I do not advocate, however, determining what is indispensable once and for all time, because this problem does not admit of such a unique solution. What I am suggesting is that educators, learned societies and text-book writers be aware of this problem and deliberately attempt to give it progressively better solutions in the light of experience.

The question "What is a dead language?" is not relevant to my suggestions and was not raised in my note.

In advocating the elimination of some topics from text-books, I have not lost sight of the student who does not intend to major in science. The examples I have given indicate that these students could dispense with the kind of topics I have in mind even more profitably than students who are to become specialists in science.

In advocating the teaching of science continuously through primary and secondary schools, I did not intimate that other subjects can not be taught so as to produce the desired results; neither did I refer to augmenting "the insight of the teacher." I claimed, first, that sciences are better adapted than some other subjects to stimulating the interest and maintaining the curiosity of the pupil and, secondly, that continuous and longer exposure to science is necessary for imparting the scientific outlook and for making science more palatable to college students.

In stating ". . . science is now taught in at least nine years of the twelve-year curriculum offered by most present-day public schools," the writers either include mathematics or use the word "taught" to mean "offered"; otherwise it would not be true. I should, perhaps, have stated explicitly that by "science" I meant the physical and biological sciences and by "teaching" I meant teaching as required subjects. These meanings of the words are clearly indicated by the context of my note.

I have before me a copy of the program of studies at the Hartford Public High Schools which are considered some of the best in the country. In this program the required and elective subjects are tabulated for each year and for each of the curricula designed for pupils who follow the courses preparatory to "Liberal Arts College," "Scientific College," "General Education," "Commercial," "Prevocational" and "General Industrial." *Not a single subject in* the physical and biological sciences is required in any of these courses, not even in the one preparatory to "Scientific College." So far as requirements are concerned, therefore, pupils could, and many of them do, graduate from Hartford high schools without having a single course in science. As to the Hartford primary schools, I am told that even the offering of a science subject is purely a matter of the discretion of the teacher and her enthusiasm for science.

The warning against producing "single track experts and the scientific ignoramus" is the old cry of "wolf, wolf" usually sounded by "liberal" educationists who ignore the fact that science has become the major source of new ideas and that the few scientifically trained men and women have done more than all the rest of mankind, during the past three hundred years, in liberating the human race from the fear of want and pain and in broadening our outlook.

To do full justice to the last paragraph of the communication of Professor and Mrs. Craft, one would have to write a book or at least a pamphlet, because it represents the epitome of a great deal of the material of articles and books on education written by "humanists" and "liberal" educationists. In these writings a single-track expert or an ignoramus is, almost invariably, a scientist. One might take the position that this is as it should be and take a criticism of this type as a compliment to men of science. For, after all, an ignoramus among scientists should be very rare and striking, in view of the fact that they not only know something about science but also perforce become conversant with a great deal of the non-scientific fields of knowledge and experience through their formal education and by virtue of being members of non-scientific communities.

The quotation from Jaques Barzun, "What do they know of science who only science know," deserves special comment. If the word "science" in this quotation is replaced by the name of any other subject the validity of the statement would not be changed. Yet, for some strange reason, only science and scientists are made the butt of this type of criticism. I should like to know the name and address of the zoo where the *only*-science-know bird is kept.

H. M. DADOURIAN

SIR ISAAC NEWTON AND THE SENSITIVE RADIOMETER

IN SCIENCE of March 9, I have read with interest Dr. C. G. Abbot's letter (pp. 244–245) describing how he was led to find a remedy for electrostatic disturbance of a sensitive radiometer by a recollection of Newton's famous proof that a uniform shell of matter exerts no gravitational force upon any *body placed within it.*

The corresponding theorem in electrostatics, namely, that no electric field exists within a hollow conducting spherical—or, as in Dr. Abbot's two-dimensional case—cylindrical shell is, of course, well known and in fact comprised in the more general theorem that no field—due to external charges—can exist within a hollow conductor of any shape whatsoever. The proof of this is usually given as a particular case of Green's Reciprocation Theorem (*vide,*

e.g., Smythe, "Static and Dynamic Electricity," p. 38).

Dr. Abbot's comparison of the electrical with the gravitational problem suggests an extension of Newton's purely geometrical proof for the latter to the electrical analogue. For a uniformly charged spherical electrical shell, Newton's proof, namely, to divide the surface of the shell by double cones with their vertex at the field-point obviously applies, *mutates mutandis,* since the law of force is in each case the same, namely, the inverse square and the effect of area is exactly cancelled by the effect of distance.

It is interesting to note, however, that in the case of a circular cylinder, if end-effects be ignored, the same method of proof is applicable when the aforesaid set of cones degenerate into a set of double planes cutting off long strips on the inner wall of the cylinder each of an area proportional to the distance from their line of intersection while the law of electric force now becomes that of the inverse distance, so that complete cancellation again results.

Newton's theorem that the force exerted by a gravitating shell or sphere at an external point acts as if the whole mass were concentrated at the center is also transferable to the electrical case and provable by the same simple geometrical construction, choosing now for the vertex of the cones or intersecting lines of the planes the point inverse to the external point.

I have not seen this method of proof applied to these simple problems.

A gravitational parallel to the more general electrical theorem which would correlate the density (per unit area) of fluid matter distributed over a shell of any form with the total curvature is a further obvious extension.

KERR GRANT

UNIVERSITY OF ADELAIDE

SCIENTIFIC BOOKS

SURVEY TEXTS IN PHYSICAL SCIENCE

Man's Physical Universe. By ARTHUR TALBOT BAWDEN. xv + 832 pp. New York: The Macmillan Company. 1943. $4.00.

Physical Science. By WILLIAM F. EHRET, editor, LESLIE E. SPOCK, JR., WALTER A. SCHNEIDER, CAREL W. VAN DER MERWE and HOWARD E. WAHLERT. x + 639 pp. New York: The Macmillan Company. 1942. $3.90.

The Study of the Physical World. By NICHOLAS D. CHERONIS, JAMES B. PARSONS and CONRAD E. RONNEBERG. vii + 883 + xiv pp. Boston: Houghton Mifflin Company. 1942. $3.85.

SURVEY courses in the sciences began to appear in college curricula in the years before the war, and it is probable that their introduction is now being considered at many colleges where they were unknown before. For this reason, though none of the texts listed above is quite new, it still may not be too late for a review to be of interest.

In the well-established fields, in which texts have been written for a century or more, the author of a new one will hope to make useful innovations, but his opportunity will be somewhat circumscribed and the risk of going far astray will be similarly limited. The author of a text for a college survey course is guided by fewer landmarks, and this should be remembered in any criticism of his work. On the other hand, since his text may be expected itself to become a landmark in a field where there are not many, it is all the more important to suggest improvements where it appears they might be made.

These three texts cover, at somewhat different levels, the same subjects: astronomy, physics, chemistry, geology, meteorology and physical geography. The boundaries between these subjects are, by design, disregarded.

"Man's Physical Universe" is the most elementary of the three. Its author is the president of the Stockton Junior College in California, and the work was doubtless written for students in that and other junior colleges. It is entirely without mathematics and almost wholly descriptive rather than quantitative. This restriction is naturally a handicap in treating the more exact sciences. The clearest exposition, in my opinion, is that of geology and physical geography, and the least clear is that of physics.

Not all the difficulties result merely from the use of descriptive rather than mathematical terms. For example, the meaning of "centrifugal force" is changed twice in four successive paragraphs, from the d'Alembertian sense of mass times negative acceleration to the sense of Newtonian reaction and back again. (Is it not high time to discard this term, at least from beginners' books? Nothing in which authors can become so involved is likely to be of any help to students). In general, I should say that basic concepts, especially the more difficult ones of physics, are too often hurried over rather than given the patient explanation they need if they are to be understood. This may make things easier for the more superficial reader, but it must confuse the earnest student, especially if he has taken seriously the author's advice at the beginning of the book to insist on careful definitions.

The sequence of topics is, roughly speaking, that of the decreasing scale of phenomena, from astronomy to atomic and molecular structure. This is a generally logical development. Every sequence must have its drawbacks, and the disadvantage of this one is that