II.—*The President's Address on some Doubtful Points in the Natural History of the Rotifera.*

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THERE is perhaps no position that so tickles our sense of humour as that of

“the engineer
Hoist with his own petard.”

That the digger of a pit for another should fall into it himself, that the biter should be bit, and that the maker of a new law should himself be the first to incur its penalty, are cases that catch our fancy, with a sense of justice flavoured with fun: and so if I,

“When caught myself, lie struggling in the snare,”

I must be content to be ranked with the “wicked who is snared by the work of his own hands,” and must try to make the best of the position, even if it is one which lights up the faces of my audience with a good-natured smile at my own expense. For, two years ago, in my first address to the Royal Microscopical Society, unaware of the future presidential honours which awaited me, and thinking only of the admirable summary given to us, every two months, by our able Editor and staff, I rashly said that no President in future would be able to take, as an obvious subject for his address, an account of the world's microscopic work during the preceding year; but that he would be compelled to follow Dr. Dallinger's shining example, as best he might, and offer to the Society some of the results of his own researches.

But we should beware of making general statements; especially such as concern ourselves. Indeed it seems to me that the safest general statement, that can be made, is, “that nearly all general statements will prove to be untrue”: and so, in this matter, scarcely had I committed myself to what seemed a self-evident proposition, than I became aware that it no longer covered my own case. For, on the one hand, I found myself suddenly forbidden to use the Microscope; and on the other, I had already in the ‘Rotifera,’ in its supplement, and in my first presidential address, said almost all that I had to say on my own subject. Being then unfortunately debarred from further research, and having already told you all that I *do* know about the *Rotifera*, what remains for me but to tell you what I *do not*? And such negative information is not entirely without precedent. “A history of events which have not happened” has been suggested as one that “might enlarge our general views of human affairs;” and even a chapter or two of it has been already written. Again, it has been urged that a list of “inventions not yet invented” might excite some fertile brains to supply our wants; and so perhaps a record of the main points in the natural history of the *Rotifera*

which are yet obscure, may serve to point out to students whither they can profitably direct their course: just as the lions and elephants, on the old charts of Africa, were the sign-boards which marked out the spots, where there was good entertainment for man and maps.

Considering first the position which the class ROTIFERA holds in the Natural Kingdom, we find that it has been placed (apparently by common consent) in the limbo "Incertæ sedis"; so here at the outset we light upon a subject, that will give ample opportunity for research and study: for, while the humbler species of *Rotifera* pass by easy gradations into larva-like worms, which have almost lost the characteristic ciliary wreath and trophi, the higher species have, standing at a great distance beyond them, a true rotiferon, *Pedalion mirum*, so far advanced in its structure that it forms an order by itself; and, moreover, the gap between this order and the other three, which contain the rest of the 450 species of the *Rotifera*, is obviously too great to be real.

The forms, then, that link *Pedalion* to the others cannot be few; and are, indeed, dimly foreshadowed by the hollow stumps of *Asplanchna Ebbesbornii*, and by similar processes in several of the male *Asplanchnæ*. We have in the latter, as it were, the first rude sketch of a *Pedalion*; for though their lateral processes do not end in swimming fans, and appear to be of no use to the animal, yet they have muscular fibres passing freely along their cavities from end to end.

The male of *A. intermedia* has three such appendages, the female of *A. Ebbesbornii* has four, the male of *A. Sieboldii* has five, while that of *A. Ebbesbornii* has six. Increase the number of the muscular fibres, expand them into bands, attach them to the body-wall (as they pass the base of each process into the cavity of the trunk), and we shall then have limbs adapted for swimming, and wanting only the finish of the terminal fan to approximate to those of *Pedalion*. Indeed the female of *A. Ebbesbornii* looks just as if some species of *Pedalion* had had its limbs rounded off at the extremities, so as to rob them of their fans.

On the other side of *Pedalion*, between it and the *Arthropoda*, there lies Schmarda's *Hexarthra* which requires a special notice, as Eckstein and von Daday both consider the two animals to be identical. How they have come to such a conclusion I cannot imagine, unless they suppose that Schmarda had less power of observation than an ordinary child. For *Pedalion* is a conically shaped animal, with six limbs arranged all round the cone, parallel to its axis, and pointing from its base to its apex; how then is it possible for the merest tyro to draw those six limbs as radiating from a common base on the surface? If a half-opened black umbrella had white pieces of tape sewn outside, along its ribs, could there be any one capable of declaring that the white tape formed a star, with six rays issuing from the middle point of one of the umbrella's ribs? And yet it is a

mistake, quite as bad as this, that Schmarda is supposed to have made; and that too, in the case of an animal, of which he had numerous examples, and whose true form could be easily seen under a low power. It is probable then that *Hexarthra* exists, and that the *Rotifera*, in this species, make a still nearer approach to the Nauplius larva of the *Arthropoda*. Of course, if the *Rotifera* do run up to the *Arthropoda* through *Pedalion* and *Hexarthra*, there must be other forms lying between the outposts of the two classes, with which we are unacquainted, and which it is possible that we may yet discover. Nor do I think that I am too sanguine in supposing, that some of these connecting links, on either side of *Pedalion*, may yet be extant. For the *Rotifera*, owing apparently to their extraordinary power of adapting themselves to varying circumstances, contain more than one long series of forms connecting species that, at first sight, seem hopelessly wide apart. Place *Trochosphæra*, *Stephanoceros*, and *Actinurus* side by side; could there be a more discrepant trio? And yet we possess many intermediate forms which link the three together.

The persistence of such links gives us, I think, good ground for hoping that the missing forms, between *Pedalion* and the other *Rotifera*, may yet exist; and (whatever may be thought about *Hexarthra*) possibly some too between *Pedalion* and the *Arthropoda*. At any rate it is worth while to try to find them; and, if so, where can we search with the best prospect of success? It is hardly likely that their natural homes are in Europe, or the United States; for, if they were, they could hardly have escaped the sharp eyes there, that are ever prying for novelties; it is in the tropical and semi-tropical countries that we must conduct our search. Their lakes, tanks, flooded rice-fields, swamps, and irrigation-canals—all sweltering under the sun, and abounding in minute vegetation—have surely a wealth of new microscopic creatures yet in store for us. I only know of four observers, who have had the good fortune to explore these almost virgin fields of research, and each has found at least one prize. Dr. Semper discovered the female of *Trochosphæra æquatorialis* in the flooded rice-fields of Manila; Dr. Schmarda *Hexarthra*, in the irrigation canals of Egypt; Surgeon Gunson Thorpe, R.N., the male of *Trochosphæra æquatorialis*, near Brisbane; and Mr. Whitelegge, at Sydney, that curious social Melicertan *Lacinularia pedunculata*; which, anchored by its long thread of intertwined stems to the leaves of *Myriophyllum*, floats on the surface of shallow pools, “like acacia blossoms that have fallen into the water from the trees above.”

Pedalion, too, which has given rise to this question, itself would seem to suggest the same answer. For it is a very rare creature, and does not thrive in our ponds, dying out after the first or second year. The only spot where it seems more at home is in the warm water lily-tank in the Duke of Westminster’s conservatory at Eaton. This

inclines me to think that it may be a sub-tropical species, whose ephippial eggs are occasionally wafted to England; especially as it has been found in great abundance, by Surgeon Thorpe, on a rocky island off the coast of Queensland.

But unfortunately those of our friends, who are spending the prime of their lives near the Equator, are necessarily too busy with more important matters to give up their time and thoughts to such researches; yet I think that there is a way in which they might effectively help us, without incurring much trouble or expense. If they would send us the hard earth pared from the surface bottom of dried up pools, it would most probably bring over, with it, ephippial eggs of tropical Rotifera; and, as these are constructed to bear a dormant condition for nine months or more, they would travel safely across the globe, and come to life in our aquaria at home. No doubt many such chance ventures would prove failures, but to hit the mark one must often throw many a stone. If we now turn from the unknown Rotifera that we wish to find, to the unknown points in those that we have found already, we shall be comforted by seeing that there is still an encouraging store of ignorance awaiting attack.

In the first place, there is much yet remaining to be discovered about the reproduction of the Rotifera. Although the dioecious character of the class as a whole has been established, yet it is a reproach to naturalists that so common an order as the *Bdelloida* should as yet have presented us with nothing but an unbroken succession of virgin mothers. There is nothing in the internal structure of any of the species to lead us to suspect that they are other than dioecious; all the organs are accounted for, and the female organs are precisely like those of the other orders, yet no one has seen the male. With such hardy creatures as Philodines, Rotifers, and *Adinetæ*—creatures to whom extremities of heat, cold, and drought are the ordinary incidents of life—nothing is easier than to keep an abundant stock all the year round; and so, one would think, to make sure of finding the male. Possibly the male and female foetus resemble each other so much, as to be not easily distinguished when *in utero*: possibly, too, the males are rare, or very small, or live only for a very short period:—and it is possible that all these conditions may exist together. If so, it would be no wonder that they have as yet escaped mere random observation. But patient, persistent, daily search through small aquaria well stocked with these creatures, must lead at last to the discovery of the Bdelloid male.

But the search for a missing male is a light matter compared with that of settling the yet doubtful points in the reproduction of the Rotifera; points on which some of the best observers hold very different opinions.

It would be impossible for me to discuss this question within the limits of this paper, but I will endeavour to give a brief summary of

the differing theories, and suggest experiments which might, I think, decide between them.

There are, as no doubt you are aware, three sorts of eggs among the Rotifera. Of these the ordinary, or "summer" eggs, have only a soft membranous covering; they are hatched soon after they are laid, and are of two sexes, distinguished from each other by both shape and size. The female eggs are large and distinctly oval; the male eggs are smaller and nearly spherical. The third sort of egg, or "ephippial" egg, has a double shell, often beset with spines, bosses, or prickles. It is sometimes termed a "winter" egg, but this is a misnomer, as it occurs at all times of the year.

Now there is no doubt of the continued production of female eggs by parthenogenesis in every family of the *Rotifera*; and indeed, among the *Bdelloida* no other mode of reproduction has as yet been seen: but concerning the origin of ephippial eggs there is no such agreement. Cohn thinks that they are the product of sexual intercourse; Huxley says that sexual intercourse gives rise to the ordinary soft-shelled eggs; Plate maintains that sexual intercourse has no effect in determining the sort of egg that is to be laid. Again, Plate declares that no female ever lays more than one sort of egg; while Balbiani, on the contrary, says that the same individual may first lay ordinary female eggs and then ephippial eggs.

It is not easy to steer one's way through such contending authorities; but before making the attempt, let us first separate the facts from the opinions.

(1) It is admitted on all hands that virgin females will produce virgin females, in unbroken succession, through many generations.

(2) Balbiani states that he has often observed, that a solitary female of *Notommatia Werneckii*, inclosed in a gall of *Vaucheria*, has first laid ordinary female eggs, and then ephippial eggs: and that the laying of the latter was preceded by a gradual exhaustion of the vitality of the germ in the ordinary female egg, as shown by a great number of them remaining sterile; or, if the embryo were formed, by its dying without hatching, even after the eye-spot had become visible. Moreover, the males had nothing to do with the matter, as they were absent during the whole of the observations.

(3) Huxley has observed in *Lacinularia socialis* that the ephippial egg is formed out of several germs and their surrounding yolk; and I have myself watched the entire process of the formation of an ephippial egg in *Conochilus volvox*, and seen that it consisted of nearly two-thirds of the ovary, with many inclosed germs.

(4) Plate has tried many experiments in coupling females (that had already begun to lay eggs) with males; and in no case did sexual intercourse alter the kind of egg that the female had been in the habit of laying.

(5) In two cases Plate observed the results of coitus on a young

female, that had laid no eggs before intercourse with the male; and, in both cases, she laid ordinary female eggs.

(6) Plate has seen the hatching of two ephippial eggs of *Hydatina senta*, and Joliet one of *Melicerta ringens*, and in each case the ephippial egg produced one female.

It is probable then, from the statements above, that the ephippial egg is not due to the action of the male; but that it is the termination of that budding process, by which virgin females produce virgin females through many generations, and that it is resorted to when the vigour of the ovary begins to fail, so that a single germ is no longer able to produce a living animal. When this time arrives many germs are separated off to do the work for which one is usually sufficient, and so combine together to produce one embryo for the next year. The double egg-shell with its deep cells, and various knobs or spines, may be due to a surplusage of material in this joint-stock egg-making.*

Of the series, of which the ephippial egg is the end, it is probable that an ovary impregnated by the male is the beginning; but this point, as well as the doubts that yet linger about the above account, could surely be cleared up by patient experiment.

It would be easy, for instance, to isolate, as soon as it is hatched, a female of each succeeding generation of a *Hydatina senta*, and to see how many generations may be thus produced; and whether the series invariably ended in a female laying ephippial eggs. There should be, moreover, two such series; one commencing with a female impregnated before she had laid any eggs, the other with a virgin female. As *Hydatina senta* is a common, large, and very prolific Rotiferon, as well as one that may be easily fed with *Euglenæ*, &c., the experiment would not be very troublesome. Possibly, too, such experiments might throw some light on the causes that give rise to the laying of male eggs; about which at present we do not seem to know anything.

There are two other points in the reproduction of the *Rotifera* which are puzzling. The first occurs in *Rotifer vulgaris* and its allied forms. In these the eggs drop off the ovary into the perivisceral cavity, and are hatched within the animal; and the young rotifer seems to lie free in the cavity, for it can stretch itself to its whole length, or twist round and reverse its position without apparent hinderance from any inclosing membrane. In the act of birth it has been seen to pass through the cloacal aperture; and one observer noticed a young *Rotifer vulgaris* protrude its head, expand its wheels in the water, and then furl them and shrink back within the

* M. Joliet's observations on the hatching of the ephippial egg of *Melicerta ringens* (Comptes Rendus, xciii. (1881) p. 856) point in the same direction. For he noticed that the young female hatched from the ephippial egg had the perfect form of the adult *Melicerta*, and was therefore in an advanced stage of growth compared with the young hatched from the ordinary thin-shelled egg.

parent. But how it can do this is a puzzle. Neither ovary appears to have any connection with the cloaca, and the young rotifer seems to be in the body-cavity *outside* of the closed tube which passes from the cloacal outlet to the lower stomach. I have suggested* that the long thread which passes from the posterior end of the ovary towards the cloaca, may really be not a muscle, as is usually supposed, but the collapsed oviduct; and that when the ovum becomes detached and seems to fall into the perivisceral cavity, it does not really do so but simply stretches out over itself the delicate membrane investing the ovary; for the collapsed oviduct, which is a prolongation of this membrane, would at once yield to the slightest pressure, and accommodate itself to the increasing size first of the ovum, and afterwards of the embryo; while the extreme tenuity of the membrane may have caused it to escape notice when expanded over the young. However, this is only a guess; for I have never seen any such membrane, and the difficulty is still waiting for its explanation.

The next point is the frequent presence of spermatozoa in the perivisceral cavity. It is as perplexing to explain how they get into this cavity, as how young *Rotifer vulgaris* gets out of it. Coitus has been seen to take place in several species of *Rotifera*, and by various observers; and with the exception of Dr. Plate, all observers agree that it takes place at the cloaca, into which the oviduct opens. Neither the oviduct, nor the cloaca, is known to have an opening into the perivisceral cavity, and yet the spermatozoa in several species have been seen in that cavity, adhering to the outside of the ovary. How did they get there? †

There may, perhaps, be minute openings in the oviduct through which the spermatozoa can pass into the perivisceral cavity, but I

* 'Rotifera,' i. p. 103, footnote.

† Dr. Plate describes experiments in which he has seen several males (in number varying from two to eight) having intercourse at the same time with the same female. He describes them as firmly fastened by the penis to various parts of her body; and he asserts that the penis bores through the body-wall, anywhere, and ejects the spermatozoa, and the rod-like bodies which accompany them, into the body-cavity. Further on, however, he qualifies this statement by saying that he never could find any traces of an opening in the cuticle, at the spot where copulation appeared to have taken place; that the penis appeared to be glued on outwardly; and that finally he believed that it was the stiff bristles of the penis which penetrated the cuticle, and gave a passage to the spermatozoa.

It is not necessary to comment further on this strange theory than to say, that Gosse has seen intercourse take place at the cloaca in the case of *Brachionus palu*; M. E. F. Weber in that of *Diglena costellina*; and Mr. J. Hood, not only in *Floscularia ornata*, *Synchaeta gyrina*, *Euchlanis tri-netr.*, and *Meliceria tubicolaria*, but also more than a score of times in *Hydatina senta* itself.

Mr. Hood further states, in the letter with which he has favoured me, that the female *Rhizota* (whose copulation he has often witnessed) "draw themselves up in their tubes, so as to bring the orifice of the cloaca above the upper edge." He also says that *Hydatina senta* copulates while clinging with her foot to some confervoid filament, but *Synchaeta gyrina* copulates while swimming.

The duration of contact, according to Mr. Hood, is from forty seconds to two minutes in *Hydatina senta*, and three to three and a half minutes in *Floscularia ornata*.

know of no one who has seen such openings. Or it is possible that the spermatozoa may pass through the walls of the oviduct, just as white corpuscles pass through the walls of the capillaries. And though it is hardly likely that this should be their regular path, yet it is obvious that they are capable of penetrating the membrane, which covers the ovary and is prolonged into an oviduct, for they have been seen to attach themselves to the external surface of the ovary,* so that their contents must pass through the membrane to get at the germ.

There remains one more organ that is waiting for a skilful experimenter and observer, viz. the contractile vesicle with its lateral canals and vibratile tags. Various functions have been ascribed to this group of vessels. It has been described as a male sexual organ, as a respiratory organ, and as an excreting one. The last explanation is the one now usually given; but there are difficulties in the way of its complete acceptance which have not as yet been met.

The theory is that the lateral canals, aided by the vibratile tags, gradually fill the contractile vesicle with a secretion derived from the perivisceral fluid; and that the contractile vesicle, as soon as it has reached its full distention, discharges this fluid through the cloaca.

Now it can be readily demonstrated that the contractile vesicle does discharge its contents through the cloaca,† but it is not easy to credit that these contents consist solely of a secretion derived from the perivisceral fluid. For the contractile vesicle, owing to its rapid and continuous action, often discharges in a minute or two a quantity of fluid equal to that of the whole body. Take for instance the case of *Mastigocerca carinata*. Gosse observed that the discharge took place twenty-five times in a minute; and, as the volume of the vesicle is greater than one-tenth of the perivisceral fluid, it would follow that the creature renews the whole of its body-fluids at least twice in a minute. Is this likely? and, if it could be established as true, what could the perivisceral fluid be but mere water drawn from without? *Secretion*, at such a rate, seems impossible. What, too, shall we say of the great contractile vesicles of some of the *Asplanchnæ*, filling more than half of the body-cavity? Or of that of *Brachionus militaris*, expanding even to two-thirds? Is it probable that they are filled with a *secretion*?

Moreover, that practised observer Cohn declares, that he has seen particles of pigment first driven away by the rush of fluid from the contractile vesicle, and then carried by a return current, through the cloaca, right into the vesicle; while other particles, turned back by its contraction, were violently driven out again from the cloacal aperture.

* Dr. Cohn and myself have seen this in *Conochilus volvox*.

† By compressing a young *Asplanchna Ebbesbornii*, so as to check slightly the action of the contractile vesicle, I have caused partial contractions, each of which has been seen to send a plug of fluid down the oviduct to the cloaca. I have also successfully tried the same experiment on *Hydatina senta*.

I do not see how we can decline to accept such a precise statement, made as it is by an expert; and, if we admit its accuracy, how can we escape from the conclusion, that the fluid, which distends the contractile vesicle, is probably little else but water drawn in through the cloaca?

And, should this explanation prove to be correct, there would then be no difficulty concerning the quantity of fluid, so frequently expelled from the contractile vesicle. The lateral canals and vibratile tags might then be considered, as before, to form a secreting organ, whose secretion did indeed enter the vesicle, but was there so diluted, with water drawn up from the cloaca, that it in no way injured that water in its office of aerating the perivisceral fluid through the delicate wall of the vesicle.*

To sum up, then, I think that of the various explanations offered of this perplexing system of organs, the most probable one is that it is an excreto-respiratory one; the contractile vesicle performing the function of respiration, and the lateral canals that of secretion; and that these functions remain unaltered, whether the lateral canals are united to the vesicle or not. It is evident, however, that to place this explanation beyond doubt, Cohn's experiment should be repeated several times; *Trochosphaera* should be thoroughly re-examined; a record should be kept of the rate at which the vesicle contracts in various species; and an estimation made in such case of the ratio of its volume to that of the perivisceral fluid.

The study of such minute details, no doubt, is dry, and I am afraid that my recital of them has proved wearisome; but then natural history, to a large extent, is a study of minute details, which, indeed, must always be its sure foundation. And yet this study has its compensations; for while engaged in it, laying the foundations of such a work as man generally raises—solid perhaps, certainly formal, and probably heavy—I became aware of the silent growth, on the same foundation, of a palace of delight, into which I could enter at a wish, and leave the world behind me. Here could I roam through pleasant chambers, rejoicing in their treasures of memory—in their store of early fancies glittering in the light of happy youth—and in strange prizes, won in dear companionship, among all the charms of cliff, combe, sea, and sunshine. Here, too, were corridors of half-formed thoughts, stretching out into that enchanted region where a few grains of fact, like a drop or two of a compressed gas, expand into clouds of ideas, hazy, yet tinted with the hue of hope—clouds that

* Now the probability of this theory being true is strengthened by the case of *Trochosphaera aquatorialis*. For Semper distinctly states that in *Trochosphaera* the lateral canals are entirely detached from the contractile vesicle; and that, instead of terminating on its surface, they both pass below it to the cloaca, and open just at the cloacal aperture. With such an arrangement of the parts, it is hardly possible to suppose that the contractile vesicle is distended by fluid discharged from the canals. So here, too, we seem driven to the conclusion, that water drawn through the cloaca is the principal agent in the distention of the vesicle.

soften the hard features of modern science, and seem as if they would some day lift a little, and give glimpses of possible replies to the three eternal questions: "Where did we come from?" "Why are we here?" "Whither are we going?" Here, too, could I please myself with thoughts that rose unbidden as I reflected on what I had seen in the world beneath the waters. What happiness reigns there! What ease, grace, beauty, leisure and content! Watch these living specks as they glide through their forests of algæ; all "without hurry and care," as if their "span-long lives" really could endure for the thousand years that the old catch pines for. Here is no greedy jostling at the banquet that Nature has spread for them; no dread of each other; but a leisurely inspection of the field, that shows neither the pressure of hunger nor the dread of an enemy.

"To labour and to be content" (that "sweet life" of the son of Sirach)—to be equally ready for an enemy or a friend—to trust in themselves alone—to show a brave unconcern for the morrow—all these are the admirable points of a character almost universal among animals, and one that would lighten many a heart were it more common among men. That character is the direct result of the golden law, "If one will not work, neither let him eat;" a law whose stern kindness, unflinchingly applied, has produced whole nations of living creatures, without a pauper in their ranks, flushed with health, alert, resolute, self-reliant, and singularly happy.

Another thing that has struck me greatly is that "the struggle for existence" leaves them so much leisure, and such famous spirits. Even the Swift can find time to play. From early morning late into the twilight, it rushes through the air, crushing into a summer's day the emotions of a season's fox-hunting; and then, having "provided for those of its own house," it takes its ease in darting from sky to earth, at eighty miles an hour, shrieking with delight in a mad game of "catch-who-catch can."

During the late hard frost, all the hills where I live, were alive with toboganners—an unwonted sight in the south-west; but the rooks invented the game long ago. I have often watched them at Ilfracombe in the evening (when a strong north-wester was blowing) flying low above the town, from the Manor House trees, to the landward slopes above the tunnels. There, closing their ranks and sheltered by the slope, they rose, almost brushing the grass, till, at the very edge of the cliff they were caught by the wind, and hurled, in a whirl of wings, back to their rookery; whence after much fluttering and cawing, they again set out for the cliffs.

The slow toilsome approach, the mad return, the intoxication of headlong flight, and the spice of possible danger, are the same in both games; but the birds have the best of it; for no policeman ever wishes to interfere with their sport; and they can enjoy it if they please, nearly all the year round.

The *Rotifera* occasionally play; at least I think so. You may

sometimes see, floating in the water of a live-trough, a tangle of what looks like spider's web. It is, I believe, a chance gathering of the threads spun by a swarm of the larger *Rotifera*. On one of these threads, I have sometimes seen a line of minute creatures ($1/250$ in. long) hanging on by their toes, and whirling round, one after another, like boys on an iron railing, or rather like professional athletes on a horizontal bar. It is hardly possible that they get their food in this way, for the pace is so great; besides, at other times, they flit about among the algæ with a decorum much more suitable to the important business of dining.

But why should I adduce further examples? Higher up in the scale, the games of animals are obvious to all; as are also, I think, their health, their leisure, and their happiness. Where they lead unhealthy and unhappy lives, I fear that man's brutality, or his injudicious kindness, are too often to blame.

All such speculations as these, however, lead to burning questions; for man is much too closely kin to the lower animals not to be conscious, that the laws, which affect their conduct, are but a rough sketch of those which affect his own. Still I may be permitted to say, without offence, that we have much to learn from our dumb brethren; and that we sometimes cut sorry figures compared with them. Indeed, we can only wince and be silent, when we read the caustic lines that sum up the discourse of Luath and Cæsar,—

“Then up they gat, and shook their lugs,
Rejoiced they werena men but dogs.”

Of the outward condition of the brute creation, and of the happiness that falls to its lot, we can perhaps form an opinion that approximates to the truth, though even here the same facts receive widely different interpretations. But of the sensations and emotions of the humbler animals what *can* we know? Of the import to them of those phenomena, which make up our own familiar world, we cannot conjecture. We can but make feeble guesses at the causes of their actions; causes lost in one of the profoundest abysses with which our reason can attempt to cope. I have seen actions among the *Rotifera* that seemed to betoken the possession of memory, consciousness, and choice; but, without the means of testing the matter by experiment, it would be rash indeed to assert that they possess them. Still, what could *look* more rational than the following conduct in a *Floscularia campanulata*? It had stretched itself well out of its case, and, fully expanded, was drawing one victim after another down to the bottom of its coronal cup, when there slipped into the latter, almost filling it, a *Euplotes charon*—one of the oval, style-bearing Infusoria. Now the Floscule's habit, when it is disturbed, is to fold up its cup, draw it into its body, and dart back into its tube. It does this scores of times during the day, and a whole series of actions—the pressing of the lobes of the cup together, their proper folding, their withdrawal within the body, the contraction of the foot,

and the consequent darting to the bottom of the tube—bring into play a number of various muscles. These are all practised to act together with the utmost precision and swiftness; and I never, except on this occasion, saw them act otherwise than in concert. But to have done so now would have been to have caused a struggle between the Floscule to get into its tube, and the *Euplotes* to get out of the Floscule's grip; in which the cup's delicate walls might have been much injured. So the latter did the only thing that there was to be done with safety. It slowly contracted its foot while *distending its coronal cup to the utmost*; and, making as it were a graceful curtsy, gave the *Euplotes* a free passage.

Here, then, was an unusual danger met promptly by the reversal of one of a group of related actions, which habit must have made almost inseparable. It *looked* as if the Floscule had consciously adopted this mode of escape from its awkward position; but, as Hamerton has well said, "the impossibility of knowing the real sensations of animals—and the sensations are the life—stands like an inaccessible and immovable rock right in the pathway of our studies. None of us can imagine the feelings of a tiger when his jaws are bathed in blood, and he tears the quivering flesh. The passion of the great flesh-eater is as completely unknown to civilised men, as the passion of the poet is to the tiger in the jungle. It is far more than merely a good appetite; it is an intense emotion."

The main difficulty in conceiving the mental state of animals is, that the moment we think of them as *human* we are lost. But the hopeless absurdity of trying to fancy how life looks and feels to a Floscule, is only a trifling instance of what meets us at every turn; our speculations constantly leading us to abysses in which thought does not so much lose itself, as expire.

Curiosity may tempt us to peer into the darkness; but if we wish

"To take what passes in good part,
And keep the hiccoughs from the heart,"

we must turn back to sunshine and our beautiful earth, existence on which is acceptable almost on any terms. It has delights for our senses, satisfaction for our affections; and, for our minds, a store of marvels which the longest life can never exhaust. For the softer consolations of hope, for dreams of the future, for the recovery of lost love, and the re-uniting of snapt heart-strings, we must step into the realm of Faith, clinging to our hopes, and declining "to lose *ourselves* while seeking for our primary cell."*

Sir Thomas Browne's advice is as good now as it was 250 years ago: "Desert not thy title to a divine particle. Have a glimpse of incomprehensibles, and thoughts of things, which thoughts but tenderly touch."

Science, though it has its own religion of wonder and reverence,

* 'Horæ Subsecivæ,' Dr. John Brown.

is in such matters hemmed in by barriers impassable by human reason ; and knows as little of first causes, as it does of last consequences. Yet from the drama of animal life we may learn wholesome lessons. Here Nature suffers us to guess at her wishes, from her acts ; and so judged, we may well say of her, that

“She too is no mean preacher.”

For though her precepts are few, they are burnt into her pupils by her unvarying practice ; as, almost from birth to death, from the Primates to the Rotifers, she trains up her dumb children in the exercise of that splendid virtue—fearless Self-reliance.