silence" followed, and at a distance of roughly 100 miles there was again a zone of strong sound. Figure 6 shows similar observations collected, after an accidental explosion in 1921, by the Swiss seismologist de Quervain. Richter and I reported an instance in 1930 in which target practice of the Navy off southern California was heard near the source; then came a zone of silence; then, at distances of about 70 miles from the source, the sound was so strong that windows rattled severely and, in one case, were even cracked. There is little doubt that sonic booms which sometimes irritate the population over fairly large areas may result from planes accelerating beyond the sound barrier; these planes may well be between 50 and 100 miles away (see, in Fig. 2, the caustic at the end of the shadow zone, and see Fig. 7). These large amplitudes correspond to those recorded in earthquakes about 1000 miles from the source (Fig. 4, middle and right).

Details of the sound propagation in the atmosphere were first investigated about 30 years ago, when the temperature in the atmosphere above an elevation of about 15 or 20 miles was still unknown. Discovery of the existence of the caustics beyond the zone of silence (Fig. 6) and the observed travel times of the sound left no doubt that at greater elevations the sound velocity, and consequently the temperature, must increase again. Figure 7 shows results for the temperature and wave paths based on calculations which I made in 1925. At that time, great doubt was expressed about the calculated relatively high temperature at an elevation of about 30 miles. Recent direct observations show that the temperatures calculated from the observed sound waves arriving at the ground were substantially correct.

In 1949 Cox pointed out that a second minimum of the temperature and the sound velocity at an elevation of about 50 miles produces a second low-velocity layer. Its effect on the wave paths is indicated in Fig. 7. However, the corresponding waves arriving at the earth's surface are relatively small, since at elevations above 50 miles the absorption of sound increases rather rapidly; the molecules are too far apart to permit good transmission of energy.

Finally, sound waves have been observed to circle the earth repeatedly after large explosions—for example, that of Krakatoa or those of atomic blasts in the atmosphere. These waves correspond in principle to the channel waves (Fig. 2*d*), although other atmospheric processes affect the details.

We thus find that one single, little-publicized phenomenon—the low-velocity layer—which has been disregarded by some geophysicists and mentioned infrequently by others in explanation of observations, plays an important role in many instances of wave propagation through the earth's solid body, the oceans, and the atmosphere (*1*).

Note

1. I presented the first version of this article, "Low-velocity layers in the earth's interior, the ocean and the atmosphere," upon invitation at a meeting of the American Physical Society in Mexico City in June 1950. A revised version was my presidential address before the International Association of Seismology and Physics of the Earth's Interior, in Rome, 14 Sept. 1954. This was published in condensed form in *Geofisica pura e applicata* [**28**, 1 (1954)]. This version contains many references and the original of Fig. 2. The present version is contribution No. 941 of the Division of the Geological Sciences, California Institute of Technology, Pasadena. More detailed data on the low-velocity layers in the earth, and on temperature and pressure and other physical conditions in the earth, may be found in B. Gutenberg, *Physics of the Earth's Interior* (Academic Press, New York, 1959). Additional data are given in B. Gutenberg, "The asthenosphere low-velocity layer," *Annali di Geofisica* (in press). For data concerning the low-velocity layer in the ocean, see M. Ewing and J. L. Worzel, "Long range sound transmission," in "Propagation of Sound in the Ocean," [*Geol. Soc. Am. Mem. No. 27* (1948)]; also, K. Dyk and O. W. Swainson, "The velocity and ray paths of sound waves in deep sea water," *Geophysics* **18** (1953). For discussion of propagation of sound in the atmosphere, see B. Gutenberg, in *Compendium of Meteorology* (American Meteorological Society, 1951), pp. 366–375.

Beno Gutenberg, Geophysicist

The death of Beno Gutenberg in Pasadena, California, on 25 January 1960 marked the end of an era in seismology. That era had been dominated by him. A prodigious worker with broad interests, his was the era before computing machines and team attacks.

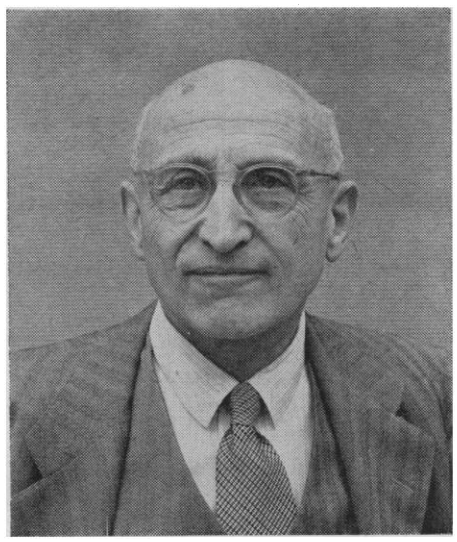
Working alone and with his colleague Charles Richter, he covered the gamut of seismology. His early interest in meteorology continued throughout his life, as did his broad interest in the general problems of the physics of the earth.

Beno was born in Darmstadt in Hesse on 4 June 1889. As a student in the University of Göttingen he worked under Emil Wiechert. At the age of 22 he received the degree of doctor of philosophy, with a thesis on the subject of microseisms. For a year after receiving his degree he remained in Göttingen and completed his great work of computing the depth of the earth's core. His value of 2900 kilometers still stands—one of the few numbers in seismology which is generally agreed upon.

Gutenberg served a year as meteorologist in the army. He then served on the staff of the International Seismological Central Station in Strasbourg. He was a professor at Frankfort in 1930 when he was called to California Institute of Technology as professor of geophysics and meteorology. He later was appointed the first director of the Seismological Laboratory, a position which he occupied until his retirement in 1957.

It is difficult to select particular items from the contributions of so prolific a researcher. The several editions of the *Seismicity of the Earth* (which he wrote with Richter) are a monumental work of great value. When Beno received in 1953 the Bowie medal of the American Geophysical Union the president referred to this work as the "Gutenberg Bible." His collaboration with Richter in the development of the magnitude scale was most fruitful. His computations of energy release by earthquakes were well summarized in his William-Smith lecture before the Geological Society (London) in 1955.

Gutenberg's particular discovery was the low-velocity layer in the earth just below the Mohorovičič discontinuity. His conclusion that this layer exists shows his remarkable feeling for seismograms. The effect of the layer on the amplitudes of *P* waves in earthquakes was apparent to him but not to others. He would reduce the records of various seismographs from various earthquakes to a common denominator. For 30 years, almost alone, he maintained the existence of this layer. Fortunately, in the last two years before his death he found his view generally accepted on the grounds of records of explosions recorded on similar instruments and of the effect of the layer on the dispersion of surface waves. We now have the Gutenberg low-velocity layer as well as the Gutenberg discontinuity at the core boundary.



Beno Gutenberg

Gutenberg's work was recognized as widely abroad as at home. He received the Prix de Physique du Globe (1952) from the Académie royale de Belgique. He was a member not only of our National Academy of Sciences but also of the academies of New Zealand, Finland, Sweden, and Rome. He had been president of the International Association of Seismology and the Physics of the Earth's Interior as well as of the Seismological Society of America.

It is fortunate for us that Gutenberg had just published his last book, *Physics of the Earth's Interior*, before he died. It leaves to young geophysicists an account of earth physics, with particular emphasis on problems needing further study.

The affection which Gutenberg's family felt for him was very strong. He reciprocated fully. He is survived by his widow Hertha, by his son Arthur, and by his daughter Stefanie.

PERRY BYERLY
University of California, Berkeley

The World into Which Darwin Led Us

The Darwinian revolution changed the most crucial element in man's world—his concept of himself.

George Gaylord Simpson

Almost everyone is aware that the year 1959 was the centennial of the publication of *The Origin of Species* by Charles Darwin. It was also the sesquicentennial of Darwin's birth and, coincidentally, of the publication of *Philosophie Zoologique* by Lamarck, the first really important work on organic evolution. That sesquicentennial has been little noted, but the centennial has been most elaborately celebrated by conferences, symposia, all manner of meetings and oratory, and a veritable spate of publications. Every aspect of Darwin, his contemporaries, and his predecessors has been presented. The gamut runs from lavish eulogy of Darwin to peevish accusation of plagiarism and dishonesty. More responsibly, almost everything Darwin ever said or did has been carefully re-evaluated.

In the face of all these studies, it is now practically impossible to say anything fresh about Darwin. (I must confess to a growing surfeit on that topic, approaching boredom.) Yet there are aspects of the subject of such transcendent importance that they bear frequent repetition. At this point there is reason for a summing up not so much about Darwin himself as about the continuing impact of the revolution of which he was the chief initiator.

It has often been said that Darwin changed the world. It has less often been made clear just what the change has been. Darwin did not—to his credit he did not—make any of the discoveries that have led to our present overwhelming physical peril. Most, although not quite all, of our technology would be the same if Darwin's work had not been done, by him or anyone else. Doubtless we would in that case still have our same traffic jams, horror movies, bubble gum, and other evidences of high civilization. The paraphernalia of civilization are, however, superficial. The influence of Darwin, or more broadly of the concept of evolution, has had effects more truly profound. It has literally led us into a different world.

How can that be? If evolution is true, it was as true before Darwin as it is today. The physical universe has not changed. But our human universes, the ones in which we really have our beings, depend at least as much on our inner perceptions as on the external, physical facts. That can be made evident by an elementary example. Suppose a stone is seen by a small boy, an artist, and a petrologist. The small boy may per-

The author is Alexander Agassiz professor of vertebrate paleontology at Harvard University, Cambridge, Mass. This article is the text of an address presented 29 December 1959 at the annual meeting of the American Association for the Advancement of Science, in Chicago.