Quixote of Mr. Bryan's calibre only appears once or twice in a century and the opportunity to study in cold print the celebrated Nebraskan's proposal to resurrect the "special creation of species" myth must be appreciated by our scientific brethren who are interested in studying the mysterious ways in which the human mind sometimes works when it approaches subjects unfamiliar to it.

My principal object in writing you is to suggest that Mr. Bryan should be invited to use the pages of SCIENCE to attack an even greater heresy than Evolution. Since Mr. Bryan still gets his biology from the Bible it appears to be a safe inference that he must draw his geography from the same source. Bible geography, or "flat geography" is, I am informed, taught nowadays only in the mountains of eastern Tennessee. Why should not our Bold Knight from Nebraska (or is it Florida?) aim his lance at the teachers of modern or "round" geography and admonish them to hark back to the geography of Joshua? This is perhaps a subject which has been overlooked by this eloquent defender of Biblical science. I can hardly believe it to be lack of courage which has led Mr. Bryan to attack the few and widely scattered teachers of evolution instead of the thousands of teachers of modern geography. Whatever the explanation of Mr. Bryan's neglect to denounce the heresies to be found in the textbooks on geography may be, I beg to suggest that the heretical character of the modern teaching in geography should be brought to the notice of Mr. Bryan.

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THE WRITING OF POPULAR SCIENCE

TO THE EDITOR OF SCIENCE: Both Dr. Alfred H. Brooks[1] and Dr. Edwin E. Slosson[2] have recently called attention to the fact that relatively few popular scientific works are being now written in this country; and the former expresses the opinion that there is to-day relatively less popular knowledge of science and less interest in its methods and advancement than there was a generation ago. This opinion will probably be generally accepted as correct. That it should be true in spite of the large amount of scientific work that has been, and is being done, and in spite of the serious attempts of scientific associations and other agencies to create a popular interest in science, indicates that it is high time for scientists to consider seriously themselves, science and the public, in an endeavor to ascertain wherein the difficulty lies. Most scientists will agree with Dr. Brooks that the lack of popular knowledge of science is directly due to the form in which science is presented, and that "what is needed is the presentation of science in a form comprehensible to the educated and thinking man." But to secure such presentation, it is necessary to understand the public, the point of view of those we desire to reach, the mental background with which the science we present must be harmonized; to understand science and ourselves; to keep in mind what constitutes science; to have a clear idea of what we wish to give the public. Otherwise we are in danger of merely groping blindly, and of, perhaps often, prostituting the name of science.

We all acknowledge that science is *organized* knowledge. That neither an isolated fact, nor an infinite number of isolated facts, is science; no matter how true and exact the facts may be. It is only when two or more facts are seen to be related, that science comes into existence. Science does not consist of facts, but of recognized relations between facts. Science is essentially a mental phenomenon[3].

But are there not, only too often, offered under the guise of science mere isolated facts trimmed with sufficient allegory and superficial analogies to fill a respectable amount of space and to attract the layman's attention? This is not science, but merely information—the raw material out of which science is made.

1 *Journal Wash. Acad. Science*, 12: 73-115, 1922.

2 SCIENCE, 55: 241, 1922.

3 Since this was written Dr. F. L. Hoffman's admirable vice-presidential address (SCIENCE, March 10), entitled "The Organization of Knowledge" has come to my attention. In this, the essential distinction between mere facts and science is strongly emphasized.

It has no cultural value other than what the reader can supply by coordinating it with other information that he has acquired from other sources. Only by, and to the extent of, such coordination does the fact become scientific.

Is it not here that the scientist needs to consider both himself and his reader? For him, this fact he offers has a wealth of associations; he sees it in its relations to numerous other facts; the mere fact that this particular fact *is*, has for him far-reaching implications; it is against such a rich and harmonious background that *he* sees the fact. But with the layman it is far different; he can furnish but a meager background, often merely a dead black drop. The fact as presented with its allegory and analogy may appear to him very beautiful, or wonderful, or surprising, but it does not mean anything to him. Is it surprising that he does not enthuse over it? A person likes to feel that he is getting somewhere. An article that establishes a recognized relationship between two or more facts meets this desire, and by the serious minded public would surely be received more favorably, than one that merely retails information.

But the choosing and presenting of a relation between facts is difficult. The scientist is embarrassed by the complexity of the relations that he recognizes; what portion of the vast web shall he choose? And having chosen, how can he supply the proper surroundings to give it in any fair degree its true significance when seen against the drab background that will be furnished by the reader? To succeed, he must know how to present his facts and arguments so that they will fit into his reader's experiences and habits of thought. He must be acquainted with his reader. Is it not here that the great difficulty lies? The scientist of this country seldom has the leisure, and often has not the inclination, to become really acquainted with the experiences and the mental processes of the non-scientist. As a result, he is unable to present his scientific knowledge in a form that is readily understandable by the layman.

The remedy is to be found in a more intimate acquaintance of the scientific and the non-scientific classes with one another. In the endeavor to secure such improved acquaintance, the scientist is called upon to take the initiative, and to do the most. He must cultivate the acquaintance of the non-scientist; must study him; must show him, in a way that he can understand, what science really is; must make him see that scientific work does not consist in merely collecting wonderful, interesting, or surprising facts and observations, nor in inventing useful or weird contrivances, but in ascertaining how facts are related to one another, so that he may be able to forecast with confidence the results that will follow from a given act, and conversely, may be able to specify what set of acts will give a desired result. The non-scientist must be made to see that science does not consist in making inventions, but in furnishing the raw materials out of which inventions are made. Once get the army of non-scientists to understand these things, and the securing of their interest in science and its advancement will cease to be a problem.

The public can learn what science is, only by being shown properly labeled examples of it. These must be understandable, but nevertheless must be real and rigid science; and in no case should the reader be relieved of all necessity for thinking. Among the types of subjects that appear to be suited to this purpose are: (1) Accounts of discoveries, in which the reason for undertaking the work and the main steps in the establishing of the conclusions are given. (2) Accounts of experimental research, or of precise measurement, in which the line of reasoning, illustrations of check experiments, etc., are given. (3) Accounts of experiments designed to established suspected relationships between observed facts. Unsuccessful experiments should not be ignored. (4) Accounts of the establishing of relationships between observed facts by purely inductive methods.

If we would avoid giving the public a false idea of what science really is, let us discourage the practice of placing the label "science" on presentations of mere isolated facts, and let us clearly inform the public, by word as well as by example, that science consists in the establishing of relations, not in the cataloguing of facts.

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QUOTATIONS

THE EARNING POWER OF RESEARCH

A few years ago the X-ray tube was an erratic apparatus not in any very general use. The research laboratory of the General Electric Company realized that there was a possibility of utilizing pure electronic emission from a hot filament to produce controllable X-rays in a perfect vacuum. They conducted extensive research upon such devices as then existed, and as a result the tungsten target took the place of platinum in the standard gas tube of that day. Research had also to be applied before the laboratory learned positively that available electrons already existed and that there was a possibility of controlling them, as, for example, focusing them on a target. The research has been continued, until today practically all the X-ray tubes of the country are made by the company in accordance with the discoveries of the man whose name the tubes bear. The Coolidge tube is also used abroad almost to the exclusion of other types. These remarkable results have been achieved through very careful, accurate, and often discouraging studies of electric phenomena in high vacua, with very pure materials. The perfection of the tube is the nucleus of an annual business, including accessories and generating apparatus used in X-ray work, of from five to ten million dollars a year. The benefit cannot be measured wholly in monetary return, for everyone is familiar with the humanitarian benefits.

Our oldest industries have been the most reluctant in establishing research laboratories. But the experience of a leader may guide the entire industry. Some years ago the Ward Baking Company established a fellowship at the Mellon Institute. The research soon brought results and the application of a more balanced yeast nutrient to the dough gave better fermentation and better bread. It was discovered that the baker can grow yeast in the dough and control fermentation wastes. This conservation amounts to 2 per cent of the flour, 15 per cent of the sugar, and sufficient yeast to make the total saving 45 cents net per barrel of flour used. It is estimated that this process saves American, Canadian, and British bakers not less than $40,000 per day, without detriment to the quality of the bread.

In 1915 a control laboratory was installed with one chemist. Today there are a variety of control laboratories with twenty-five technical workers. A chemist has frequently saved two months' salary for his employer with a report on samples from a single carload of butter. The control which has been established as a result of research upon the raw materials makes possible uniformity in the finished product. Time, temperature, and other factors which influence fermentation have been established, and since no two carloads of flour are alike the data are vital in determining how fermentation must be varied to secure uniformity. The study of enzymes, proteins, colloids, yeasts, bacteria, and nutrient value is pointing the way to still better bread, higher nutritive values, economy in production, and the elevation of the entire industry. It is no wonder that during these days of industrial depression this pioneer in research as applied to baking has increased the number of its scientific workers. Results continue to justify the increase.—*The Journal of Industrial and Engineering Chemistry.*

SCIENTIFIC BOOKS

A Monograph of the Existing Crinoids. Volume 1. The Comatulids. Part 2. By Austin Hobart Clark, Curator, Division of Echinoderms, United States National Museum. Bulletin 82. Washington, 1921. 4 to Pp. xxvi + 795; with 949 text-figures and 57 plates.

The first part of Clark's monograph appeared in 1915.[1] The present brochure, fully twice the size of its predecessor, constitutes the concluding part of the general introduction to The Comatulids. The systematic description of the group will follow. The major part of this work has already been completed and much of it has appeared in a series of monographs and

[1] Reviewed in Science, N. S., Vol. XLII, No. 1080, p. 342, Sept. 10, 1915, by Frank Springer.