to be regretted that the limits of the book did not allow a somewhat more expanded treatment, especially of the Reptilia and Primates.

On pages 403 to 406 one finds a brief bibliography of some of the more important books on subjects treated in the volume, and then follow three pages giving in tabular form the geological time scale and the geological ranges of the principal classes of plants and animals. The remaining 39 pages are devoted to an unusually full index and glossary.

The illustrations in the book deserve special mention. They are very numerous, and an unusually large number are original or redrawn for this work, and all are remarkably clear, well executed, and well reproduced. The figures of the echinoid, pages 167 and 168, may be particularly noted for their delicacy and clearness. Altogether the illustrations are better than those usually found in an elementary text-book.

A very useful feature is the practise throughout the book of giving the derivation of the generic and other group names. The questions, designed to direct laboratory work in connection with the text, will be of more or less value, according to the individual teacher. They serve as a review for the reader and draw attention to the important points in the descriptions. The book is of convenient size, the type good, and though certain paragraphs and the questions are set in another font from the main part of the text, the differences are not so great as to mar the appearance of the page, and are by no means comparable to the "fine print" of a generation ago.

As a text for an introductory course in paleontology the book strikes one as especially well balanced and well done. It will also be found extremely useful to the students of zoology and historical geology, and furnishes us with an answer to the question put so often to a geologist or paleontologist: "Where can I find a book about fossils which I can read without first studying paleontology?"

This review is not meant either as a eulogy or as a criticism of the book in hand, but the writer is aware that the text does contain some small slips, of the kind so peculiarly annoying to the author, but so difficult to detect in proof-reading. Most of these are small things which are either so obvious as to be without danger to the student, or things which would be apparent only to the specialist, and may easily be corrected in a later edition. One which might perplex the beginner is on page 352, where the Urodela are called Lizards. The others are almost all in the explanations of the figures.

PERCY E. RAYMOND

HARVARD UNIVERSITY

SPECIAL ARTICLES

ON THE LIFE OF ANIMALS WITH SUPPRESSED KIDNEY FUNCTION

BOTH clinical and laboratory observations agree in demonstrating that many of the so-called consequences of kidney disease are really nothing of the kind, but must be interpreted in some other fashion. Thus, the assumption that the edema sometimes found in patients suffering from kidney disease is the consequence of the disturbed kidney function lacks all support, for patients with complete suppression, or animals from which both kidneys are removed, do not show any consequent edema. In fact, such patients and animals steadily *lose* in weight unless special efforts are made to keep this up. Large, nephrectomized rabbits, for example, will lose some 50 grams per day before they succumb some four to eight days later.

In the same way that clinical experience and experiment have shown that the edema accompanying certain kidney disturbances is not to be regarded as a consequence of the loss of kidney function, they prove also that high blood pressure, cardiac hypertrophy, and the clinical manifestations of headache, stupor, coma, etc., so commonly regarded as "uremic" are not secondary to such loss of kidney function as so widely believed. The fact remains, however, that even though much revision is necessary in our interpretation of the signs and symptoms evidenced by victims of kidney disease, loss of kidney function is commonly regarded as incompatible with any prolonged continuance of life.

Why does man or an animal deprived of his kidney function die? Since nephrectomized animals regularly show a progressive loss in weight, and since this is, in the main, only water, a first reason for death might reside in the gradual drying-out of the tissues. Whether the animal is fed or whether it is starved, a certain minimum of necessary chemical changes goes on, which continue, as long as the animal remains alive. A second reason for the death of the kidneyless animal resides, therefore, in the accumulation of metabolic products within the organism which normally are thrown off in the urine. A third reason for death (but one for which at present we lack every experimental proof) might reside in the loss of some internal secretion produced by the kidney and necessary for life of the organism as a whole.

The analysis of the conditions necessary for a proper exhibition of kidney activity would seem to indicate that it is the primary function of the kidney to secrete water. It secretes water in proportion to the amount brought it in a free state in the arterial blood stream. As this free water passes down the uriniferous tubules it leaches out of the cells bordering it and constituting the kidney parenchyma the dissolved substances which give urine its distinguishing characteristics (urea, ammonia, creatin, sugar, salts, etc.) which substances originally diffused into the kidney parenchyma from the blood stream.

If we ignore the matter of an internal secretion, these considerations, if correct, compel the conclusion that the kidney is of importance to the animal, first, because it is an organ through which water may be lost when present in amounts over and above those necessary to saturate the tissues (saturate the hydrophilic colloids); and second, because this loss of water makes possible the loss of certain dissolved substances which appear in even normal metabolism.

The steady loss of water in the ill or by a nephrectomized rabbit, for example, need not, of course, be an important element in the causation of death. Care in the administration of water by rectum or subcutaneously can overcome this. Nor is the inability to lose much water quickly, as by the kidney route, alone an insurmountable cause for death. Even under physiological conditions the human being not only can but does lose more water from the lungs and skin than through the kidneys. What is missing is the possibility of losing along with the water the various dissolved substances which appear as the products of metabolism. If this reasoning is sound it is to be expected that, other things being equal, *animals deprived of their kidney function should live the longer the better the possibilities of securing an adequate loss of dissolved substances along with their water elimination.* The facts bear this out. The furred animals, for example, which lose no water except through the lungs, after the kidneys are removed, survive this operation little more than four to eight days. The human species with its ability to sweat tolerates loss of kidney function some six to twelve days. James Taggart Priestley has reported the case of a patient who lived 22 days with complete suppression of urine. It is considerations of this kind that have prompted clinical workers to resort to sweating and catharsis by way of transferring to the skin and gastro-intestinal tract the functions which are ordinarily subserved by the kidney whenever this organ is pathologically affected. But even when advantage has been taken of such potentialities, the lives of patients with complete loss of urinary function have not been long.

It occurred to me that it ought to be possible to observe a greater span of life in animals after complete suppression of kidney function if only it were possible on the one hand to cover the needs for water absorption and water loss, while on the other, provision were made for an adequate loss of the products of metabolism which normally are leached out by the water which passes through the kidney.

Such conditions are satisfied in the case of the frog. Not only does the frog cover its daily needs for water (saturate its body colloids) by spending a part of its time in the water, but it also loses under the same circumstances the same group of materials which ordinarily give the urine its characteristic composition. The problem is similar to that in man, who loses the same dissolved substances in the sweat that he loses in the urine, only in less amount. The frog does the whole more easily. When sitting in the water it not only absorbs water to supply its needs, but loses at the same time the non-volatile products of its daily metabolism (these diffuse into the water from the skin exactly as the same substances in the mammal diffuse from the kidney cells into the water running down the uriniferous tubules). As I have so frequently insisted, solutions are not absorbed or secretions given off "as such." While a secretion of water and of dissolved substances may occur in the same direction, they may quite as easily take opposite ones. These considerations make it apparent why on *a priori* grounds alone *the frog (and other amphibia) should be able to tolerate a loss of kidney function better than land animals.*

Experiment has justified the conclusion. I tried originally to bring proof in this direction by cutting the kidneys out of frogs. The operation is not only difficult, but fails because of the anatomical peculiarities which characterize the circulation in these animals. Since the venous blood returning from the legs passes through the kidneys, their excision is followed by an edema of the hind legs. To escape this effect and yet to exclude the external function of the kidneys, the ureters were therefore tied. Under aseptic precautions a series of frogs were operated upon through the flanks and the ureters isolated. They were tied with a first ligature close to the kidney and with a second as near the bladder as possible, the connecting segment of ureter being cut out. *These animals have now lived since January 8 of this year and are perfectly normal.*

My technical assistant, Josef Kupka, showed me how to keep these animals in excellent condition. They are housed in glass boxes heavily padded with moist moss. Inverted porcelain dishes with side openings permit them to hide. A shallow enamel pan always filled with fresh water is placed at one end of each cage. Every few days the frogs are fed live meal worms, which they devour ravenously. The wounds heal completely two weeks after the operation. At the present writing the animals thus operated are livelier and in better physical condition than the winter frogs comprising the stock from which they were chosen.

The kidneys of the frog after ureteral ligation seem to suffer but slight if any change. What has been observed will be discussed at another time.

These experiments prove that *frogs may live for weeks after complete suppression of external kidney function.* If the explanation of why this is possible in the frog is accepted as correct, it not only gives scientific support to long-established empirical clinical practises, but emphasizes the importance of a closer analysis of the conditions which may improve qualitatively or quantitatively the matter of absorption and secretion of water and absorption and secretion of food and the products of metabolism through the skin and bowel in the patient suffering from an inadequate kidney function.

MARTIN H. FISCHER
EICHBERG LABORATORY OF PHYSIOLOGY,
UNIVERSITY OF CINCINNATI

SOCIETIES AND ACADEMIES

THE CHICAGO ACADEMY OF SCIENCES

THE annual meeting of the Chicago Academy of Sciences, held January 12 at the Academy building in Lincoln Park, Chicago, was an occasion of special interest. The chief speaker was Dr. Albert A. Michelson, of the University of Chicago, who presented in simple, untechnical language the results of his remarkable studies on the rigidity of the earth. Dr. T. C. Chamberlin reviewed the history of the academy during the past eighteen years, during which time he had been president, and the following officers for the coming year were elected:

Professor John M. Coulter, President.
Professor Henry Crew, First Vice-president.
Dr. Stuart Weller, Second Vice-president.
Dr. Wallace W. Atwood, Secretary.
Mr. Henry S. Henschen, Treasurer.

Mr. LaVerne Noyes, president of the board of trustees, spoke encouragingly of the present and future work in the museum. Mr. Noyes is especially interested in the construction of habitat groups illustrating the natural history of Chicago and vicinity, and through his personal supervision and generosity a remarkable series of forty-one new groups was opened for inspection at the close of the business meeting. Dr. Wallace W. Atwood, of Harvard University, who has held the secretaryship of the academy during the last few years, and been associated with the academy boards in the or-