first contact with Drosophila, which he and his pupils subsequently studied with such intensity and magnificent success.

Woodworth was thus the prime mover in what Sturtevant and Beadle in their recent text-book of genetics call "the domestication of Drosophila by Woodworth and by Castle in 1901," which in the work of their successors has had such tremendous scientific consequences. Dr. Castle has checked over this communication.

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QUOTATIONS

SCIENCE AND THE MORAL ORDER

IN spite of its claims and accomplishments science is to-day under sharp attack. The growing public realization that its powerful tools can be used for man's enslavement and destruction has given rise to bitter questions and charges; and we read to-day of "civilization betrayed by science" and of "a degraded science that shirks the spiritual issues and hypnotizes its victims with its millions of gadgets." In this hour of intellectual confusion and moral chaos the social consequence of science have been brought to the fore, and the question is persistently asked: Are these consequences so important, because of technical applications that the social interest is paramount over intellectual interest? Are there too many nations and too many people everywhere using the instruments of a civilization they have not achieved? Are bigger telescopes and cyclotrons needed in a world like this?

It would be presumptuous to attempt an answer to this question in a few brief paragraphs even if the writer were especially competent to make any answer at all. The question arises, of course, because science as a technique for gaining understanding of nature is also a technique for gaining control over nature—that is, it is a technique for gaining power. And power can be used by evil men to do evil even more obviously and dramatically that it can be used by men of good will to do good.

But this is true of many things in life. Sulfanilamide, perhaps the most amazing development of modern medical science, came from the German dye industry, but so did mustard gas. Exactly the same principles of physics are employed to point a 500-ton telescope at a star and a 15-inch naval gun at its target. Language is a powerful tool which can be used to mirror spiritual insight or to spread false and destructive propaganda. The possibility of misuse is not an argument for no use at all.

However, this point of view would scarcely justify science in dissociating itself from considerations of value and purpose. The disavowal of concern with social ends would seem to be a callous and irresponsible way to defend science against the charge that it provides man with forces which outstrip his powers of control. Such a defense in fact arises from too narrow a view of science. For science is more than the technologies which cluster about it—more than its inventions and gadgets. It is even more than the discovery and correlation of new facts. Science is a method, a confidence and a faith. It is a method of controlled and rechecked observations and experiments, objectively recorded with absolute honesty. It is a confidence that truth is discoverable. It is a faith that truth is worth discovering.

The contribution which this aspect of science can make to human problems is too often overlooked. Science has developed a specialized set of mental procedures and a noble tradition concerning their use. Confronted by a problem, the scientist begins by sorting out the pertinent factors. He discards the irrelevant, testing relevancy as critically and dispassionately as possible. Then with the relevant material in front of him he begins the painstaking tasks of describing, classifying, discovering correlations, constructing hypotheses, experimentally testing, discarding or adjusting these hypotheses—and extending them to new fields. It is of the essence of this whole process that he should suspend judgment until ponderable evidence is at hand, that he should continually reexamine underlying theories and definitions, that he should be prepared to abandon a position however attractive it may be, that he should be sanely skeptical of conclusions and that he should maintain complete dispassionate intellectual honesty.

Surely a technique of this kind has some meaning in the confused issues which we are now facing. We can scarcely afford to declare a moratorium on this kind of intellectual objectivity. It has undeniable social serviceability. It can create what John Dewey calls "a new morale," a new approach to the solution of the difficulties which now overwhelm us. It can be a nourishing atmosphere for the development of a factual outlook, of a healthy and flexible skepticism, of a disposition to seek for the causes of things and of objectivity and tolerance in the appraisal of evidence. As Professor Dewey says: "The future of democracy is allied with the spread of the scientific attitude. It is the sole guarantee against wholesale misleading by propaganda. More important still, it is the only assurance of the possibility of a public opinion intelligent enough to meet present social problems."

In giving expression to this faith one would wish to

guard against excessive optimism. Measurement and accuracy by themselves do not touch even the fringe of social questions. Human relations can not be reduced to mathematical formulae or deterministic sequences. Knowledge of facts does not tell us what to do about them. The social sciences can successfully copy some of the techniques of the physical sciences, but ahead of us is the long difficult road, through trial and error, toward goals of social organization and control that lie obscured on the far horizon.

But science at least furnishes us a lead. Its methods teach patience; it stands for detachment and suspended judgment; it emphasizes the value of imagination and doubt; in a world of emotion and passion it shows us what the weighing of evidence means. That its by-products have created an unbelievably complex tangle of human ordering beyond our present means of guidance can scarcely be denied; but as a pattern of intelligence it still furnishes us the hope of deeper understanding and insight, and perhaps of some ultimate solutions.—*Dr. Raymond B. Fosdick, president of the Rockefeller Foundation, in his review for 1940.*

SCIENTIFIC BOOKS

SCIENTIFIC COMPUTATION

Punched Card Methods in Scientific Computation. By W. J. ECKERT. ix + 135 pp. Published by the Thomas J. Watson Astronomical Computing Bureau, Columbia University. 1940. $2.00.

BEFORE the beginning of the seventeenth century all scientific computations, no matter how intricate, were carried out by the slow and laborious method that the schoolboy still uses in doing his home work. The invention of logarithms by Napier in 1614 and the publication of convenient logarithmic tables by Briggs soon thereafter were the first powerful expedient to lighten the labor of computing. During the three centuries that followed mathematicians aimed to transform their formulae so that they would be adapted to logarithmic tables, and a great variety of such tables were published. At the end of the nineteenth century came the development in practical and inexpensive form of the multiplying machine, and this constitutes the second great advance. For some kinds of computing these machines offer advantages over logarithms, especially since the publication of many convenient tables of the natural (instead of logarithmic) functions. A third great advance is the invention by Hollerith of the punched card method with which the present book by Dr. Eckert deals. This was applied by Hollerith to the United States Census where it was used to great advantage in tabulating and sorting according to various arrangements millions of cards. Recently the International Business Machines Company, which has acquired the rights to the Hollerith machines, has developed among others one that is capable of doing multiplication and this has greatly widened the scope of this method and made it especially serviceable in astronomy.

The cards to be punched are very thin and measure 19 by 8 cm. They contain 80 columns of 12 spaces each, one space for each digit and two extra ones for the algebraic signs and for special purposes. As the cards are run through the machines electrical contacts are made through the punched holes and electrical impulses are brought to a switch-board which distributes them according to the nature of the problem. It is possible to add or subtract two or more quantities that have been punched on the cards, to multiply them or to dispose of them in a number of other different ways. The most recent machines are capable of performing in this way operations like the following:

$$\pm A \pm B \pm C \pm D \pm E \pm F \pm G$$
$$A \pm (B \pm C \pm D)\ E \pm (F \pm G \pm H)\ I \pm J$$

The results of these operations either appear as punches in other columns on the card or are printed on the face of the card.

Recently, Thomas J. Watson, who is president of the International Business Machines Company, has set up at Columbia University, under the direction of Dr. Eckert, an astronomical computing bureau to which has been generously contributed the free use of a complete battery of these machines. This has enabled the bureau to undertake several large pieces of work: the numerical vertification of Brown's lunar theory; the computation of standard places on Yale photographic plates, starting with the right ascensions and declinations of several hundred thousand stars; planetary perturbations, and so on. Dr. Eckert describes in detail how each of these problems was attacked, and this makes very useful reading for one who is contemplating a large piece of computation. Ordinarily it does not pay to use the punched-card method for a small or even a moderately large piece of work. Time is consumed in adapting the data to the machines, and more time is spent in adjusting the switchboards to the problem in hand. But if the problem is extensive enough the saving may be very great. Thus, for example, the cost of verifying Brown's lunar theory at the Watson Astronomical Computing Bureau was at most one tenth of that of doing it by the ordinary methods.

Dr. Eckert has done science a valuable service in