the result; for the detailed reasoning one must consult Fisher's original papers. To Karl Pearson, the great contributor of many important advances in probability and statistics and builder of the science of biometry upon the foundation of Galton, his master, it must be a source of genuine satisfaction, as he nears three score years and ten, to see near at hand so able a disciple as Fisher, an Elisha, who as so often in the history of science, is embroidering, and maybe patching up a bit, the mantle of Elijah ere it falls upon him.

It is interesting to note that the methods of fitting by moments and of estimating goodness of fit by X^2 are logically inconsistent.[4] This may be seen most easily on the zeroth moment which is the total number N of the observations. Let F be the observed frequencies and y the fitted values and let us consider for convenience the actual fit in the intervals tabulated —a discontinuous problem instead of the continuous problems—graduation only instead of graduation plus interpolation.

$$X^2 = \Sigma \frac{(F-y)^2}{y} = \Sigma \frac{F^2}{y} - 2\,\Sigma F + \Sigma y = \Sigma \frac{F^2}{y} - N$$

if we take $\Sigma y = N$. Suppose however that after making this fit we adjust the values of y to new values Z by applying a factor c so that $Z = cy$ and $\Sigma Z = cN$.

$$X^2 = \Sigma \frac{F^2}{Z} - 2\Sigma F + \Sigma Z = \Sigma \frac{F^2}{cy} - 2N + cN$$

The minimum value of X^2_Z will not be given by $c = 1$ but, differentiating, by

$$-\left(\Sigma \frac{F^2}{y}\right)\frac{1}{c^2} + N = 0 \quad \text{or by } c = \sqrt{\Sigma \frac{F^2}{Ny}} > 1$$

$$X^2 = N(c^2 - 1), \qquad X^2_Z = 2N(c-1)$$

The factor c and the change in X^2 are

$$c = \sqrt{1 + X^2/N}, \qquad X^2 - X^2_Z = N(c-1)^2$$

If X^2/N is well below 1, the results simplify to

$$c = 1 + X^2/2N, \qquad X^2 - X^2_Z = X^4/4N$$

and $\Sigma Z = cN$ becomes $N + X^2/2$. In the case above we should have a better fit by taking the total number of observations not as the actual number 234 but as $234 + 7 = 241$, but the improvement in X^2 would not be great. (However, the fit at the two extremes is so bad, small as are the actual numbers of cases, that X^2 if rigorously computed would obtain from the single observation in the 0–19 interval the value 427 which would make c about 1.7 and $X^2 - X^2_Z = 117$ or $X^2_Z = 327$, a great reduction, but still indicative of a very bad fit. Moreover, a change of N from 234 to about 400 is ridiculous, and although X^2 is thereby reduced the fit by any intuitive judgment is far worse.)

From such a simple consideration as this we obtain light on the significance of the X^2 test and yet more upon its limitations which are these: It is not a perfect abstract test but depends on the judgment of the person who uses it in respect both to the details of its arithmetic computation and to its interpretation as a criterion of goodness of fit; it is merely one factor, and a somewhat subjective factor, in aiding the investigator to make up his mind as to whether an attained fit is good enough or not. In the three cases of infant mortalities above mentioned my judgment based largely on graphical evidence and somewhat on a knowledge of the unreliability of the reported figures is that the simple solution I have given is as good as any reasonable person can ask, and this judgment is to my way of thinking not in the slightest called in question, but rather corroborated, by the application of the X^2 test. Many of the criteria of statistics are likewise of this loose character, they are not precisely mathematical truths as statistical criteria no matter how exact they may be as theorems in probability—and no other situation is useful or possible. For this reason I am not interested in a five-figure table of X^2, presumably two significant figures are all that are significant. It is so with many other matters and because it is I prefer that my students should not so much indulge by rote in elaborate but insignificant arithmetic as to form correct judgments by right of sound understanding. It is for this reason that I lament the low intellectual level of books and courses in statistics. It means too much of one kind of mathematics, too little of another kind.

EDWIN B. WILSON
HARVARD SCHOOL OF PUBLIC HEALTH

[4] Puristically speaking. A minimum problem determines its own criteria. Practically, if the fit is efficient (R. A. Fisher), the inconsistency is insignificant. If for simplicity I make so bold as to test the zeroth moment I should perhaps point out that ordinarily the number of observations N is not taken to be a disposable or fittable constant and that the theory of the X^2 test and the tabulated values of X^2 seem to depend somewhat on regarding N as given. Yet in some actuarial practices N is not preserved in the fitted graduation, it is not preserved by the ordinary least squares fit except when the type of fitted function y is of a restricted sort, and there seems to be no reason why a method of fitting appropriate to the theory of sampling might not be developed which should leave N disposable.

THE IMPORTANCE OF BIOLOGY FOR MANKIND[1]

PERMIT me to begin my short address by expressing my great joy to take part in such an important event

[1] Address delivered at the dedication of the new Charles Rebstock Biology Hall of Washington University, St. Louis, November 10, 1927.

for science as the dedication of Rebstock Biology Hall. This event seems to me to be an especially joyful one. I came to this country from Europe only a few weeks ago, where the interest in biological science is abating. The biological laboratories are not frequented in Europe, and one can not dream of founding there new biological institutions, where scientific work could be maintained in a proper manner. It is, therefore, especially joyful that the merits of biology are recognized in this country; and in St. Louis, the name of which has been recently so often repeated by the whole world, a new temple of science arises, devoted to the propagation of biological knowledge.

Biology, including as it does the study of both plants and animals, represents the only basis on which many sciences necessary for mankind are built. In order to avoid the transformation of medicine, agriculture and other applied sciences into quackery and primitive housekeeping their base must be made firm. All success of these sciences depends now only upon the further development of biology. And when their results do not satisfy us sometimes, the cause of this helplessness lies only in an insufficient or not quite correct development of biology. Let us, for instance, regard the cause of the well-known failure to successfully combat such an important and extended disease as cancer.

Our present medical treatment is mostly based on a cardinal principle of biology confirmed by Pasteur, that a spontaneous birth of living beings from dead material is impossible not only in reference to higher organisms but also to bacteria. As many diseases prove to be of a bacterial origin, one supposes usually that all diseases must be produced by microorganisms, though they could not be found in some important and even contagious diseases, as, for instance, in variola or smallpox and scarlet fever. Therefore sometimes cancer is supposed to be produced also by microorganisms. But on the other hand it could only be shown that bacteria can sometimes produce this disease, but it can also be brought about by other organisms and by some poisonous substances. As at the same time some observations have shown that cancer may be hereditary it is very probable that the cause of this disease lies in the organism itself. As is known, cancer consists in an uncommonly luxuriant growth of the epithelic tissue, of the skin, in such a luxuriant growth that the other tissues and even organs are deadened and destroyed thereby. It is evident that we shall only then understand the cause of cancer when we know the phenomena of growth. But what is growth? It is an elementary phenomenon of life, a necessary property of living matter filling those small parts of an organism which are called cells.

It may seem perhaps somewhat incomprehensible that on the occasion of the dedication of a new biological institution a botanist lectures on diseases. But elementary phenomena of life are appropriate to all living cells independently, whether they are plant or animal cells. At the same time only the study of these elementary phenomena of life will permit us to discover the cause of cancer.

I have chosen as an example the case of cancer, but not only this disease, but all the physiological and pathological phenomena of plants and animals depend upon the properties of the living contents of cells. All these processes are carried on in their contents, that is: in protoplasm and nucleus. Therefore in order to direct physiological and pathological processes we must know first of all the properties of protoplasm and nucleus, the properties of living matter.

This thesis has been recognized by a great number of physiologists and physicians, and we see towards the beginning of this century two new branches of biology arise, the so-called cytology and physiology of the cell, which have now hundreds of followers. One of these branches endeavors to study the form and shape of various formations which have been found in the cells of animals or plants. The other branch studies their physical and chemical structure, and physiological properties. Although both these sciences arose not more than 30 years ago, their discoveries are already very important, and it would be no great fault if we predicted that the future of biology will depend upon the progress of these sciences.

More than a hundred years ago chemistry experienced an analogical process of methodical transformation. Thanks to the introduction of quantitative analysis chemistry was able to study the molecules and the change of their structure. The chemistry of substances became the chemistry of molecules and the chemical reactions became quite clear; they proved to be only a consequence of the atomic structure of molecules. The success of the new ideas was so great already at the beginning of the nineteenth century that hundreds of organic and inorganic substances were artificially obtained, and among them such substances as have become so necessary for industry, medicine and agriculture.

Cells play such a part in biology as molecules in chemistry. The atoms are analogous to the formations and structures we find in cells. And since biology studies these formations and structures we could predict its further progress.

But living matter consists of chemical substances. And we see that cell physiology transforms itself by degrees into the chemistry and physics of cells. The chemical composition of the principal substances of living matter is now established, and the following step of the chemistry of cells will be the artificial production of these substances.

The chemical and physical investigations of cells have explained to us the phenomena of diseases and death. The principal substances of living matter have proved to be so very inconstant as to be compared with explosive substances, which explode very easily, that is: they disintegrate into their component parts. They explode by a blow, by heat, by strong light, by the action of various chemical reagents, which react on their component parts. And accordingly the principal substances of living matter could be very easily destroyed by analogical agents: by a blow, by heat, by strong light, by the action of various chemical reagents, which react on their component parts. Therefore the study of explosive substances could help us to learn the properties of living matter. In order to combat against illnesses and diseases we must make the principal substances of living matter constant, so that they would not be so easily destroyed and would not lead living matter and organisms to death. But how can we make them constant? The study of explosive substances shows that the introduction of some chemically indifferent substances, for instance, narcotics, into liquid explosive substances, as for example into nitroglycerin, abolishes their explosive properties. It is sufficient to add only five per cent. of aceton to nitroglycerin to make it quite inexplosive. Accordingly, the introduction of like substances into living matter diminishes its sensibility to injurious influences. But whilst narcotic substances are really indifferent to explosive substances, they are not so in reference to the principal substances of living matter, because these substances contain proteins, which are destroyed by narcotics, and after a short excitement an injurious and dangerous effect is produced and makes living matter more sensible than before. But if we could find such a harmless narcotic substance which would not destroy proteins we could make our living matter constant and in this manner abolish illnesses and diseases. On the other hand, the study of the chemical composition of living matter in bacteria shows that this living matter differs from the living matter of animals and men. We can therefore expect that there are chemical substances which would destroy the principal substances of living matter in bacteria but would not destroy them in man. Therefore the time will certainly come when all harmful bacteria and the diseases produced by them will be expelled from earth forever, and it depends upon us to accelerate the coming of such a time. I am delighted to be able to predict it, and I hope that biology will be able to widen its ways, and to bring near this happy time. The foundation of this new institution proves to me that my hope is not in vain, and that this great country will help biology to display all its manifold powers. Therefore permit me to finish this speech by exclaiming: Long live biology!

W. W. LEPESCHKIN

SCIENTIFIC EVENTS

THE SOUTH AFRICAN STATION OF THE HARVARD OBSERVATORY

WITH the recent purchase of a permanent site on which the South African station of the Harvard Observatory will be erected, the work of erecting the plant has just begun, it is announced by Dr. Harlow Shapley, director of the Harvard Observatory. The site is on top of one of the "kopjes" located outside of the city of Mazelsport, which is fourteen miles from Bloemfontein, Orange Free State, South Africa. Building material, equipment and the instruments which will be used have been arriving in the city since July 1, 1927, when the astronomers first began activities there.

Until the new buildings are completed, the temporary station, which has been operated for some time, will continue to be used. Dr. J. S. Paraskevopoulos, who has been recently appointed assistant professor, and his wife are now in charge of the work of the temporary plant, and two of the four telescopes that are now in Mazelsport, with lenses of ten and eight inches, respectively, are in operation every night.

Cooperating with the Harvard authorities in the erection of the new station, the city of Mazelsport has constructed recently a new highway leading to the top of the hill on which the observatory will be located. When completed, the plant will include a group of buildings consisting of residences, office buildings, laboratories, work shops and garages.

When fully in operation the observatory will house more operating telescopes than any astronomical plant in the world. With three 60-inch telescopes, the observatory will be outclassed in the power of its equipment by only three institutions.

To secure a constant series of photographic plates of the various stars in the Milky Way will be the principal function of the observatory. Studies of these plates, Dr. Shapley states, will have considerable bearing on the knowledge of the size of the universe. The plates will be mailed to the observatory in Cambridge to be studied and filed away in their proper classification.

W. F. Waterfield, of the Cambridge Observatory staff, will leave within a few months to take charge of the final placing of the instruments. Dr. Shapley intends to visit Mazelsport in the future.