The resulting reduction in inorganic phosphate and creatine and increase in phosphocreatine displaces the equilibrium of reaction 1 toward the left. Glycogen resynthesis then begins, the inorganic phosphate thus produced being continuously reesterified by reaction 3. The mechanism of energy coupling is clear. A part of the energy of carbohydrate oxidation is converted to energy of phosphorylation by the aerobic phosphorylation mechanism. This energy of phosphorylation is then expended in resynthesizing glycogen from lactic acid.

In a steady state of rest or low work output, under aerobic conditions, glycolysis would be regulated by the fact that the aerobic phosphorylations can proceed at a lower concentration of inorganic phosphate than is compatible with an appreciable glycolysis rate. Furthermore, the rate of carbohydrate oxidation will be limited by the available concentration of inorganic phosphate. It would thus necessarily follow that oxidation is slow in the resting state because of the lack of the inorganic phosphate which is essential to the phosphorylative oxidation process. Only the liberation of inorganic phosphate concomitant with metabolic work would permit acceleration of carbohydrate oxidation. When the rate of inorganic phosphate liberation exceeds the rate of oxidative phosphorylation, the resulting accumulation of phosphate will accelerate glycolysis.

In view of the foregoing, the mechanism of the Pasteur effect in muscle and other tissues is readily outlined. Since oxidative phosphorylation is more energetic (*i.e.*, capable of attaining a higher phosphocreatine-creatine ratio) than glycolytic phosphorylation, the admission of oxygen to muscle rapidly reduces the level of inorganic phosphate and raises the phosphocreatine-creatine ratio until a point is reached where glycolysis must begin to reverse. Since the number of molecules of phosphoric acid esterified per molecule of carbohydrate consumed is much larger in oxidation than in glycolysis, a much lower rate of carbohydrate disappearance suffices to maintain a high phosphorylation level in the face of the energy demands for muscular work or other energy-consuming reactions. One measure of the Pasteur effect is the number of carbohydrate molecules protected from glycolysis per carbohydrate molecule oxidized. This quotient should be equal to the ratio of the number of molecules of phosphoric acid esterified when a carbohydrate molecule is oxidized to the number esterified when a carbohydrate molecule is glycolized.

When yeast grows anaerobically its sole source of energy is, as far as present knowledge goes, the two molecules of phosphate ester which are produced when one molecule of glucose is converted into ethyl alcohol and carbon dioxide. In other words, the yeast cell seems able to utilize energy of phosphorylation for every energy requirement of its metabolism. It is only reasonable to suppose that aerobically, the energy of phosphorylation used by the cell is supplied by the phosphorylations accompanying aerobic oxidation. If the respiratory mechanism of yeast is similar to that of animal tissue, it may be assumed that the number of aerobic phosphorylations is sufficiently large to account for the decreased fermentation observed[10] for yeast under aerobic conditions.

The Pasteur effect in yeast, as in muscle, would thus be interpreted as following from the fact that, aerobically, a relatively low rate of sugar utilization suffices to reesterify phosphate as rapidly as it is liberated by energy-consuming metabolic reactions.

Since the foregoing was submitted, the paper of Colowick *et al.* (*Jour. Biol. Chem.*, 137, 343, 1941) has appeared, in which it is concluded that at least 10 atoms of phosphate are esterified per glucose molecule oxidized. This is supporting evidence for point (4) above. Moreover, Cori (Biological Federation Annual Meeting, Chicago, April, 1941) has announced the experimental reversal of the conversion of glucose-1-phosphate into glucose-6-phosphate (point (1) above), and has independently reached the conclusion that energy of aerobic phosphorylation is utilized for carbohydrate resynthesis. Once this conclusion is reached, it becomes difficult to escape consideration of the interpretation of the Pasteur effect outlined above.

OBITUARY

GEORGE ELLETT COGHILL

George Ellett Coghill belonged to that small and select group of scientific workers who at the beginning of a fruitful career formulate a specific program of research with a clearly defined objective and thereafter devote themselves consistently and unfalteringly to intensive investigation of the chosen theme. In his case the problem has so wide implications and the results of the inquiry are of so great interest in fields as far apart as comparative embryology and human motivation that it may safely be said that his work is one of the major American contributions to fundamental biology.

After completing the classical course at Brown University and a year of study in a conservative theological seminary, he found further effort in this direction unsatisfying. In perplexity and mental agitation he retired to the open spaces of the Southwest, where he spent five months of vagrant wandering in northern

[10] O. Meyerhof, *Biochem. Z.*, 162: 43, 1925.

New Mexico. With horse and camp equipment he drifted as the mood directed, alone with his thoughts most of the time, but accompanied occasionally by his younger brother Will, who was then beginning his engineering education. This thinking in solitude culminated in the resolve to study the nervous system as a biological approach to a scientific psychology and a naturalistic philosophy.

This was in late summer, 1897, when a chance meeting with the president of the Territorial University at Albuquerque opened the way toward the accomplishment of his purpose. Three years of apprenticeship with President C. L. Herrick fixed his resolve and defined the objective. Returning to Brown University, he earned the Ph.D. degree in zoology, then taught zoology in three colleges, anatomy at the State University of Kansas, and later occupied a research position at the Wistar Institute of Anatomy and Biology.

He was born at Beaucoup, Illinois, on March 17, 1872. The academic record includes, A.B., Brown University, 1896, Ph.D., 1902; M.S., University of New Mexico, 1899, assistant professor of biology, 1899–1900; professor of biology, Pacific University, Oregon, 1902–1906; professor of biology, College of Arts, and of embryology and histology, College of Medicine, Willamette University, Oregon, 1906–1907; professor of zoology, Denison University, Ohio, 1907–1913; associate professor of anatomy, Kansas State University, 1913–1916, professor, 1916–1925, head of the department of anatomy and secretary of the School of Medicine, 1918–1925; professor of comparative anatomy, Wistar Institute, Philadelphia, 1925–1935. Broken in health, he retired in 1936 to Gainesville, Florida, where he built a dwelling and a small private laboratory and continued his research program as strength permitted until his death, July 23, 1941. Honorary Sc.D. degrees were received from Pittsburgh, Denison and Brown Universities. He was a member of the National Academy of Sciences, American Philosophical Society, American Association of Anatomists (president, 1933), American Society of Zoologists, American Neurological Association (associate) and other scientific societies. He was editorially connected with the *Journal of Comparative Neurology* from 1904 until his death and was managing editor from 1927 to 1933.

The task to which Dr. Coghill addressed himself can be stated very simply—the correlation of development of patterns of behavior with the progressive differentiation of the organs which execute the behavior. He selected for intensive study a primitive and generalized animal in which the essential features are reduced to simplest terms, the salamander, Amblystoma. In this choice he showed insight, for during the span of the forty years of his labor this has proved to be the most serviceable type for a wide range of experimental researches. In this program he broke new ground in both aim and methods of work.

The first step was the determination upon statistically adequate numbers of specimens of the actual sequence of development of patterns of overt behavior characteristic of this species. A series of specimens, each of which was known by test to have reached a specific stage in this physiological scale, was then examined microscopically to detect the structural changes in internal organization correlated with the successive steps in the growth of the action system.

Most of the factual material published is included in the twelve parts of his "Correlated Anatomical and Physiological Studies of the Growth of the Nervous System of Amphibia."[1] These papers are models of close, accurately controlled observation and clear description, but the technical details are hard reading for any but experts in the field. As the mass of data began to reveal meaning to his mind he published from time to time brief summaries and interpretations. These papers are listed in the bibliography to be published.[2] The most important of them are the lectures on "Anatomy and the Problem of Behavior" delivered in London (Cambridge University Press, 1929) and the presidential address before the American Association of Anatomists on "The Neuro-embryologic Study of Behavior: Principles, Perspective and Aim."[3]

This was pioneer work, the first and until now the most complete account of the actual relationship between progressive differentiation of bodily structure and the operations of that structure as manifested in the maturation of patterns of overt behavior. The accuracy of the observations has been checked by numerous other observers and the conclusions drawn from them seem to be valid for the material studied. Caution must be observed in the extension of these principles to animals differently organized and with different developmental history. These questions will be clarified in due time, for many similar studies are now in process on the development of other animals from fishes to man.

The most important and far-reaching result of this series of researches is the impressive demonstration of the unity and integrity of the organism, the dominance of the "total pattern" over "partial patterns" at all stages of normal development, and illustrations of types of structural organization which perform both the integrative and the analytic functions. Dr. Coghill's original interest in the psychological and philosophical implications of his observations never waned, but unfortunately little of his thinking in these fields

[1] *Jour. Comp. Neur.*, 1914–1936.
[2] *Jour. Comp. Neur.*, Vol. 75, October, 1941.
[3] Science, Vol. 78, 1933.

came to expression in print. Scattered comments in his lectures and theoretic papers show that his comprehension of the significance of his observations for psychology and philosophy was clear-cut and profound.

C. JUDSON HERRICK

THE UNIVERSITY OF CHICAGO

HARRY MILTON WEGEFORTH

HARRY MILTON WEGEFORTH, M.D., born in 1882, in Baltimore, Maryland, died in San Diego, California, on June 25, 1941, at the age of 59. He was a graduate of Maryland University in 1906. He practiced as physician and surgeon in San Diego from 1910 until 1935.

In 1916 he became interested in founding, organizing and developing the San Diego Zoo. He served as its president from its inception until his death, nearly 25 years. His first objective for the Zoo was to make it of value to the children of the community. To attain this objective, he pioneered many modern procedures; barless moated grottoes, animal family groups and lecture bus trips. To make the Zoo more realistic, he obtained plants from the countries from which the animals came and tried to make the entire background reflect the home environment.

He sponsored an animal hospital and research laboratory making available full utilization of animal exhibits both during exhibition and death for scientific study. Research fellowships made possible the study of special problems in animal health.

By his leadership and example, he gained the confidence and support of the many friends that have made the San Diego Zoo a monument to his memory.

W. C. CRANDALL

LA JOLLA, CALIF.

RECENT DEATHS

DR. CHARLES BRANCH WILSON, biologist, from 1897 to 1932 head of the department of science of the Massachusetts State Teachers College at Westfield, died on August 18 in his eightieth year.

DR. ELLISON ADGER SMYTH, JR., until his retirement in 1925 professor of biology and from 1903 to 1906 dean of the faculty at Virginia Polytechnic Institute, died on August 19 at the age of seventy-seven years.

DR. JOHN MORPHY SNELL, since 1937 research chemist of the Eastman Kodak Company, died on August 8 in his thirty-fifth year.

A CORRESPONDENT writes: "Dr. Mataro Nagayo, formerly president of the Tokio Imperial University, Japan, director of the Japanese Foundation for Cancer Research, and the editor of *Gann,* the Japanese journal of cancer research, died on August 16 at the age of sixty-three years. In recognition of Dr. Nagayo's achievements, the Emperor of Japan conferred on him the title of Baron."

SCIENTIFIC EVENTS

FIELD WORK IN GEOLOGY IN CANADA

A PROGRAM of field work comprising the mapping and examination of many thousands of square miles of mineral areas throughout the Dominion of Canada is being undertaken this year by the Mines and Geology Branch, Department of Mines and Resources, Ottawa. Twenty-seven geological parties and nine topographical parties have been assigned to the work. A feature of the program is the investigation being made of possible commercial sources of tungsten, chromite and manganese, three of the strategic minerals, the production of which in Canada has been small.

Two of the geological parties are working in the Northwest Territories, one in Yukon, six in British Columbia, four in Alberta, one in Saskatchewan, one in Manitoba, two in Ontario, six in Quebec, one in New Brunswick and three in Nova Scotia. Two of the topographical parties have been assigned to British Columbia, two to Alberta, three to Quebec and two to Nova Scotia.

The program includes the following projects:

In British Columbia five of the geological parties are engaged in the mapping of areas in which deposits of mercury, chromite, gold, copper and other minerals occur, as an aid to prospecting and development. The areas are being mapped on a four-mile scale and have a total area of approximately 15,000 square miles. Another party is reexamining the geology of an important gold-producing area. A. F. Buckham is reexamining the Barkerville gold belt in the Cariboo district. Since 1934, when the area was last examined, its gold production has shown a threefold increase and developments at depth have disclosed structures, the relationship of which to the gold deposition is not clearly defined. The work in Alberta and Saskatchewan is part of the general effort to aid in the search for new oil fields. The Province of Alberta is the source of about 96 per cent. of Canada's annual output of crude petroleum.

In Quebec the geological and topographical exploration of the 40,000-square mile region east of James Bay, in charge of G. Shaw and J. Carroll, is one of the largest projects undertaken by the Mines and Geology Branch in recent years. The purpose is to produce an 8-mile-to-the-inch exploratory map; to outline areas favorable for prospecting, and to indicate the main travel routes. At