My dear Dr. ————:

Your very kind favor of April 3 to hand.

I am sorry that your position on the question of evolution is such as to make it impossible for me to recommend you for election to the Chair of Biology. Personally I hold you in high regard.

With very best wishes, I remain,

Yours most cordially,

————, President.

SCIENTIFIC BOOKS

The Biology of Population Growth. By RAYMOND PEARL. Alfred A. Knopf, New York, 1925. pp. 260.

THAT the growth of populations, whether they be of yeast cells, flies, rats or men, has a biological basis is a fact of elementary knowledge, but the essence of Professor Pearl's thesis in his latest contribution is that the *principal* factor in the numerical growth of peoples within modern times is the fundamental biological process of "multiplication of cells by successive division of existing cells."

Present-day discussions of population questions, although usually admitting the soundness of Malthus' arithmetic, have been concerned mainly with various conditions of a more or less temporary character, with the results of man's inventions and "victories over nature," and with the possible influence of "social self-control." Professor Pearl, after long study of the matter from the viewpoint of the biologist, is convinced that these, "the complexities of human behavior, social organization, economic structure and political activity, seem to alter much less than would be expected the results of the operation of those biological forces which basically determine the course of the growth of populations of men, as well as those of yeast cells and . . . flies" (p. 18). In developing his thesis he indulges in no quaint notion of society such as Lester F. Ward propounded a generation ago; society does not have to be regarded as an organism to obey biological laws. "It is the normal natural increase," he says quite simply, "the steady excess of births over deaths—which fundamentally determines the form of the population curve" (p. 18). The proposition that even in such an era as this we can not get away from the most elementary biological fact in accounting for the course of human population challenges keenest interest.

His development of this theme is reading of a fascinating kind. One is loath to attempt to summarize it or to consider it critically in a brief review. For his argument, with a wealth of detail and a refreshing originality of presentation, hangs together so well that it would be unfair to consider it except in its entirety. Only a brief outline is essayed here, with a word or two of comment ventured now and then upon some particular point, as a pardonable reaction to a most stimulating book.

There is general familiarity among students of biology in its broader aspects and of the population question with the previous work of Professor Pearl and his collaborator, Professor Reed, on the mathematical expression of the course of population growth by the curve of the general type—

$$y = d + \frac{k}{1 + e^{a_1 x + a_2 x^2 + a_3 x^3 \ldots a_n x^n}}$$

which is commonly referred to as the logistic or "growth" curve. In the present treatise these earlier studies are reviewed and somewhat amplified, particularly on *drosophila* and human populations. Probably the most interesting addendum is that in which he makes use of the vital statistics of the indigenous native population of Algeria. In this instance he believes he has found a human population "which has in the 75 years of recorded census history practically completed a cycle of growth along the logistic curve" (p. 208). The data relating to the Algerian instance are considered *in extenso* and can not be summarized here, but its chief significance, as Professor Pearl points out, lies in the facts that during this period the trend of the birth-rate was unaffected by contraceptive methods, and that the death-rate was unaffected by public health measures. The recorded census histories of other peoples, although some of them cover a longer period of time, yielded only fragments of the curve of growth; here, apparently, was one so nearly complete that it could be used as a fairly good demonstration of the human fitness, as it were, of the mathematical expression. There will be no lack of sympathy with the author in the difficulties of his search for census materials of the kind that he needs for his purpose, since dependable enumerations obtained at regular intervals over a long enough period are hard to find. He has undoubtedly done the best that can be done with the Algerian records, and I confess an envy of his ingenuity in dealing with rather unsatisfactory material, for it is not as satisfactory as could be desired. The impression left is not wholly convincing, so far as the indigenous natives of Algeria are concerned, not only because of the material but also because one wonders how, even if birth and death rates were left untampered with, so complete a cycle of population growth could have been accomplished in so short a time as seventy-five years in any human population. At least, this point does not seem to have been made perfectly clear to the non-biological reader. This, in the light of the manifestly important considerations

which he treats of in the second part of his book, *viz.*, the biological causes influencing the *shape* of the logistic curve.

For, obviously, this is the crux of the question. To engage in the pastime of fitting curves to data of this kind or even to find that they fit, yields nothing more conclusive than argument by analogy in favor of the existence of a hypothesized law, a truism not always fully realized by those who apparently are fonder of their mathematics than their facts. But, characteristically, Professor Pearl has not stopped here, and in following his research beyond this point one can appreciate something of the admiration felt by his students and his associates for his courage in tackling elusive and difficult problems.

That part of the curve of population growth in which we naturally are most interested is the latter half of it, where the curve is "damped off," as it were. The first part of the curve, whether as a whole it describes a complete history of a population's growth or only a single cycle, is easier to understand: it is a form of progression that can be visualized when we think of an excess of births over deaths, of an increasing number of parents, an increasing progeny, and so on. The question of intriguing interest is, what are the factors that arrest the accelerating upward course of the growth and finally bend it until it reaches the asymtote? In fact, we may even leave the actual attainment of this level out of consideration for the present, since we do not know that it actually has been reached or will soon be reached in the history of human populations and concern ourselves with the more immediate reasons why the curve bends at all. To the biological phases of this question the author has addressed the latter part of his inquiry.

The first biological fact he considers in this connection is the inverse correlation of fertility, or the rate of reproduction, with density of population. His prior experiments with *drosophila* are reviewed in some detail and attention is called to the similarity of the equation expressing this association of density with fertility to that expressing Farr's law relating human death-rate to density—a similarity which is logically reasonable because "death and reproduction are both fundamental and antithetical biological phenomena." But in the case of *drosophila* something more than mere overcrowding and the attendant struggle of the fittest is shown to bring about a lowered rate of reproduction, for the astute observation is made that fertility lessened before there was any actual overcrowding, food, temperature and other conditions supposedly having been held constant. Professor Pearl's observations a decade ago upon the fertility of hens confined in quarters having different amounts of floor space pointed to the same phenomenon. "Apparently there is an effect," he concludes, "upon the physiological processes of reproduction resulting from the keeping of large numbers of individuals together in a confined area or space, even though the amount of space or area *per individual* is identically the same in the larger crowds of individuals as in the smaller crowds" (p. 145). In carrying this inquiry into the realm of human populations, he is fully aware of the imperfections of the statistical material relating to density as well as the factors which modify the meaning of the term density when applied to population. Space here does not permit a discussion of the data employed or of his scrutiny of the limitations, and the result only may be stated. By the statistical method of partial correlation he finds that the net coefficient using cities having a population of twenty-five thousand or over in the United States, between the births per one thousand women of the ages fifteen to forty-four and persons per acre holding constant size of populations, per capita wealth, percentage of population age eighteen to twenty attending school, and persons per dwelling, to be $-.175 \pm .057$, a result which he takes to indicate a relation "of the same character fundamentally as that we have found in experimental populations of flies and hens" (p. 155). To those who are accustomed to placing dependence upon coefficients of a higher order of magnitude and bearing a higher ratio to the probable error, when using statistical material of this kind, this result may not be wholly convincing. The extreme variableness of the birth rate from year to year in the small city suggests itself as one weakness in the data, as he has used the birth-rates for only a single year. Professor Pearl, referring to the more positive results for flies and hens, interprets the smallness of the relationship thus indicated as "merely an expression of the fact that human life is in many ways far more complex than that of lower animals" (p. 155). Yet it must be confessed that the doubt intrudes itself, in view of the complexity of human life, that a coefficient of this order can be interpreted with any great satisfaction one way or the other, or, if more factors were held constant, the indication itself might not be changed. This is a question of opinion, however, since it involves not the statistical method but the material in the analysis of which the method is applied.

The second biological consideration he brings forward is the negative correlation of the birth rate with wealth, an observation frequently made by his predecessors, but which he supports by interesting statistical evidence from American data in the form of a net correlation coefficient of $-.615 \pm 0.086$ between the birth-rates for native-born white women in 1920 with the estimated per capita value of all property in

1922 in the different states. Although he admits that he is "certainly no violent environmentalist," he vigorously combats the deduction from this correlation that "somehow high fertility in a group is *in itself* an indication of probable racial unfitness." On the contrary he submits the interpretation that a lessened birth-rate tends to accompany increase in wealth, although he places emphasis upon the consideration that other factors than economic ones are involved.

From this point, the reader is logically led into a discussion of human behavior and the birth rate, which is original not only because the data relating to normal sex behavior are new but also because of the author's implications. His presentation of the data is in the nature of a report upon a study still in progress and he warns against too sweeping conclusions. After an extremely painstaking statistical analysis the material so far collected is interpreted as pointing to a lessened frequency of sexual activity as "the intellectual content of life" becomes "more varied and interesting," an indication which receives support from further statistical evidence pointing to a smaller mean total progeny of men engaged in professional pursuits as compared with that of men engaged in pursuits less intellectual in character. To put it very crudely, the curve is "damped off" not only as a population lives in crowds, and tends to get above the poverty line, but also as it gets away from physical labor and occupations concerned with material matters and becomes more and more engaged in intellectual interests.

These are very stimulating conclusions not merely because they suggest, as the author says, further research at many points, but because of their "humanistic implications." Professor Pearl yields for a few pages only to the temptation to discuss them, but what he says is distinctly worth reading. As it may be inferred, his research has not made him gloomy in his outlook. Population will continue to increase, and the growth in population will very probably lead to wars, but it will not "inevitably increase the general wretchedness of human life apart from wars." In support of this optimistic view, he points to the facts that although we have gone a considerable way in the present cycle of growth, squalor, wretchedness and general unhappiness have not increased; that there is going on an orderly evolution of knowledge of how to control and use natural processes and, finally, that the human race is adaptively responsive to population pressure. To the modern adherent of the "inevitable misery doctrine" who is genuinely interested in an open-minded approach to the population problem Professor Pearl's contribution is to be recommended. No commendation is necessary to those who are conversant with the quality of his scientific work or with the vigor of his writing.

EDGAR SYDENSTRICKER

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN AUTOMATIC THERMOREGULATOR, DEPENDING ON THE FLOW OF WARMED LIQUID[1]

THE following device has proved useful for maintaining a constant temperature in saline solutions that could not be heated by a direct flame; for instance, in the method described by Sollmann and Rademaekers[2] for studying exposed intestines of living animals in a saline bath formed from the abdominal walls, it is necessary to keep the bath at strictly body temperature, and this is done by adding saline solution, warmed to 55°, at a proper rate. This regulation requires a great deal of attention, and this was the immediate occasion for the construction of an automatic flow-thermoregulator. A toluene thermoregulator (I, in the figure), which is inserted in the bath, controls the admission of air and therefore the discharge of warmed saline from a Mariotte bottle (II).

The thermoregulator (I) consists of a glass tube (T) filled with toluene. The lower end of this is bent into a coil (C) which is immersed in the bath. The upper end of the tube is bent into a U, which is filled with mercury (M), with a setscrew (S), by which the level of the mercury can be regulated, as in an ordinary toluol thermoregulator. The tube above the mercury is somewhat expanded with an opening (O) blown in one side about 1 cm above the level of the mercury. The neck of the tube bears a stopper, perforated by a smaller tube, which ends just above the mercury and which is connected with the tube of the Mariotte bottle (II). The latter is maintained at a fairly uniform temperature in an ordinary water bath.

The level of the mercury is adjusted so that it is below (X) when the temperature in the abdominal pouch falls below 38° C., air then passes through (O) in the direction of the arrows into the Mariotte bottle, and the hot saline flows from the tip (P) into the pouch. As the temperature in the pouch rises, the mercury expands, closes X and shuts off the supply of air and therefore the flow from the Mariotte bottle.

W. F. VON OETTINGEN

WESTERN RESERVE UNIVERSITY

SPECIAL ARTICLES

NEW TERMS IN THE SPECTRA OF ZINC AND MERCURY

WE have recently reported (*Nature*, December 26, 1925) a pp′ group in the arc spectrum of zinc. This multiplet is similar to the one found by Ruark in the arc spectrum of cadmium in that it consists of four

[1] From the Department of Pharmacology, School of Medicine, Western Reserve University.

[2] T. Sollmann and A. Rademaekers, "Investigations on Saline Catharties," *Trs. int. d. Pharmacodyn. et de Thér.*, XXXI. 39, 1925.