References

1. BAVINK, B. *Ergebnisse und Probleme der Naturwissenschaften*; 8th Aufl. Bern: A. Francke, 1944.
2. BERTALANFFY, L. VON. *Biol. Zbl.*, 1929, **49**, 83.
3. ———. *Human Biol.*, 1938, **10**, 181.
4. ———. *Naturwissenschaften*, 1940, **28**, 521.
5. ———. *Biologia Generalis*, 1941, **15**, 1.
6. ———. *Theoretische Biologie*. Band II. Berlin: Gebruder Borntraeger, 1942. (2nd ed. in press.)
7. ———. *Naturwissenschaften*, 1944, **32**, 26.
8. ———. *Experimentia*, 1948, **4**, 255; *Nature*, Lond., 1949, **163**, 156.
9. ———. *Biologia Generalis*, 1949, **19**, 114.
10. ———. *Das biologische Weltbild*, Band I. Bern: A. Francke AG, 1949.
11. ———. *Nature*, Lond., 1949, **163**, 384.
12. BURTON, A. C. *J. cell. comp. Physiol.*, 1939, **14**, 327.
13. CLARK, R. E. D. *Darwin: Before and after*. London: Colin, 1948.
14. D'ANCONA, U. *Abh. z. exakten Biol.*, Berlin, Heft 1, 1939.
15. DEHLINGER, U. and WERTZ, E. *Naturwissenschaften*, 1942, **30**, 250.
16. DENBIGH, K. G., HICKS, M., and PAGE, F. M. *Trans. Faraday Soc.*, 1948, **44**, 479.
17. HILL, A. V. *Adventures in biophysics*. Philadelphia: Univ. Pennsylvania Press, 1931.
18. ———. *Proc. roy. Soc.* Lond., 1936, **B11**.
19. KOSTITZIN, A. *Biologie mathématique*. Paris: Colin, 1937.
19a. LEBLOND, C. P. and STEVENS, C. E. *Anat. Rec.*, 1948, **100**, 357.
20. LEPESCHKIN, W. W. *Protoplasma-Monogr.*, Berlin, Band 12, 1937; *Ber. Dtsch. bot. Ges.*, 1939, **57**.
21. LOEWE, S. *Ergebn. Physiol.*, 1928, **27**, 47.
22. LONGWORTH, C. G. *Cold Spr. Harb. Sympos. quant. Biol.*, 1934, **2**, 213.
23. OSTERHOUT, W. J. V. *J. gen. Physiol.*, 1933, **16**, 529.
24. OSTERHOUT, W. J. V. and STANLEY, W. M. *J. gen. Physiol.*, 1932, **15**, 667.
25. PRIGOGINE, I. *Etude thermodynamique des phénomènes irréversibles*. Paris: Durrod, 1947.
26. PRIGOGINE, I. and WIAME, J. M. *Experientia*, 1946, **2**, 450.
27. RASHEVSKY, N. *Mathematical biophysics*. Chicago: Univ. Press, 1938.
28. REINER, J. M. and SPIEGELMAN, S. *J. phys. Chem.*, 1945, **49**, 81.
29. RITTENBERG, D. *J. Mt. Sinai Hosp.*, 1948, **14**, 891.
30. RYSSELBERGHE, P. VON. *Scientia*, 1948, **83**, 60.
31. SKRABAL, A. *Oesterr. Chemiker-Ztg.*, 1947, **48**, 158; *Mh. Chem.*, 1949, **80**, 21.
32. SPIEGELMAN, S. *Quart. Rev. Biol.*, 1945, **20**, 121.
33. VOLTERRA, V. *Lécons sur la théorie mathématique de la luite pour la vie*. Paris: Gauthier-Villars, 1931.
34. WERNER, G. *Sitz. Akad. Wiss. Wien, Math.-naturw. Kl.*, Abt. IIa, 1947, **156**, 457.
35. WERNER, G. and HOBBIGER, F. *Z. Vitamin-Hormon-Fermentforsch.*, 1948, **2**, 234; *Arch. int. Pharmacodyn.*, 1949, **79**, 221.
36. WIENER, M. *Cybernetics*. New York and Paris: J. Wiley, 1948; *Ann. N. Y. Acad. Sci.*, 1948, **50**, 187.
37. WOLTERECK, R. *Ontologie des lebendigen*. Stuttgart: F. Enke, 1940.

Technical Papers

Structure of the Earth's Crust in the Continents

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In 1910 A. Mohorovičić published the first paper in which arrival times of elastic waves from a near-by earthquake were used to calculate the velocity of earthquake waves in the earth's crust. He found for longitudinal waves a velocity of 5.4 km/ sec in the upper 50 km and a velocity of about 7.8 km/sec below that. Earthquake records from other regions furnished similar results and indicated one or more intermediate layers. Later, when artificial explosions were recorded, it was found that the velocity in the uppermost layers is appreciably higher than that found from earthquake records. Data are available now for parts of Europe and the United States. They indicate a velocity of about 6 km/sec immediately below the sedimentary layers, increasing (in some regions) to as much as 6¾ km/sec at a depth of about 10 km. The Mohorovičić discontinuity is found in general at a depth between 30 and 40 km, and the velocity below it is between 8.1 and 8.2 km/sec. The discrepancy between the results from earthquake waves and those from artificial explosions is beyond the limits of error. This new interpretation is suggested to explain all observations:

Below the sediments the material has a velocity of about 6 km/sec for longitudinal waves; this increases with depth and in some areas approaches 7 km/sec at a depth of about 10 km. At a depth of roughly 15 km the velocity decreases (it may be either an abrupt or a gradual decrease), reaching a minimum of about 5½ km/sec at a depth near 20 or 25 km. Below this, it increases again, possibly with a sudden jump, and shows a sudden increase to 8.1 or 8.2 km/sec at the Mohorovičić discontinuity at a depth of between 30 and 40 km in most continental regions, but deeper (up to 60 km at least) under some mountain ranges ("roots of mountains"). At a depth of about 80 km the velocity decreases slightly, and begins to increase again at a depth of about 150 km. It shows no further irregularities down to at least 900 km.

In artificial explosions the waves refracted through the surface layers with relatively high velocities are recorded, but the waves reaching the low velocity layer would be refracted downward and would not turn upward again before they reached a deeper layer with a velocity at least equal to the maximum in the upper layers. Thus, the existence of the low velocity layer could not be revealed by refracted waves from artificial explosions. Calculations of the depth of the Mohorovičić discontinuity would have to consider the low velocity layer.

The source of most shallow earthquakes would be in the low velocity layer. The amplitudes of the direct waves would decrease rather fast with distance, and their travel times would be affected by the velocity in all layers above the earthquake source. Rays starting not too far from a horizontal direction, upward or downward, could not leave the low velocity layer in accordance with ray optics. Thus, they could form a ''sofar channel'' with the peculiar properties which have been studied in the atmosphere and the ocean. At some distance outside such a channel rather large amplitudes are found. Energy radiating from the channel would form the phase (indicated by $\overline{P}$) which has been considered the direct wave in earthquake records. Actually, the direct longitudinal wave in earthquake records would arrive almost simultaneously with the sofar wave at certain distances. The inside limit of the sofar wave would be at distances of 50 km or more, depending on local conditions. The direct wave, traveling above the channel, would precede the $\overline{P}$-wave by increasing time intervals. This phase (called Py in records of California earthquakes) has been considered previously to be a wave refracted through a deeper layer. C. F. Richter is now investigating a number of records from smaller earthquakes in southern California, including data from four semipermanent stations with highly sensitive Benioff-vertical seismographs that have been installed especially for such research. His results to date (unpublished) are in excellent agreement with the new hypothesis. The interpretation of earthquake records studied previously requires an origin time 1–2 sec later, since in the earlier interpretation it has been generally assumed (incorrectly) that $\overline{P}$ starts at the time of origin of the shock. This difference of 1–2 sec has to be subtracted from all Pasadena travel time curves. It explains the fact that waves from the Baker Day test at Bikini arrived about 2 sec earlier than was calculated. The new hypothesis explains other phenomena found from earthquake records.

Thus far, few attempts have been made to explain the fact that material with higher velocity exists on top of material with lower velocity. The author had previously assumed that this was explained by local patches of old sedimentary rocks covering the ''granitic layer'' and H. O. Wood assumed it was owing to local effects of high pressure. It seems now that the phenomenon of the low velocity layer is much more general, at least in the continents. It must be explained either by assuming a succession of relatively thin layers of different material in many regions of the earth's crust or, what is more likely, by the effect of physical processes. In a given material, the velocity of the elastic waves is mainly an effect of pressure and temperature. Experiments indicate that the pressure increases the wave velocity in a given material rather considerably in the upper few kilometers, but much less below about 10 km. Few data are available for the effects of temperature; for quartz, and to a lesser degree for diabase, they indicate a decrease in wave velocity with increasing temperature, followed by an increase. For quartz, a strong minimum can be expected at a depth of roughly 25 km, where the transition from alpha quartz to beta quartz should take place. For diabase, a minor minimum has been calculated by Birch and Dow to occur at a depth of about 10 km. Similar data for feldspar and other constituents of the material in the earth's crust are necessary to establish the actual cause of the low velocity layer at a depth below about 15 km if its existence is proven.

The Mohorovičić discontinuity is not much affected by the new hypothesis. It is still considered by the author to mark the transition from simatic material (basalt, gebbro, etc.) above it to ultrabasic rock below; the decrease in wave velocity at a depth of about 80 km is believed to result from the transition from crystalline to amorphous material near or at the melting point.

References

1. Birch, F. *Geol. Soc. Amer. Special Paper No. 36*, 1942.
2. Gutenberg, B. *Geol. Soc. Amer. Bull.*, 1943, **54**, 473.
3. *Ibid.*, 1943, **54**, 499.
4. Wood, H. O. *Seismol. Soc. Amer. Bull*, 1948, **38**, 33.

Effect of Insulin on the Potassium and Inorganic Phosphate Content of the Medium in Experiments with Isolated Rat Diaphragms

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In 1923 and 1924, Harrop and Benedict (*6, 7*) and Briggs *et al.* (*2*) found a drop in serum potassium after administration of insulin to normal and diabetic human individuals and experimental animals. Their observations have been confirmed repeatedly and it has been shown that this effect was due to a shift of potassium from the extracellular to the intracellular space (*3, 11*). No studies have been made, however, of the effect of insulin on the potassium metabolism of isolated organs or tissues.

In recent years, the rat diaphragm has been widely used for the study of carbohydrate metabolism of the isolated muscle (*4, 9*). For the present investigation the technique of Gemmill (*4*) has been used.

Ten rats of 80–100 g body weight, which had been fasted for 24 hr, were killed by decapitation. The diaphragms were taken out and divided in two halves. Ten hemidiaphragms were incubated in 20 ml of a buffer solution with a mineral composition closely resembling blood plasma (*5*) and equilibrated with a gas mixture of 93% oxygen + 7% carbon dioxide. The pH of this buffer after equilibration is 7.4. The buffer solution contained glucose in a concentration of 200 mg%. The ten other hemidiaphragms of the same animals were incubated under similar conditions in a buffer solution

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