authors, most of them now active but also including Louis Agassiz, the late R. A. Daly, Percy E. Raymond, and S. J. Shand. Somewhat less than half of the book is the work of Harvard men, and most of the small but adequate photographs have been supplied from the Harvard collections.

Following the introduction—a quick review of the history and of various fields of earth science—each of the 19 chapters, with one exception, is adapted from a single work and is prefaced by a page or two of information about its subject and author. Most of the earth sciences are considered, but a specific list of subjects and authors is not repeated here: it is enough to say that each author is authoritative in his field, and that the prose, supplemented by photographs and diagrams, is clear and often dramatic.

I made no point of detecting errors, since these must be attributable to the original sources, not to the present volume, but I did note a minor inconsistency. The Leets (flatly) and Simpson, Whipple, and Colbert (in qualified terms) agreed that no rocks were known which are older than 3000 million years; yet on page 43 there is a photograph of algae from Ontario ". . . which existed 3500 million years ago. . . ."

It is to be hoped that the editors or others will compile a companion volume that will: Present opposing authors on half a dozen controversial issues; present a few new lines of such research as paleotemperature, paleomagnetic, and high-pressure studies; take its illustrative examples largely from abroad.

CHARLES D. CAMPBELL
Department of Geology,
Washington State University

On Innovation and Imitation

Productivity and Technical Change. Cambridge University, Department of Applied Economics, Monograph No. 6. W. E. G. Salter. Cambridge University Press, New York, 1960. xi + 198 pp. $4.50.

To understand the process of economic growth, it is necessary to analyze developments not only in the economy as a whole but also in its component parts.

If, as Salter has done, one takes the time and the trouble to study the records of individual industries, he will be struck by two facts. First, the rise in labor productivity—that is, the upward trend in physical output per worker or per worker-hour that characterizes a growing economy—is a general phenomenon. Second, however, industries differ greatly in the rate at which labor productivity rises.

Rise in labor productivity is widespread because technical change and capital accumulation affect production in all sectors of the economy. Technical advance of almost every kind, sooner or later and in one way or another, leads to improvements in the methods, equipment, and materials used in every industry; thus technical advance increases (or tends to increase) output per man directly, and by also increasing output per machine and per unit of materials, it increases output per man indirectly. Technical progress in the capital equipment industries lowers the cost of equipment relative to the cost of labor, induces substitution of capital for labor wherever equipment is used, and thereby strengthens the tendency for output to increase in relation to labor input. Technical progress has a like effect in the industries producing fuels and other materials and supplies. Technical progress in the transport and communication industries serves to enlarge the scale of markets; and this makes possible the finer "division of labor," domestic and international, that helps raise productivity. As for saving, it proceeds at a sufficiently high rate to cause wealth to rise more rapidly than the labor force; in this way, capital accumulation joins in lowering the cost of using capital equipment, especially long-lived equipment, relative to the cost of labor, and thus reinforces the general tendency to substitute capital for labor. The increase in population and in per capita real income brought about by technical progress and savings also widens markets and creates economies of large-scale production. Rising income, in addition, finances the investments in education that help push up labor productivity everywhere.

Labor productivity rises at disparate rates in different industries because technical change varies in its impact on individual industries. Variation among industries also occurs in the ease with which capital may be substituted for labor and in the size of the economies brought about by a given increase in volume of production. Further, rates of increase in demand that occur in response to increase in income also vary, both systematically and randomly, from one class of product to another; this, too, causes industrial variation in the economies brought about by larger output. It also causes variation in the rate of investment, which determines the speed with which technical advance can be embodied in new and better equipment, and thus in the rate of increase of labor productivity.

The above summarizes part of Salter's study of trends in British and American industries. While it is possible that I have read more into what Salter has to say than he intended, it is certain that I have omitted findings that are important and interesting. For Salter concerned himself also with the relations between changes in productivity and changes in prices and in wages and with the role these relationships play in the process of adjustment of industry and employment to technical change and capital accumulation. His results extend or—always important in scientific work—confirm findings of previous studies.

Economists may be spurred by Salter's model of economic change to quarrel and perhaps to improve. For example, Salter sees the diffusion of technical change within an industry as resulting from the replacement of old plants with new ones. Replacement occurs when the direct costs (per unit of output) of manning, supplying, and maintaining old plants come to exceed the total costs of new plants—that is, their direct costs plus depreciation and interest charges. The model implies that an industry is homogeneous in all respects except vintage of plant and correlated technical level. However, in a study of the spread of hybrid corn over the United States [summarized in an earlier issue of *Science* **132**, 275 (1960)], Zvi Griliches emphasized the heterogeneity of the corn producing areas and the problem of adapting the innovation to the varying circumstances of each area. Salter's model may be appropriate for manufacturing and Griliches' for agriculture; in any case, the general applicability of Salter's model seems doubtful.

A related assumption, to which exception might be taken, is that investment is the prime vehicle of technical change. But Salter is well aware that other factors play a role in the application of technical advance. He would acknowledge that investment is a necessary but not a sufficient condition, that the rate of innovation may not in fact be associated in any stable manner with volume of investment, and that it is important to determine just what the relationship is.

No reasonable reader could expect Salter to cover everything important that is implied by the words "productivity and technical change." Salter does not ask why technical change occurs the way it does, or what determines the rate of saving, for example. Nor does he deal (except incidentally) with the questions of policy—regarding monopoly, capital markets, money, taxes, tariffs, patent laws, agriculture—that concern everyone who asks how economic growth may be accelerated. Salter's is a scientific work—an intelligent and workmanlike piece of scientific work—of the kind needed to put solid ground under policy to stimulate growth.

SOLOMON FABRICANT
New York University and
National Bureau of Economic Research

Pro and Contra Darlington

The Sounds of Language. An inquiry into the role of genetic factors in the development of sound systems. L. F. Brosnahan. Heffner, Cambridge, England, 1961. 250 pp. 25s.

Brosnahan writes well. He has a wide knowledge of linguistic, psychological, and genetic facts and the gift of clear presentation. He is fair in his presentation of other theories and modest in the claims he makes for his own. Nevertheless, I remain unconvinced of any solidity in his fundamental thesis: that inborn factors have an appreciable role in predisposing populations toward developing given types of sounds. The idea is that of the geneticist, C. D. Darlington; Brosnahan attempts to support it as a linguist.

As the author states it, the problem is "why any community of speakers should select, and indeed should be continually selecting certain articulations in preference to others" (page 7). His answer is that over long periods of time there is a tendency to move toward the sounds which are easier to produce and that these are different for each human group, depending on hereditary physiology. The matter seems to be exaggerated. The structure of the mouth and throat and the capacity to hear sounds are sufficiently developed in all humans, with rare individual and no racial exceptions, to handle all sounds used in all the languages of the world. The minor differences can hardly explain the phonetic changes which have occurred in languages. For example, what could have happened to the mouths of the forerunners of the historic Greeks to cause them to change *s* to *h*? Whatever caused this, why did it subsequently permit the Attic Greeks to bring into use new instances of *s* as a replacement for *t* before the vowel *i*? And what did the ancient pre-Greeks have in common with other human groups in scattered parts of the world, which at one time or another made the same transformation of the sibilant?

To carry conviction for this thesis, Brosnahan would have to show sound changes in relation to specific physiological characteristics of the speaking organs, but he deals rather with blood factors. Thus, he presents an apparent correlation between the geographic distribution of the O-factor in the blood and the development of dental fricatives (*th*-sounds) in Europe. Since the blood does not directly participate in the production of sounds, one would have to find some indirect link between the two facts, and this link need not be physiological as such. The development was certainly related to the movement and the influence of Germanic peoples and languages and to the effect upon these of contact with Slavic and other groups. Thus phonetics and blood show a correlation only because both reflect the distribution, movement, and mixing of historic peoples and not for any causal relation between genes and speech sounds.

A few considerations can be mentioned to support the explanation which I have given here and which is opposed to that of Darlington and Brosnahan. First of all, it should be emphasized that the correlation claimed by Darlington and Brosnahan is positive but not closely so. Furthermore, there are evidently other linguistic features with a more or less similar correlation to O-blood in Europe, for example the use of the definite and indefinite articles in Germanic and neighboring languages and the absence of these articles in Slavic and other Eastern languages. Obviously differences in the patterns of word combination cannot be explained by genes, and especially not by the same genes as those supposed to account for phonetic differences. And finally, the changes discussed by Brosnahan are found in other parts of the world, where there is no connection with O-blood.

In only one place does Brosnahan seem to deal with phonetic changes that may be physiologically induced, and that is when he speaks of Chatterji's observation of a tendency toward the fronting of sounds during recent millennia. Conceivably this is related to change tendencies which occurred during the skull's development from long-headedness to round-headedness, changes which were accompanied by reduction of the length of the palate, thereby giving less contrast to the position of back and front consonants; this could favor the elimination of certain phonetic contrasts, which would then need to be replaced by new ones. Yet, even here, the evidence is far from unmistakable. Perhaps the capacity to distinguish sounds has advanced along with changes in the cranium. At any rate there are round-headed populations whose language differentiates more front-back sound types than other, long-headed ones. Any firm conclusion on an interrelationship will have to be based on much careful study.

MORRIS SWADESH
Universidad Nacional Autonoma de Mexico

Structure Analysis

X-Ray Analysis of Organic Structures. S. C. Nyburg, Academic Press, New York, 1961. xii + 434 pp. Illus. $13.

Organic chemists and biochemists who wish to deepen their understanding of the techniques of x-ray structure analysis and the results of its application to organic systems will find here a book tuned to their needs. The author's aim is to provide a foundation, "with the minimum of formal mathematics . . .," on the basis of which the reader will be able "to assess the reliability of the published results [and] appreciate fully the powers and limitations of the method."

The book is divided into two main parts. In the first, comprising a little over one-third of the book, the x-ray diffraction method of structural analysis is developed. The discussion ranges from experimental techniques (chapter 1) through crystal and molecular symmetry (chapters 2 and 3) to Fourier analysis (chapter 5) and the problems of accuracy of structure determinations