film sells for $20 per 1,000 feet, and since two pages are photographed upon each 1½ inches of film there would be 16 pages per foot. Allowing for the title page, identification reference and a short blank space at each end, the film for a 10-page article would cost about 2 cents. The developing and labor would probably not amount to more than 8 cents per 10-page article, hence it is likely that the service could be rendered by a library, without loss, at 10 cents per article of 10 pages or less and 5 cents for each additional 10 pages. This, however, is only a preliminary estimate and may be subject to revision on the basis of experience gained during an experimental period of operation.

When one considers the complex and expensive organization required for keeping track of borrowed books, the wear and tear to which they are subjected, and the messenger or other service required to deliver them, the saving effected by reducing the number which would leave the library would certainly be an important item. It is even possible that film-copying service rendered free might be a saving over the present system of lending library books. It is therefore not unreasonable to expect that even at the low price mentioned, the adoption of film-copying by libraries would lead to a considerable economy of operation.

With this end in view and also in consideration of the great service that film copies may be expected to render research workers, Miss Barnett has arranged to have made, at the prices mentioned above, with the equipment of Dr. Draeger, film-strip copies of articles contained in publications on file in the library of the Department of Agriculture.

Those desiring to avail themselves of this service should send their orders to the "Biblio Film Service," care of Library, U. S. Department of Agriculture, Washington. It is expected that within a short time film-strip magnifying and projecting apparatus, such as described above, will be available.

ATHERTON SEIDELL
NATIONAL INSTITUTE OF HEALTH
WASHINGTON, D. C.

ORIGIN OF PETROLEUM

THE notes on this subject by J. M. Macfarlane and E. Berl recently published in SCIENCE are worthy of some comment. Macfarlane appears to favor the old theory of the decomposition of fish oil, or lime soaps of fish oil, by heat. Berl believes there is evidence that the source material of both coal and oil was "carbohydrates and carbohydrate-humic acids."

The writer has pointed out in two recent papers[1] that the older theories of petroleum origin were proposed almost entirely without consideration of the chemical character of petroleum and with little reference to or knowledge of the conditions of its geological occurrence. It was also pointed out that there is abundant factual evidence, of both chemical and geological nature, that petroleum has had a low temperature history, of the order of 100° F. There is also abundant evidence against the early, but still widely prevalent, idea that petroleum is nevertheless the result of heat decomposition of fatty oils or other organic material, these decompositions being assumed to take place at low temperatures by virtue of the great periods of time available, in the case of the older strata, for such change. The evidence is much too abundant to summarize adequately in this brief note.

Berl evidently accepts the evidence of low temperature history. It is a pity that theories of "distillation" and heat decomposition, set up years ago on the simple experiments of Warren and Storer (1867) and of Engler, which do much violence to the many chemical and geological facts that we now know, should continue to clutter up our scientific literature. Surely we owe it to youth, seeking to learn, to clear some of our scientific debris.

The chemical history of petroleum is still bristling with unsolved questions, but how to produce petroleum by cooking fish is not one of them.

BENJAMIN T. BROOKS
NEW YORK, N. Y.

1 *Bull. Am. Ass'n. Petr. Geol.*, 15: 611, 1931; *Jour. Inst. Petr. Technol.*, 20: 177, 1934.

ARE FISHES THE PRINCIPAL SOURCE OF PETROLEUM?

DR. MACFARLANE'S recent communication in SCIENCE[1] calls to mind his theory that fishes are the principal source of material from which natural petroleum has been derived.[2] Even admitting that petroleum may have been derived from fish oil in the rocks by natural processes, he has failed to present convincing evidence of fish remains in sufficient quantity to account for the enormous quantities of petroleum in some formations, having attempted to account for the large quantities in other formations by assuming, without proof, migration from far distant sources, and ignored all other as likely sources. In his interesting book he assumed, for example, that fish remains are very abundant in the Green River oil shales. As I have elsewhere stated, such remains are confined almost entirely to a thin series of strata in a very small area of that thick, wide-spread formation.[3] Even in the limited region where the beautiful fish skeletons are

1 SCIENCE, November 23, 1934.
2 Macfarlane, "Fishes the Source of Petroleum," The Macmillan Company, 1923.
3 Henderson, *Proc. California Acad. Sci.*, 4th series, Vol. XV, pp. 269–278, 1926.

found they are not very abundant, and at most localities and horizons they are so scarce as to be wholly negligible. If the fish bones and teeth were destroyed by organic acids, that would have left the scales intact, as actually happened in the Mowry formation. Dr. Macfarlane perhaps also overestimated the abundance of fish remains in the latter formation. True, scattered scales are quite numerous in portions of the formation, but a few fishes would account for a great many of the scattered scales. The Pierre formation is yielding petroleum in quantity at many localities, yet fish bones, teeth and scales are very scarce throughout the formation at all the numerous localities I have examined, and there are no extensive fish beds from which one may safely assume that the oil has migrated. Many such examples may be enumerated, while places where fish remains are abundant in the neighborhood of oil fields have not been found over great areas occupied intermittently by oil fields. On the other hand, some of the oil-bearing formations contain vast quantities of remains of mollusks, diatoms, foraminifers and other organisms that may have stored in the rocks enormous quantities of carbonaceous material, which may be a source of petroleum. In addition, forms of algae and protozoa without durable parts that would be preserved in recognizable condition in the rocks, some of which represent groups that produce numerous generations per annum, may have deposited carbonaceous material equalling or exceeding the bulk of all other organisms. The protoplasm of all these organisms contain the elements entering into the composition of petroleum. I see no *a priori* reason why any or all of them may not have contributed toward the petroleum.

It is impossible to duplicate experimentally all the deep-seated natural conditions within the thick geological formations, such as heat, pressure, chemical associates and more particularly the time factor. Failure to produce petroleum experimentally from any organisms would not prove conclusively that it could not happen or has not happened under natural conditions during a very long lapse of time. Success in such experiments possibly would not conclusively demonstrate that the same thing has happened in nature. If petroleum is of organic origin, as is rather generally believed, experimentation and discussion, in order to command complete respect, must take into consideration all forms of animal and plant life, and especially the microscopic forms so abundant and almost universally distributed in both fresh and marine waters, all composed chiefly of the elements that enter into the composition of petroleum, each individual of many of the species containing a minute globule of oil.

JUNIUS HENDERSON

UNIVERSITY OF COLORADO

SCIENTIFIC BOOKS

PHYSICAL THOUGHT

The Development of Physical Thought. By LEONARD LOEB and ARTHUR S. ADAMS. John Wiley and Sons, New York.

ACCORDING to the preface, this book is the outcome of a course of lectures prepared and given at the University of California by the senior author. The notes of these lectures were used and revised by the junior author and are published as a joint production.

There is wide recognition of the difficulty of the graduate student and the younger physicist in coordinating his rather patchy knowledge and in getting a proper perspective of his science. The historical chronological development of a science is perhaps the natural one. Ideas grow. Even the mistakes and false starts are of value. The student who studies the development of ideas, including the errors, is sure to obtain a knowledge of the growth of his science which will be useful in his later specialization and teaching.

A comprehensive knowledge of the growth of physical ideas is also particularly valuable to the teacher who is presenting the science to the beginning student as a cultural subject.

This book should be a help both to the student and to the teacher of physics, and the reviewer recommends it to their attention. The first chapter, which is headed "Historical," gives an interesting account of the thought and activities of the early Greeks and Romans and the limitations of their scientific methods. The importance of Aristotle and his great influence on thought through the Middle Ages is discussed and stressed. Also the authors point out the great influence of economic and political conditions on the growth of science.

The succeeding chapters take up successively the development of mechanics and dynamics, heat and the structure of matter, electricity and magnetism, light, and finally the electrical structure of matter and the new physics. The space given to each of these topics varies considerably, perhaps according to the special interest of the authors. The chapter on light might have been more extensive and clearer, particularly in the treatment of refraction and dispersion. The last chapter on the new physics is much the longest. This is not so desirable, as the young physicist is apt to know this field fairly well. A philosophical grasp of the growth of classical physics is more important for him and also more difficult.