brane and the digestive epithelium, as well as the latter itself, being clear and unstained. Moreover, the wall of the mesenteron can be dissected away without difficulty, leaving intact the tough peritrophic membrane with its oily contents.

It might be thought that the water supply would be an acute problem for an animal living in such a medium, but this is not so, for distillation tests reveal that there is a considerable amount of water contained in the oil in the form of minute droplets, and, moreover, in many cases the oil pools overlie shallow pools of water, those most frequented by larvae being those in which there is no great depth of oil.

One would have imagined that an animal living in oil would be immune from the attacks of parasites, and it is interesting to find that a protozoan has been able to follow its host into such an environment. Certain of the epithelial cells of the mesenteron are seen in section to be distended with spores of a sporozoan parasite, apparently a microsporidian, the nucleus often being pushed to one side by the mass of spores. These bodies are approximately 4 μ in length and stain very intensely with toluidine blue, hematoxylin and methyl blue-eosin, the multinucleate nature of the spore being most clearly seen with the latter stain. Lack of material exhibiting further stages in the life history has so far prevented closer identification.

It is a remarkable thing that *P. petrolii* should exhibit no structural peculiarities correlated with its unique mode of life. With the possible exception of the unusually great muscular development which enables the larva to swim actively in such a viscous medium there are no *essential* morphological differences between the petroleum fly and a typical aquatic ephydrid. Such adaptations as must have occurred are physiological rather than morphological and are of a puzzling nature. What, for instance, can be the peculiarity about the spiracular structures which prevents the oil from spreading into them? Possibly the peristigmatic glands yield an aqueous secretion in place of the more general waxy or oily substances. Similarly, what substance can be produced by the glandular hairs of the tarsus of the adult fly which enables it to walk on oily surfaces which will entangle other insects almost immediately? Again what can be the change which must have taken place in the composition of the digestive juices to enable them to act upon food saturated with petroleum? These are the problems which concern the biochemist and the physical chemist rather than the entomologist, and appear to the writer to have a very considerable theoretical interest.

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THE MORPHOLOGICAL BASIS FOR CERTAIN TISSUE RESISTANCE

TISSUE resistance against bacterial invasion generally finds an explanation in the production of specific bactericidal and antitoxic substances on the part of the organism or in the increased activity of certain wandering cells of the infected host. The resistance which may develop in the higher animals against certain drugs and chemical poisons can not be explained by any of the above-mentioned mechanisms.

The fact has been known for many years that when either the acetate or the nitrate of uranium is given subcutaneously to dogs they develop an acute experimental nephritis in which the injury to the kidneys is at first, in so far as structural changes are concerned, very largely confined to the epithelium of the proximal convoluted tubules. Suzuki,[1] working in Aschoff's laboratory, was of the opinion that this acute injury was confined to the epithelium in certain segments of these tubules.

In a recent Harvey Lecture[2] and in two investigations[3,4] which formed the basis for the experimental data presented in this lecture, a discussion was undertaken of the toxic effect of uranium on the kidney and the mechanism of repair in the injured kidney, and certain observations were presented relative to the resistance which the kidney, the seat of a chronic uranium injury, developed against subsequent acute injuries from the same nephrotoxic substance.

During the past two years these studies have been continued by using repeated injections of uranium with the object in view of obtaining more evidence regarding the morphological changes developing in the kidneys which give to them both a structural and functional resistance to this poison. These experiments have been conducted by first anesthetizing normal dogs and removing from the left kidney a small wedge-shaped piece of tissue which, in its study, has served as the normal control for the acute and chronic changes developing in the kidneys fol-

[1] T. Suzuki, "Morphologie der Nierensekretion," Jena, 1912.

[2] Wm. deB. MacNider, "Urine Formation during the Acute and Chronic Nephritis Induced by Uranium Nitrate," *The Harvey Lectures*, 1928–1929.

[3] Wm. deB. MacNider, "The Development of the Chronic Nephritis Induced in the Dog by Uranium Nitrate. A Functional and Pathological Study with Observations on the Formation of Urine by the Altered Kidneys."

[4] Wm. deB. MacNider, "The Functional and Pathological Response of the Kidney in Dogs Subjected to a Second Subcutaneous Injection of Uranium Nitrate," *Jour. Exp. Med.*, XLIX, 411, 1929.

lowing a series of intoxications by uranium. Prior to such operative interference the functional value of the kidneys has been ascertained by the use of the phenolsulphonephthalein test for renal function, by determinations of blood urea, blood non-protein nitrogen and creatinine, and by estimating the reserve alkali of the blood. Following the subcutaneous injection of uranium in normal dogs and also in animals with a chronic renal injury from such injections, kidney tissue has been removed for microscopic study and observations have been made on renal function by the methods just indicated.

When a solution of uranium nitrate is given subcutaneously to dogs in the dose of from 2 to 4 mgs per kilogram the animals show an initial increase in the formation of urine, which is albuminous, a decrease in the elimination of phenolsulphonephthalein, a reduction in the reserve alkali of the blood, and a commencing retention of blood urea and non-protein nitrogen which is later followed by a retention of creatinine. Kidney tissue removed from such acutely nephritic animals has shown the characteristic uranium injury which anatomically is localized in the epithelium of the proximal convoluted tubules. The cells in this location have become edematous and vacuolated and have shown varying degrees of necrosis. The majority of animals with this type of acute renal injury effect either a partial or a complete functional recovery. On this basis they may be divided into two groups. In Group I, represented by animals with a return to a normal renal function, kidney tissue which has been removed has shown but slight evidence of injury to the vascular tissue of the organ. In the convoluted tubules, the seat of the initial selective epithelial injury, there has developed a process of repair consisting in a relining of these tubules by cells similar in configuration to those normally present in this portion of the tubule. These cells have their origin from convoluted tubule cells which have not been killed by the acute injury from uranium. When the animals of this group (Group I) that have effected a normal type of epithelial repair are given a second subcutaneous injection of uranium nitrate in an amount per kilogram similar to the first injection, they show no evidence of having acquired any tolerance or resistance in so far as the nephrotoxic action of the poison is concerned. This lack of protection in the kidney against uranium is indicated functionally by the development of a marked albuminuria, a reduction in the reserve alkali of the blood, a decrease in the elimination of phenolsulphonephthalein, and a retention of urea, non-protein nitrogen and creatinine. Animals of this group rarely survive a second injection of the poison. The histological study of renal tissue from such animals shows a repetition of the acute epithelial injury in the convoluted tubules. The regenerated cells of the normal type in this segment of the tubule become edematous and necrotic.

The animals falling in Group II are represented by those dogs which, after having developed an acute renal injury from the primary injection of uranium, failed to establish a complete restoration in renal function. They have shown such changes in the blood and urine with such pathological alterations in the kidneys as to enable them to be classified as animals with a chronic nephritis. The evidence of a partial restoration in renal function by the dogs of this group is found in the very greatly diminishing amount of albumin in the urine or its entire disappearance, by an increase in the ability of the kidney to eliminate phenolsulphonephthalein, by a return of the reserve alkali of the blood to the normal, and by a decrease in the retention of urea, non-protein nitrogen and creatinine. The histological study of renal tissue from the animals of this group, after they had established their functional pathological normal, shows that connective tissue changes varying in degree have taken place in the vascular tissue of the kidney. These changes are of the same type but are more advanced in their development than similar changes occurring in the animals of Group I. The striking difference which has taken place in the processes of repair in the kidneys of animals of Group II which separates them anatomically from the animals of Group I is to be found in the restoration of cells in the proximal convoluted tubules. The repair to the epithelial damage in these tubules has taken place by their relining with a type of cell morphologically different from normal proximal convoluted tubule epithelium and therefore different from the type of cell which was regenerated in these tubules in the animals of Group I. The repair process of the tubules in the animals of Group II which have failed to return to a functional normal has consisted in an ingrowth into the tubules of a flattened, non-specialized type of cell or by an ingrowth of an undifferentiated syncytial layer of cell substance containing large, deeply-staining nuclei. Mitotic figures are frequently found in either type of epithelial replacement.

The animals of Group II have been used for subsequent uranium injections, as was the case with the animals of Group I. When the animals of this latter group were given a secondary injection of 2 or 4 mgs of uranium per kilogram, they were found to have developed a definite resistance to its toxic effect in so far as this action was expressed by a functional renal disturbance. The amount of albumin appearing in the urine was definitely less than that occurring from such secondary injections in the animals of Group I. The reduction in the elimination by the kidney of phenolsulphonephthalein was not so great, the reserve alkali of the blood was usually undisturbed, there was no retention of creatinine, and the retention of both urea and non-protein nitrogen was slight or failed to occur. In six dogs with a partial restoration in renal function from an initial uranium injection, the amount of uranium has been increased from the primary dose of 2 mgs per kilogram to 8 mgs and in each instance the same type of modified nephrotoxic action has been obtained.

The morphological basis for this resistance on the part of the kidney to uranium has been associated with the type of epithelial repair to the convoluted tubules and the extent to which this repair has taken place. Those animals with a chronic nephritis in which the epithelial replacement has been very largely effected by a relining of the tubules with a flattened, non-specialized type of cell, have shown functionally the highest tissue resistance against repeated intoxications by uranium. This type of cell is resistant to the toxic action of the poison. It fails under its influence to become edematous and necrotic.

These experiments would not indicate the acquisition on the part of the animals of an immunity to uranium, but the substitution in the kidney, as a result of a process of repair, of a type of epithelial tissue atypical for the convoluted tubules, which either fails to secrete uranium and subject itself to an injury from the substance, or an epithelium which is resistant to it during secretion. Such changes in cell types in the kidney may be looked upon as a morphological defense mechanism giving to the organ an acquired tissue resistance which varies in degree for subsequent injuries from the same chemical substance.

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A NEW FACTOR IN THE TRANSPORTATION AND DISTRIBUTION OF MARINE SEDIMENTS

ONE of the well-known facts concerning the distribution of marine sediments on the continental shelves is that there is a progressive gradation from coarse to fine-grained material away from the shore. The mechanism of the sorting power of the sea and its ability to transport material still remain an unsolved problem of the sedimentationist. Many explanations have been put forward as to the action of currents in the sea produced by tides, winds and differences in density, but no observational data have been accumulated to give us any definite knowledge of the method by which grains of sand and silt are actually transported. With the object of making an investigation of this subject, Mr. Stetson devised a trap which could be placed on the sea bottom in such a way as to catch particles which were traveling in suspension within a few inches of the sea floor. The traps are boxes of heavy galvanized sheet iron 1 foot 2 inches square in ground plan, with the sides bent in and sloping up to a central opening 8 inches square. In some cases the trap was constructed with the lip 1 inch from the bottom, in other instances 6 inches. The deeper traps seem on the whole to be the more satisfactory. Two half doors hinged in the middle were fitted to the opening, which could be tightly closed by a messenger dropped from the surface before the apparatus was hauled up. It is planned to place a series of these traps along a profile on the continental shelf, with the hope of obtaining from them some knowledge of when, and possibly how, the grains travel.

Among the first results of the preliminary work with the traps has been to find, on hauling the first of them after it had been a week on the bottom in about eight fathoms of water, approximately a half mile east of the sandy bluff known at Fourth Cliff, Scituate, that it contained a layer 2 inches deep of a jelly-like substance concerning which little or nothing seems to be known. This jelly is practically colorless, and, when examined under the microscope, also structureless. In it are found grains of sand and silt, fragments of eel grass and fucus, much macerated particles of various algae, shells of diatoms and foraminifera, and small spicules of various sorts. The origin and composition of the jelly are a subject for investigations which are now being carried out. The late C. G. Joh. Petersen investigated the organic matter in the waters off Denmark, and found at the bottom a layer from one to three mm in thickness, composed largely of organic matter, which on account of its color he called the brown layer. He also found in certain localities what he spoke of as mud which quivered like jelly. The material he found seems to have been very much like the jelly in our trap. Petersen's studies, summarized in the report of the Danish Biological Station, Vol. XX, 1911, led him to the conclusion that the material with which he was dealing was made up principally of decomposed vegetable matter, the chief contributor being eel grass. Another suggestion is that the material might be sewage, but it is seemingly too abundant and too widely distributed to be so explained.

A survey of the distribution of this material has been carried on, using a scraper dredge. Several lines of stations were run, beginning at the beach and going off shore about ten miles, with bottom samples taken about every mile. The places selected were the south