reported before the Central Society of Clinical Investigation that the syndrome of agranulocytosis might be precipitated by the use of drugs composed of a combination of a barbiturate with amidopyrine. This type of medication is often prescribed by physicians and is used more and more by the non-medical public on their own initiative. These investigators observed that 14 of their patients with the disease had taken amidopyrine alone or in combination with other drugs, such as a barbiturate, immediately before the onset of the disease. This report immediately aroused my interest in this possible etiological relationship and as a result a study was made of our cases of the disease at the University of Michigan.[14] Ten patients have been observed in this hospital and it was definitely established that all of them had taken drugs or combinations of drugs containing amidopyrine in a short time before the earliest symptoms appeared. Although these observations and those contained in a number of other subsequent reports indicate clearly that patients with this disease frequently take amidopyrine before the onset of the condition, it is only indirect evidence that there is a causal relationship between this drug and agranulocytosis. More convincing data have been obtained by administering small doses of amidopyrine orally to patients who had recovered from the disease and determining the white blood cell count every half hour for four hours. In each one there was a striking decrease in the number of polymorphonuclear neutrophil cells of the peripheral blood which reached a maximum in 1½ hours and then returned to normal at the end of 4 hours. A repetition of the test in two of the patients produced exactly the same effect. These tests were controlled by observing the white blood cell count every half hour in these same patients, during which time no drug was given. Furthermore, the administration of this drug to two normal persons did not produce significant changes in the leucocyte count during a four-hour interval.

It is my opinion that amidopyrine is the drug which precipitates the disease in certain persons who are susceptible to it. As it is a widely used therapeutic agent and agranulocytosis does not have a high incidence, it must be concluded that the percentage of persons who are sensitive to it is not great.

WHAT IS A PROOF?[1]

By Professor EDWIN B. WILSON
HARVARD SCHOOL OF PUBLIC HEALTH

OUR first notion of proof may have been different from person to person, but I dare say that for none of us was it the logical process and the Q.E.D. of geometry; for all of us it was probably something quite authoritarian which first brought conviction—a reiterated statement, a punishment, an emphasis, possibly just the stamp of a foot, maybe an example, a bit of cajolerie, a reward or merely an acquired habit. This type of proof is not to be ignored, it is widely and effectively used to demonstrate the excellence of a cigaret, the indispensability of a governmental measure or the soundness of a social theory. Thus, if we were to give to the term proof a definition which had any wide validity in human affairs we should have to use some such phraseology as "a process by which A induces in B a sense of the justification for a conviction."

We may remark that A and B may be the same individual. We should note that the proof is relative to B in whom the sense of justification for the conviction is induced by the process. When a class in plane geometry first meets the Pythagorean Theorem (Euclid I, 47) with its complicated auxiliary construction lines and lengthy reasoning, the proof given will not be such to most of the youngsters because it does not carry to them a sense of justification, it is blind. Or, again, when a class in differential calculus reaches the subject of maxima and minima, the teacher with a few necromantic passes, verbal and graphical, may prove in a manner which carries both a conviction and the sense of its justification, the rule that to find maxima or minima of a function the derivate is set equal to zero; yet he knows that the theorem as stated is neither proved nor true. What may be a perfectly good proof to B may be none to A, who gives it, and a perfectly good proof to A may be none to B, who receives it.

That which has been illustrated relative to proofs of familiar propositions, holds equally of facts, as may be seen by reading "Fact: The Romance of the Mind," the latest book of Henry Osborn Taylor, our very illustrious historian of thought, wherein you can learn that what at some time has been considered indubitable fact might not be so considered now—

Benzene Chain,'' presented at annual meeting of Central Society for Clinical Research, Chicago, Oct. 27, 1933.

[14] Cyrus C. Sturgis and Raphael Isaacs, ''Observations concerning the Etiology of Agranulocytosis'' (*Trans. of the Assoc. of Amer. Physicians*, 49: 328, 1934).

[1] Read at the Pittsburgh meeting of the American Association for the Advancement of Science, before a joint session of Sections K and A with the American Mathematical Society and the Mathematical Association of America and the Econometric Society.

and who among the ancients if he should be now among us could consider as fact some of the things we here cherish as such?

I have alluded to mathematical proofs. We learned the paraphernalia thereof in geometry, consisting of definitions, postulates or axioms and demonstrations. The whole was a logical construct based on conceptions and without any other kind of reality. However much you might stumble mentally at the Pons Asinorum, you could not stub your toe on it! So far as many of us believe, we sense only material things, things containing mass or energy. A point being position without extension could therefore not be directly sensed. Indeed, if we adopt the principle of indeterminacy, as some of us do, how could we specify the position of a point without endowing it with an infinite momentum? And in view of our notions on relativity should we not have to speak not at all about points in space but of events and of space-time?

You thus all see what a terribly unreal fiction this plane geometry is. Fortunately, this does not bother the high-school teacher or the modern physicist could never have got his necessary mathematical start.

In the above extravaganza, or excursion into reality, I am merely trying to emphasize the idealization which is necessary to get up a system of plane geometry and the purely conceptual nature of geometry. Our definitions, postulates and theorems apply to things which do not exist materially. Now when the trusting schoolboy, who does not appreciate what is being imposed on him, having learned that the area of a triangle is half its base times its altitude, undertakes to apply this theorem to find the area of a somewhat triangular object, as may be needed for some practical purpose, he quite unconsciously makes more postulates or assumptions, to wit, that the given object is sufficiently triangular so that he may apply his theoretical formula to the solution of a practical problem. In more complicated fields of theory and practice such additional assumptions may be wide of the mark. In other words, applied mathematics must, in the nature of things, transcend pure mathematics.[2]

If we turn now to the social sciences do we find definitions, postulates and theorems? Certainly we find a lot of statements, but which are the definitions, which the postulates and which the theorems? And which of the statements have to do merely with the conceptual scheme we are trying to set up, and which with those supplementary transitional propositions whereby we assert that in the particular practical situation which confronts us the elements of the conceptual scheme correspond adequately to the realities of the situation to enable us safely to assert that the application of the conceptual scheme to the actual situation is justified?

To take a special instance: Is there any theory of money which does not appear to fly in the face of enough facts, which does not patently neglect enough possibly important variables of our economic (and psychological) system, which does not so much lean on secular trends as to render doubtful the feasibility of accomplishing by monetary manipulation that degree of economic control which some claim? Even if you can follow, as I can not, the logic of J. M. Keynes's "Theory of Money,"[3] can you follow with conviction his transition to a system of regulation by manipulation of the bank rates or by large-scale governmental spending, or would you be tempted to give the citation: "J. M. Keynes, dazzling terpsichorean, enricher of his College by war time speculation with her funds, now impoverishing a great republic by her adoption of his even more speculative theories." The social sciences must become less enamored of the dazzle of the intellectual dance hall and more satisfied with the daily grind of work. Maybe the long-continued studies of our vice-president, Mr. Snyder, will help both with their findings and by their example.[4]

I would not imply that there is no ascertained and widely agreed-to body of knowledge in the social sciences; there is, at least in a general way, a larger amount of agreement and of demonstration than is commonly believed by those unfamiliar with the social sciences, but efforts at reducing the body of the subject to neater form are very necessary in order that all may have a clearer picture of that on which they agree and a sharper realization of the crucial elements in the disagreements which must ever be in evidence so long as the subject is alive and advancing.[5] It is, I understand, the object of the Econometric Society to proceed along those lines. The society will, however, be handicapped in its efforts unless it can draw a line between pure science and applied science. The task will require patience; for a long time we shall

[2] "What is sometimes called 'applied' science, may then be more truly science than what is conventionally called pure science. For it is directly concerned with not just instrumentalities, but instrumentalities at work in effecting modifications of existence in behalf of conclusions that are reflectedly purposed." From John Dewey, "Experience and Nature," p. 161. (Not from the "People's Lobby.")

[3] See, among other references, John Williams, *Quarterly Journal of Economics*, 45: 547–587, 1931; A. H. Hansen and H. Tout, *Econometrica*, 1: 119–147, 1933; K. Rübner-Petersen, *American Economic Review*, 24: 595–602, 1934.

[4] Carl Snyder, *Quarterly Journal of Economics*, 49: 173–205, 1935.

[5] That there are disagreements at the research frontier is well illustrated by R. A. Millikan, SCIENCE, 81: 1935.

have difficulty in limiting ourselves to proofs which have mathematical precision. Moreover, there need be little correlation between the amount of formal mathematics used by the investigator and the substantial validity of the proof offered.

It is a homely saying that the proof of the pudding is in the eating thereof. For most practical purposes this may be a sounder proof than any based on the perusal of the recipe or on a chemical analysis of the constituents. Many a recipe which ought to have made a fine pudding has resulted in one quite inedible.

In many proofs we introduce the notions of cause and effect. We do not often so speak in the composition of puddings, and the validity of a notion may be questioned. In geometry we do not say that the base and the altitude of a triangle cause the area to be what it is. We think merely of the three quantities, base, altitude, area, as connected by a certain relation. In mechanics we no longer think that the force causes the motion; we have only concomitancy of variables. In complex systems which depend on a multitude of variables connected by a variety of relations, often unknown, it is clear that the usual situation must be that any imposed change in one of the variables may be distributed widely through the system; if the system is in quasi-equilibrium, if it is a going concern, it will probably exhibit the characteristic of homeostasis,[6] in the terminology of Dr. Cannon. The analysis into cause and effect is more necessary when one comes to speak of control, for control consists in obtaining the desired effects (and avoiding undesired ones) through specific measures. The element of the will enters, the individual or social will, and, with it, causation in a sense somewhat different from that in which it is attributed to non-willing nature. It does not do to overlook such generalities in speaking of proofs in a practical world.

My fundamental contention, then, is that proofs, truth and facts must be relative to our culture and conditioned by it; that for different purposes they must not only be different but may even be differently conceived; that science can not be all things to all men but must consist of some very special things to limited groups of specialists who deal with various questions of pure and applied science. For our development we have to depend on the professional ethics and the professional discrimination of those small groups; they must not fool themselves or attempt to fool one another within a group as to what is a proof or as to what are the facts; it may be impossible for them to explain themselves truthfully to non-specialists without departing widely from the strict canons of proof which they adopt among themselves.

SCIENTIFIC EVENTS

THE NEW CHAIR OF ASTRONOMY AT THE ROYAL INSTITUTION

IN connection with the establishment of the professorship of astronomy at the Royal Institution, to which Sir James Jeans has been nominated, the London *Times* writes as follows:

The year 1863 was the last occasion when a new chair was created. This was for Dr. (afterwards Sir Edward) Frankland, who was elected to a separate professorship of chemistry, while Faraday was still the Fullerian professor of chemistry. Frankland's professorship lapsed after Faraday's death. The other "elected" professorship in the institution at the time, that of natural philosophy, had been established ten years earlier, and was not so short-lived. It was created for Tyndall when he went to the institution in 1853, and since his retirement in 1887 has continued by election and reelection down to the present day.

By their resolution to establish a new professorship, the members of the Royal Institution have exercised a privilege they have possessed since the foundation of the institution. A proposal for a professorship in astronomy was made and agreed to in 1811, but no appointment followed and the proposal was dropped. But astronomy is by no means a new subject to the audiences at the Royal Institution. It has appeared at intervals in the lecture lists and has been of particular interest to the sons and daughters of members, for the first of the famous Christmas courses "addressed to a juvenile auditory" was given by Wallis in 1826 on an astronomical subject; and in later years Sir Robert Ball, Sir David Gill and Professor H. H. Turner became popular Christmas lecturers on astronomy.

Sir James Jeans is already known to the children of the present members of the institution, for he gave the Christmas lectures of 1933 on "Through Space and Time." It is by these lectures that he satisfies the requirement of the by-laws that a new professor must have delivered a course of lectures to the institution within two years previous to his election.

Since Tyndall, three physicists of great distinction have held the professorship of natural philosophy at the institution and have also been, in turn, the Cavendish professor of physics at Cambridge. The late Lord Rayleigh soon after his retirement from Cambridge accepted an invitation to the chair of the Royal Institution

[6] The effort to view the economic system of a country as a whole with the understanding that a multiplicity of well-balanced measures is necessary to get and keep the balance of the system is well illustrated by Douglas Copland's "Australia in the World Crisis." Dr. W. B. Cannon's book is entitled "The Wisdom of the Body."