that SO_4^{--}, PO_4^{---}, SeO_4^{--}, and Ca^{++} were easily washed from outer space, and Russell and Adams (*24*) found that considerable phosphate was removed from barley roots by washing prior to analysis.

Leaves often are washed to remove dust from their surfaces, but this may also remove considerable amounts of various solutes. Although Hammar (*25*) found that washing did not materially affect the chemical composition of pecan leaves, the results of leaching studies on other species suggest that considerable salt and even organic solutes might be removed by washing. This increases the difficulty of dealing with roots covered with soil and leaves covered with dust or spray residue, but the probability of significant leaching during washing cannot be evaded. Britten (*26*) recently reported that proline is washed out of *Escherichia coli* cells by washing in water or a dilute solution.

It would be interesting to know more about the relative physiological importance of the ions and other solutes in outer and inner space. It might be argued that those substances which occur in outer space are in more intimate contact with cytoplasm and are more important physiologically than the larger fraction which is accumulated in the vacuoles. The usual methods of analysis do not distinguish between the fractions in inner and outer space, but methods could be devised to estimate the two fractions. Such information might be more useful in studies of translocation and plant nutrition than information concerning the total amount of an element present in a plant.

Need for Correlation of Research

Failure of previous investigators to apply the concept of outer space to an explanation of the various phenomena discussed in this article illustrates a basic weakness in modern science. Too little attention is being given to the correlation and interpretation of separate pieces of research. Thousands of investigators are collecting data and publishing data, but very few are correlating and interpreting their results. Investigators working with bacteria, yeast, plant roots, and animal tissue have all observed similar phenomena, but little attempt has been made to draw any general conclusions from these observations. The investigators who first developed the concept of outer space in roots thought of it only in terms of salt absorption in roots, while the workers studying salt absorption through leaves, leaching of solutes out of leaves, or the relation between water and salt absorption were so concerned with their own particular problems that they failed to see the relationship between their work and that of other investigators. As a result, the broad implications of the concept of outer space have been overlooked by most physiologists.

It is possible that further research will result in revision of the rather simple concept of outer space or free space which is now held. Its potential importance in explaining several different phenomena certainly justifies additional research to gain a better understanding of it. If outer space occupies as large a volume in plants as now seems probable, considerable revision of our present explanations of ion absorption and translocation may be necessary.

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A. S. Pearse, Ecologist

Arthur Sperry Pearse, emeritus professor of zoology at Duke University, died 11 December 1956 in Durham, North Carolina, at the age of 79 years. He was born 15 March 1877, on the Pawnee Indian Reservation near Crete, Nebraska, where his father and mother managed a trading post. His boyhood was spent there and in Denver, Colorado. In growing up he experienced many colorful adventures in the rough life of the western mining camps and pioneer farms of the period, and throughout his life he, like Theodore Roosevelt, was an ardent exponent of the strenuous life.

From the very beginning he was intensely interested in natural history, and it is not surprising that he became an ecologist. He began collecting in these early years. In his autobiography, *Adventure: Trying To Be a Zoologist,* he writes, "As a boy I loved animals and everything concerning them. I was born to be a zoologist." Many events and many people were to influence his career. While attending high school at Beatrice, Nebraska, he studied chemistry and physics under Samuel Avery, who later became president of the University of Nebraska.

At the University of Nebraska he played football—the beginning of a lifelong love of athletics. Characteristically, he left the university in 1898 to serve as corporal with the 4th Nebraska Volunteer Infantry in the Spanish-American War, returning to receive the bachelor of science degree in 1900. While teaching high school at Omaha he worked for his master's degree under the direction

of his old professor at Nebraska, H. B. Ward, who gave him his fundamental training in parasitology. In 1941, the University of Nebraska conferred an honorary LL.D. degree on this distinguished alumnus.

After receiving his Ph.D. degree at Harvard University in 1908, under George H. Parker's guidance, Pearse began an active career in parasitology and ecology. These fields of investigation carried him from the shores of Lake Michigan and Lake Mendota in Wisconsin to the Philippines, to the rain forests of Colombia and Venezuela in South America, to the cenotes and caves of Yucatan, to the Dry Tortugas, on to Japan, China, Siam, and India, and to England and Nigeria. In 1929–30 he was visiting professor at Keio University in Japan. From these experiences came his volume, *Hell's Bells,* a reflection of his philosophy and his wide interest in the life of the peoples among whom he visited.

At the University of Michigan there developed the beginnings of his lifelong friendship with Alexander G. Ruthven, who later became president of the university and with whom he made a scientific expedition to Colombia. An ecologist at Wisconsin during a portion of the lengthy Birge and Juday era of lake studies, Pearse, too, contributed extensively to the biology of fresh-water fauna. As a special member of the field staff of the International Health Board of the Rockefeller Foundation, he studied the incidence of hookworm infection in Alabama in 1925, and the next year, in Nigeria, was ecologist on the team of scientists that established the fact that yellow fever was not carried by spirochetes, as had been previously suggested by Noguchi. Pearse's early affiliation, for three seasons, with the invertebrate zoology class at the Woods Hole Marine Biological Laboratory acquainted him with marine life and furnished the background for much of his later research on the ecology of marine fauna, a field in which he made perhaps his greatest contribution.

While Pearse was teaching in the zoology department of Duke University, his interest in marine biology led to the founding of the Duke University Marine Laboratory at Beaufort, North Carolina, in 1938. The station, in its present state of development, has largely followed the plans he originally envisioned. Pearse served as director of the station for 10 years.

His publications, numbering about 175, were not limited to a narrow field of specialization. A dynamic worker, he was readily able to adjust himself to new conditions, so that, wherever he was, he quickly found research interests. Inland, in lake country, he studied fresh-water fauna; at the seashore, he concentrated on beach and estuarine animals; on the Duke campus, stimulated by the proximity of the Duke Forest, he investigated the fauna of soil and forest environments. An expert on Crustacea, he published numerous papers on parasitic crustaceans and described many new species of copepods parasitic on marine fishes. His studies of animals living in association with one another led to coinage of the term *consortes* to cover the numerous conditions found in the ocean where the nature of the interrelationship, whether symbiotic, commensal, or parasitic, was not clear. An underlying theme of much of his work in marine ecology was the migration of animals from sea to land. This idea was ever before him as he traveled in various parts of the world. His book, *Emigrations of Animals from the Sea,* summarizes much of this research and shows his originality of thought. Among other books written by him is his *Animal Ecology,* one of the few important textbooks in that field in his day. This book demonstrates the depth of his knowledge of animal associations. Pearse founded *Ecological Monographs* and found time to be its editor from 1930 to 1950.

His early efforts to educate himself, in Beatrice, at the University of Nebraska, and later at Harvard University, gave him an understanding and love of students which continued all his life. In the teaching positions he successively held at Harvard University, the University of Michigan, the University of the Philippines, St. Louis University Medical School, and the University of Wisconsin, and as chairman of the department of zoology at Duke University, he always insisted that the welfare of the students came first. Although he was reported by a faculty colleague to violate every known rule of pedagogy, he always had an enthusiastic following of both graduate and undergraduate students. He especially liked to teach freshmen, with whom he said "one could do much before they were contaminated by college life." His graduate students will remember the genial hospitality of his house, where, with his wife and children, he entertained a great many of them. He instilled his love of field work in his students and never let them be daunted by high winds, torrential rains, or other minor discomforts. Brusque and brief, always ahead of schedule, he sometimes overawed them until they came to understand his informality and kindness. Generous as he was to organized charities, he was even more generous to those he knew to be in need. Stories cluster about his name, making him an almost legendary character in the various places he lived.

Pearse was a member of many scientific societies and served as president of the Ecological Society of America (1925), American Society of Zoologists (1945), Association of Southeastern Biologists (1942), and North Carolina Academy of Science (1951) and as vice president of the American Association for the Advancement of Science, Section F (1936).

His influence contributed in no small measure to the development of modern scientific scholarship at Duke University. Among the first group of graduate professors to be appointed, he helped to organize the University Research Council and was its first secretary. His aim was always to promote more effective teaching, research, and scholarship. As he gratefully acknowledged his debt to his teachers and associates in zoology, so, too, his many students will continue to credit him with the inspiration which he so notably contributed to their lives and their research. He left an indelible mark on all who knew him.

I. E. GRAY
Department of Zoology, Duke University, Durham, North Carolina