to take such an exhaustive survey of biological data as Darwin did in his time. The enormous mass of accumulated facts already far transcends the power of any one mind to grasp, and it would seem that organized cooperation is the only method of dealing with such vast accumulations. When that time arrives, the paleontologist will be able to render even more conspicuously valuable services that he has done in the past.

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ON PHOLADIDEA PENITA AND ITS METHOD OF BORING.

The Piddock of the northwestern coast, Pholadidea penita, is found in its curved conical burrow in the rocks near the tide marks. These rocks, so far as the writer's observation goes, consist of soft limestone or sandstone of varying hardness, the animal choosing the softer portions for its home. How the Piddock accomplishes the task of burrowing into the even moderately hard sandstone is a question upon which little light is thrown by an examination of the mature, or as I shall call it, the resting form, which is characterized by the complete absence of its foot muscles and an almost complete fusion of the mantle lobes along their ventral margin, leaving an opening hardly 2 mm. long. The inference is that Pholadidea penita is a degenerate form, as is the oyster. Further facts, however, will show that this degeneracy does not occur till late in life, when its burrow, the home of its old age, is completed.

The shell of the animal during its period of diligence, like that of other Piddocks, gapes widely in front. Through the upper portion of this gape protrudes a thick fold of the mantle which overlaps the antero-dorsal margin of each valve and secretes a layer of calcareous matter on the outside of the shell. The gape is much wider below

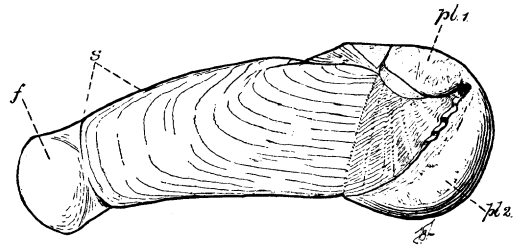

Fig. I. Left side of resting form, specimen 9 cm. long.

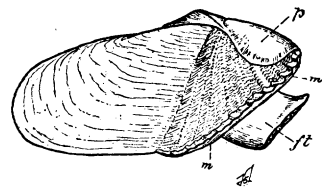

Fig. II. Left side of working form, specimen 6 cm. long.

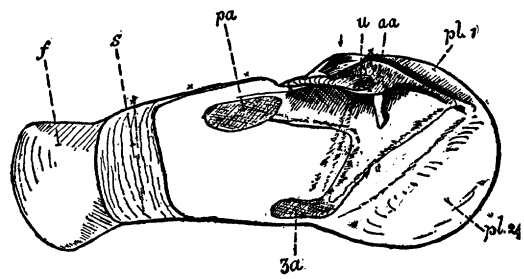

Fig. III. Inside of left valve showing hinge mechanism and muscle markings, specimen 9 cm. long; Siphon retracted in all. aa. Anterior adductor muscle mark; the arrow point indicates its posterior limit. 3a. Third adductor muscle mark at angle of pallial sinus. f. Cuticular flap. ft. Foot. m. Thick antero-ventral edge of mantle surrounding foot. p. Pad formed by antero-dorsal mantle folds. pa. Posterior adductor muscle mark. pl. 1. Plate secreted by antero-dorsal mantle fold, of that side. pl. 2. Plate secreted by m. in Fig. II. S. Additional extent of shell added at the same time with cuticular flap. u. Umbo. The leaders end in patch of abrasion, the point where the valves articulate. The small crosses indicate attachment of hinge cuticle.

and through it protrudes a strong cylindrical muscular foot, the muscles of which are attached at a point of vantage supplied by a curved process on the inside of each valve. The mechanical result of this ar-

rangement is that the foot moves about a point near the common axis of the animal and its burrow and not at one side, thus enabling the foot to work with equal advantage in all directions.

The mantle lobes are fused, except in the antero-ventral region (and, of course, at the siphonal openings), where an opening is found sufficiently large for the protrusion of the foot. The edge of the mantle opening seems to be provided with circular muscle fibres, by means of which the opening is kept just large enough for the foot. Specimens of this form when removed from the burrow will be found to have the foot armed with grit, and a glance at its size and musculature is enough to convince one that it is functional.

These characters remain unchanged until the work of drilling the burrow is completed. The depth and size of the hole will be determined by the number and frequency of the neighboring burrows or the hardness of the rock. Assuming that the work is finished and the author is ready to rest from his labors, let us see what changes take place. The foot, being thereafter of no use, begins to atrophy, till at last the muscular tissue is entirely lost, the whole bulk being taken up by the genitalia and digestive tract. As the foot disappears, the opening through which up to this time it has protruded grows smaller by further fusion of the mantle lobes, till there is left at the extreme anterior end a small opening about one and a half mm. in diameter. This opening is supplied with a sphincter muscle and two valves on the inside, so placed that egress of water at this point may be prevented. The opening seems to be used in drawing in water and débris chancing to be in the burrow.

As this fusion takes place the gape of the shell becomes closed by plates secreted by the antero-dorsal mantle folds above and by the thick mantle now closing in front of the foot below. This results in the complete armature of the anterior end of the animal. At the posterior end an extra length of shell and two cuticular flaps, leathery continuations of the shell, are produced. The shape and size of these is such that the burrow is completely closed at this point by them as by valves. After these changes have taken place there is no more boring done, and we have now the fully matured but degenerate animal. It is interesting to note that not infrequently other clams Saxidomus are caught when very small in the burrow of the Piddock. Such forms have, it is well known, a very strong and muscular foot, which, however, becomes functionless in imprisonment and dwindles away until it is almost, if not entirely, lost. The shell becomes elongate or otherwise changed from the normal shape by pressure of the walls which imprison it. Mussels, too, attach themselves by their byssus to the wall of the burrow near its mouth, where it is narrow, and become much elongated.

The absence of an elastic hinge ligament is a striking character, not only of this form, but of Piddocks in general, and of another allied form, Teredo. The valves are held in position each relatively to the other by the common cuticular investment, which is, however, rather thicker and stronger along the dorsal line. The point at which the valves actually come in contact is morphologically the outside surface of the umbo, thus forming a double ball joint about which the dorsal cuticle is so disposed as to give rise to an incomplete capsular ligament. In place of the hinge ligament we find that the anterior adductor muscle, instead of remaining inside the shell, extends backwards and dorsal to the umbones, so that contraction of this muscle does not result in closing the valves, as it, aided by the posterior adductor, does in other dimyarians, but in separating them ven-

trally and approximating them dorso-anteriorly. Compensation takes place, however, by the development of a third adductor muscle, which occurs at the lower angle of the pallial sinus. This adductor muscle is in fact composed of pallial muscles diverted to this use. Such a muscle occurs in Zirphæa and Teredo and another Piddock which I have examined, said to have been brought in ballast from Panama.

By means of muscles arranged with respect to the point of contact, as these are, the valves of the shell can be moved mutually in any plane excepting a dorso-ventral one. The antero-ventral margin of the shell of the working form is armed with teeth, which are constantly renewed by shell accretion, forming a good rasp. Certain scratches in the wall of the burrow show that this rasp has been used in enlarging the hole, the anterior mantle pad and foot being used as fulcra. There are, however, other scratches at the apex of the burrow which indicate that the foot armed with sand serves also as a drill, but all attempts to watch the operation have so far been futile.

Specimens of this form have been found by the writer showing all degrees of degeneracy.

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SIR JOSEPH PRESTWICH.

The Nestor of English geologists—Sir Joseph Prestwich—late professor of geology at Oxford, died on the 23d of June, last, at the ripe age of 84 years. The life of Prof. Prestwich covers the most eventful period in the past of geology. The problem whose solution has established the principles of the new science all arose during his lifetime, and of these all he could say with truth

"quaeque ipse vidi
Et quorum pars magna fui."

Born near London on March 12, 1812, he received his early education partly in England and partly in France, becoming later a student of University College, where his attention was chiefly turned to chemistry and natural philosophy, geological study not being then a recognized part of any course. While there he founded among his fellow students the Zetetical Society, composed of about 14 young men who arranged to lecture to one another for the purpose of mutual improvement.

Necessity, rather than inclination, turned his course into business, in which he was closely occupied for nearly 40 years, but during this long time his thought and his holidays were employed in his favorite topic, geology. It was his enthusiasm and stern earnestness that enabled him to accomplish so much in hours that most men would have devoted to mere amusement. The necessary books and travel were obtained by the strictest self-denial in personal expense, sometimes, perhaps, to an excessive degree, but the results became manifest in a series of investigations that rapidly brought him to the front, and resulted in his appointment to the chair at Oxford in 1874.

To enumerate the successive publications that came from his pen would scarcely befit this notice. A glance at the many problems that engaged his attention and which were in part or altogether solved by his efforts will prove more instructive and interesting. One of his earliest papers appeared in the transactions of the Geological Society of London in 1836, and contains an investigation of the Coalbrookdale coal field, but his attention was soon directed to the English and French Tertiary strata and their correlation, and from these he passed to the younger or quaternary deposit on which most of his later work was done.

In several years reports had been current of the occurrence of human relics in the form of flint implements in gravels of very