieties	14	1,429
Month-variety interactions	140	203

It is assumed that the mean square for interactions is a valid estimate of experimental error.[3] If so, it may be further assumed that this mean square is the result of the addition of two estimates of variance: (i) that due to errors of measurement by the heat-of-fusion method, designated by V_M, and (ii) that associated with the biological variation in percentage of unfrozen water, V_B. The value of V_M is given directly by the mean square "within composite samples"; that is, $V_M = 70$. Hence,

$$2\ V_B + 70 = 203,$$

and therefore, $V_B = 66$. The conclusion is that the errors of measurement and the biological sources of variation in this experiment are almost equally represented in experimental error. So long as the former are so great, any increase of precision may well be sought in the improvement of the technique of measurement as well as in replication of the composite samples.

Smith and Brown[4] measured the percentage of carbon dioxide in the soil air at three positions in each of six 14 by 56 foot experimental plots on Carrington loam. At each position determinations were made in triplicate. The analysis of variance is shown in Table 2.

TABLE 2

Source of variation	Degrees of freedom	Mean square
Within positions	36	3.68
Between plot means	5	760.15
Between positions within plots	12	63.11

It may be assumed that the mean square "between positions within plots" is the sum of variances attributable to (i) errors in measuring the percentage of carbon dioxide in the soil air at each determination, $V_M = 3.68$; and (ii) variation in the concentration of carbon dioxide from one position to another in the plot, V_B. Then,

$$3\ V_B + 3.68 = 63.11,$$

from which, $V_B = 19.81$. This indicates a fairly satisfactory method of measurement. Increased precision in experiments of this kind lies in replication of the plots, accompanied by such experimental designs as will enable the investigator to separate from experimental error the natural variation among the plots.

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[1] R. A. Fisher, "Statistical Methods for Research Workers," Oliver and Boyd, Edinburgh, 1932; George W. Snedecor, "Calculation and Interpretation of Analysis of Variance and Covariance," Collegiate Press, Inc., Ames, 1934.

[2] Arvil L. Stark, "Unfrozen Water in Apple Shoots as Related to their Winter Hardiness," a thesis submitted for the degree of doctor of philosophy, Iowa State College, 1934.

[3] George W. Snedecor, *loc. cit.*, pages 45–47.

[4] F. B. Smith and P. E. Brown, "The Concentration of Carbon Dioxide in the Soil Air under Various Crops and in Fallow Soils," *Iowa State College Journal of Science*, 8: 1–16, 1933.

POLYEMBRYONY IN THE DOMESTIC FOWL

COMPLETE monovular twins and even triplets are occasionally found among chick embryos. Incomplete posterior or anterior duplications are more frequent. Quantitative data on the incidence of duplication appear to be lacking.

During the years 1929–1933, inclusive, a large number of incubated eggs of known history have been broken incident to hatchability studies at the U. S. Animal Husbandry Experiment Farm, Beltsville, Md. Eggs containing embryos which had died during the first week of development were broken on the seventh day of incubation. Those dying later and the hatched chicks were examined on the fourteenth day or at the close of the incubation period. All embryos which