Summary and Conclusions

We feel that the observations described here indicate the molecular heterogeneity of the lactic dehydrogenases obtained from different tissues and from different animals. The data presented indicate that it is possible to classify animals not only by their physiological and morphological characteristics but also by their enzymatic properties, and they also suggest that change in enzyme structure may have been of significance in the establishment of new species. It is also our impression from this preliminary survey, that lactic dehydrogenases of the heart may have undergone considerably greater evolutionary changes than those of the skeletal muscles.

We believe that the results outlined in this article may be of value in studying the interrelationship and origin of species. This may be of particular importance in connection with the flatfish, since the origin of this group of fish is at present quite unresolved. We hope our investigations will eventually enable us to ascertain whether certain peptide chains have been altered during species evolution, as well as in individual differentiation. It is evident from the data presented that the coenzyme analogs (some of which have been used previously and some of which have been recently synthesized) are valuable adjuncts in detecting the heterogeneity of dehydrogenases. It is our hope that studies with crystalline dehydrogenase may enable us to ascertain what part of the enzyme molecule is undergoing structural change during evolution (*18*).

References and Notes

1. W. F. Henion and E. W. Sutherland, *J. Biol. Chem.* **224**, 477 (1957).
2. M. Schlamowitz, *ibid.* **206**, 369 (1954); *Ann. N.Y. Acad. Sci.* **75**, 373 (1958).
3. J. E. Hayes, Jr., and S. F. Velick, *J. Biol. Chem.* **207**, 225 (1955); H. Theorell and R. K. Bonnichsen, *Acta Chem. Scand.* **5**, 1105 (1951).
4. F. Sanger, *Science* **129**, 1340 (1959).
5. C. H. Li, *ibid.* **129**, 969 (1959).
6. L. J. Zatman, S. P. Colowick, N. O. Kaplan, M. M. Ciotti, *Bull. Johns Hopkins Hosp.* **91**, 221 (1952); L. J. Zatman, N. O. Kaplan, S. P. Colowick, M. M. Ciotti, *J. Biol. Chem.* **209**, 453, 467 (1954).
7. N. O. Kaplan, M. M. Ciotti, J. van Eys, R. M. Burton, *ibid.* **234**, 134 (1959).
8. N. O. Kaplan and M. M. Ciotti, *ibid.* **221**, 823 (1956).
9. B. M. Anderson, N. O. Kaplan, C. J. Ciotti, *ibid.* **234**, 1219 (1959).
10. N. O. Kaplan, in *Methods in Enzymology*, S. P. Colowick and N. O. Kaplan, Eds. (Academic Press, New York, 1957), vol. 3, p. 874.
11. N. O. Kaplan, M. M. Ciotti, F. E. Stolzenbach, *J. Biol. Chem.* **221**, 833 (1956).
12. Since most of the analogs react more slowly with the lactic dehydrogenases than with the natural coenzyme, the reactions were carried out with different levels of enzyme. This was particularly true with the mammalian systems. The data in the table represent five times the actual reaction rate observed with acetylpyridine DPN and pyridine-3-aldehyde DPN and twice the actual rate with thionicotinamide DPN. The ratios for deamino DPN and deamino DPNH were obtained from the actual rates. For purposes of comparison, this system has been maintained even in those cases where the reactions are faster with the analogs than with the natural coenzymes—that is, with enzymes from invertebrates.
13. J. S. Nisselbaum and O. Bodansky, *Federation Proc.* **18**, 294 (1959).
14. C. L. Markert and F. Møller, *Proc. Natl. Acad. Sci. U.S.* **45**, 753 (1959).
15. T. E. Mansour and E. Bueding, *Brit. J. Pharmacol.* **8**, 431 (1953); W. F. Henion, T. E. Mansour, E. Bueding, *Exptl. Parasitol.* **4**, 40 (1955).
16. T. E. Mansour, E. Bueding, A. B. Stavitsky, *Brit. J. Pharmacol.* **9**, 182 (1954).
17. P. Elödi, *Acta Physiol. Acad. Sci. Hung.* **13**, 199, 219, 233 (1958).

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L. V. Heilbrunn, General Physiologist

An Outline of General Physiology appeared first in 1937. Like its author, the book was definitive, far-ranging in scope, imaginative, and provocative. Lewis Victor Heilbrunn was certainly one of the most influential individuals in general physiology during the last four decades. Through his book on general physiology (which was thoroughly revised in 1943 and 1952), his scientific papers, his monographs, and most especially his many devoted graduate students, his influence was felt throughout the scientific world. His untimely death in an automobile accident on 24 October snuffed out a creative spirit science can ill afford to lose, but his influence will continue for generations to come.

L. V. Heilbrunn was born in Brooklyn, New York, 24 January 1892. He attended Cornell University as an undergraduate and was awarded the Ph.D. under the direction of Frank R. Lillie at the University of Chicago in 1914, at the age of 22. He then taught for a brief period at the University of Illinois Medical School and for 8 years at the University of Michigan, and he spent a year abroad as a Guggenheim fellow. In 1929 he was appointed to the staff of the department of zoology, University of Pennsylvania—an association that continued for 30 years, until his death.

At Pennsylvania he helped to organize, and became chairman of, the graduate department of general physiology. His course in general physiology was given to senior premedical students and biology majors as well as to graduate students in the department of zoology, and through his course he had a marked influence on many physicians and on scientists in other fields of biology. The course was always popular and well attended and, as one of its most interesting features, the students were given research projects during the second semester rather than formal laboratory work.

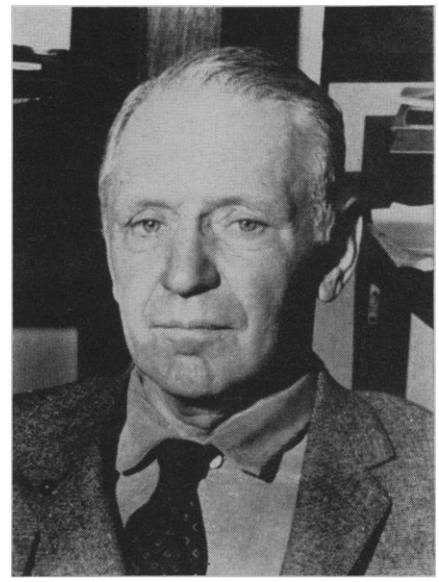
Well over 50 scientists took their Ph.D. degrees under Heilbrunn's direction, and many others did part of their graduate work with him. This group, with its members located all over the United States and abroad, probably represents the most scientifically productive group in general physiology in America to be trained by one individual. Their influence on biology in this country is undoubtedly immense.

Heilbrunn's research interests ranged widely, but with a central theme of protoplasmic structure and action. At a time when general physiology tended to be preoccupied with membranes and permeability, he pioneered in focusing attention upon actions within the body of the cell. His views were first summarized in *The Colloid Chemistry of Protoplasm* in 1928, a book which laid the foundation for an important aspect of cell physiology and which evoked discussion for many ensuing years. One of the most important and influential

fruits of his own work is his calcium release theory of stimulation and response. While his theory has a rare universality of application to biological problems, perhaps his greatest efforts were directed towards the application of his theory to the phenomenon of cell division. Not only was he an authority on cell division as a basic phenomenon but he also attempted to extend his efforts to practical considerations, such as the problem of cancer. He carried out research on such processes as muscle contraction, ameboid movement, and fertilization, and published scores of papers on his scientific efforts. *The Dynamics of Living Protoplasm*, published in 1956, summed up his views and his life's work as well as the work of many of his students and was in his own opinion his most significant statement.

On a strictly scientific basis, Heilbrunn's reputation abroad is as great as in this country. To many in Europe his name is almost synonymous with general physiology in the United States. He made a number of trips abroad to lecture and participate in symposia. In this country he was president of the Society of General Physiologists, an organization he helped found, and he held office in a number of other societies as well as posts on editorial boards of scientific journals, including *Physiological Zoölogy* and the *Biological Bulletin*. He was also coeditor of the extensive monograph series "Protoplasmatologia." His own contribution to that series, *The Viscosity of Protoplasm*, was published in 1958 and was his last major publication. As a graduate student he started work at the Marine Biological Laboratory at Woods Hole, and his association with that institution continued, interrupted only for foreign travel or by his services as a military aviator in the 88th Aero Squadron during World War I (services for which he received the Silver Star with two oak-leaf clusters). He was a trustee of the Marine Biological Laboratory from 1931 on, and served twice as a member of the executive committee. He always took a vigorous interest in that laboratory and participated in many of its activities.

As with many men of great stature, Heilbrunn's major influence was on his associates, especially his graduate students. He loved his science with a devotion that left no tolerance for intellectual sloppiness or dishonesty. His assumption that all scientists did likewise



Lewis Victor Heilbrunn

was one of the early lessons for his students, taught not by edict but by precept and example. Students came from all over the world to work with him and left to occupy positions of influence in their field, enriched with a set of intellectual standards that cannot easily be forgotten. He was a superb teacher who fell into no set educational pattern. His philosophy of education is best stated in his own words from the preface to his textbook: "Some writers in presenting a scientific subject, attempt to over-simplify it in order to make it more understandable. I have known textbook authors who believed in teaching simple facts, right or wrong, rather than run the risk of confusing the student. Such a scheme may have advantages, but I believe that any tampering with truth is extremely dangerous. It is far better to acquaint students with the uncertainties of knowledge in such a frontier subject as general physiology, and to make them sceptical of new experiments. If there were more teaching of this sort, our laymen and our physicians might not be so gullible in accepting false discoveries . . . An enthusiastic teacher is essentially an optimist, and he delights in the achievement of his science."

He had a fine flair for writing and, had time permitted, would have been a leading interpreter of science to the public. As it was, in his general public lectures and in articles in general periodicals he did much to forward public understanding of science. He insisted on sound writing from his students and constantly encouraged them toward good writing.

Heilbrunn worked hard, played hard, and thought hard. For many years he was a prime mover in organizing baseball games at Woods Hole, ping-pong tournaments, and beach parties. More recently his annual "ice-cream parties" on the lawn of his place at Woods Hole were attended with pleasure and profit by many. At the University of Pennsylvania he organized and was for years the moving spirit in the University Research Club, a group of faculty members from the humanities, social sciences, and natural sciences which met monthly for discussion of new research in various fields, and for a social evening. He also, for many years, ran the Journal Club of the department of zoology, a group which met weekly to discuss current topics in biological sciences. His students, past and present, were his personal friends and his personal responsibilities. Their problems were his problems, and he was always ready to lend a helping hand, be it with advice, good conversation, or the loan of a car to go on a date. He could take on such chores of advising and helping because he had an active, not a protective, regard for people.

His interest in the arts, particularly in writing and painting, was an everyday interest, not merely evident on a rare visit to a museum. He established, in 1950, the Ellen Donovan Gallery to promote the appreciation and sale of the work of living Philadelphia artists. His wife, Ellen Donovan Heilbrunn, is a painter and teacher of art. In his life with her and with his daughter Constance he included his students, and drew them into an appreciation of and sometimes a participation in the arts which is rare in a world turned more and more toward science and its techniques. He did not paint himself, but he wrote whenever and wherever he found the time to explore an idea or a way of life—in a small European railroad station, in the dentist's waiting room.

Heilbrunn was a man of strong opinions and had an ability to state them forcefully and clearly. His was a tough mind with little inclination to compromise. His criticisms were stated as clearly as were his praises, and his critics were frequently as vocal as his supporters. His refreshing presence in scientific arguments will be missed by all.

A man who partook of life as intensively and joyously as L. V. Heilbrunn is difficult to write about. Perhaps it is best to use his own words to illustrate the man. In the preface to his *An Outline of General Physiology* he wrote, "In dedicating this book to my students I have thought especially of the men who have done research with me in the laboratory. Eager seekers after truth, they have not hesitated to disagree with me when they thought I was wrong. In their young energy and courage I have taken pride; in their support I have found inspiration." Heilbrunn was an eager seeker after truth; his was ever-youthful energy and courage, and in his support many found inspiration.

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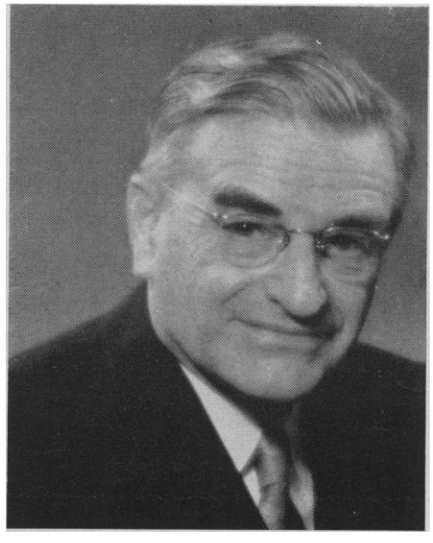
Science in the News

Academy Mission to Asia Will Study Scientific Cooperation

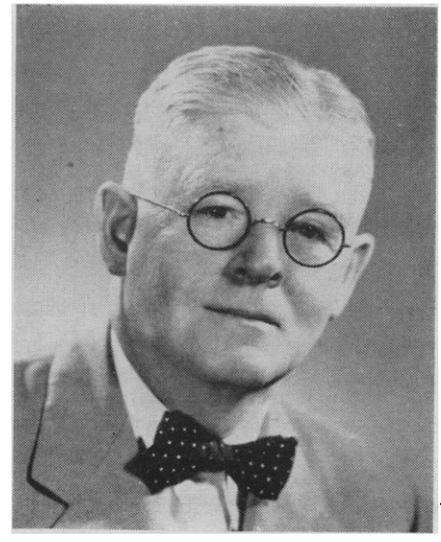
Two members of the National Academy of Sciences will visit 11 Asian countries during the next 4 months to explore with Asian scientific leaders how the development of their countries can most effectively be furthered by science and technology. The two academic ambassadors of science are Farrington Daniels, vice president of the academy and professor emeritus of chemistry, University of Wisconsin, and Ralph E. Cleland, distinguished service professor of botany, Indiana University, and chairman of the academy's UNESCO Committee on Science.

Between them, Daniels and Cleland will visit Pakistan, India, Burma, Thailand, Malaya, Indonesia, the Philippines, Viet Nam, Republic of China (Taiwan), Republic of Korea, and Japan, as well as Singapore and Hong Kong. Conversations, formal and informal, will be held not only with the heads of leading scientific organizations in each country but also with government officials in science and education, members of science and engineering faculties, and researchers in basic and applied sciences.

It is hoped that these contacts will lead to closer working relationships between scientists of both regions and to deeper understanding on the part of the academy of the scientific and technical aspirations of each country and of how these aspirations can best be served by the academy and the private and governmental organizations with which it is associated.



Farrington Daniels



Ralph E. Cleland

Asia Foundation Supports Mission

This first Asia-wide study of the problems of scientific development in emerging nations has been arranged under the joint auspices of the academy and the Asia Foundation (San Francisco, Calif.). The latter has representatives in nearly all countries to be visited and supports science programs in Asian scientific and educational institutions.

Robert Blum, president of the foundation, points out that in science, as in other fields, too few Asian leaders have had an opportunity to exchange views with Americans of distinguished reputation and broad interests. Blum sees the tour of Daniels and Cleland as part of a broader program in which outstanding Americans may visit Asia under private sponsorship for candid discussions on issues and problems of mutual interest.

In addition to their more general discussions, Daniels and Cleland plan to report on recent findings in two scientific fields of particular interest to Asian countries—solar energy and plant genetics. They will give popular lectures to large groups and technical lectures to professional specialists. Daniels—a distinguished physical chemist whose special interest in the applications of solar energy has taken him previously to India, Pakistan, and Thailand—will propose that concentrated research in this field of study offers greater and far more immediate rewards to most nations than corresponding efforts in the fields of atomic energy. Cleland, an internationally recognized botanist, will carry a similarly affirmative message on the subject of plant genetics; he says that there are many countries on his itinerary where agriculture could profit directly from an increased emphasis on research in this field.