XII. *On certain Appearances observed in the Dissection of the Eyes of Fishes.* By JAMES L. DRUMMOND, M. D. of Belfast. Communicated by Dr THOMAS BROWN, Professor of Moral Philosophy in the University of Edinburgh.

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SOME months ago, in investigating the anatomy of the eyes of fishes, I washed off the back silvery part of the choroid coat of the haddock, with a hair pencil, and about half a teaspoonful of water. The latter became of a milky colour, and on examining a drop of it, with an ELLIS's aquatic microscope, I found the milkiness to be owing to innumerable slender, flat, silvery spicula, which had composed the *substance* of the choroid. They seemed to be in constant motion, apparently rolling upon their axes, but having no degree of progressive movement. The light reflected from their surface was very brilliant, like that from polished silver, and often disappeared, and again returned, with alternations so rapid, as to produce a twinkling, very like that of a fixed star.

Sometimes, on examining an individual specimen, it would disappear altogether, but in a few minutes return, renew its twinkling, and apparent revolution on its axis, and again disappear, to return as before.

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Frequently also, some were observed to be in the fluid, or on its surface, for a long time motionless, but very brilliant; then they would give a few slight twinkles, seem to turn round, and almost disappear; then resume their original situation for a moment, appear more brilliant than at first, partly disappear again, and again return, and so on, for a number of times, till at length they would disappear entirely; but, after a time, perhaps five or ten minutes, shew themselves in the same spot as before. These observations could be made only on the larger spicula; the minute ones being in incessant motion.

On the first examination of this appearance, it seemed probable, that the motion might be communicated by animalcula swimming through the fluid, and that these had been propagated after the death of the fish, as the eye was not quite fresh. Soon afterwards, however, I examined the choroid in the same way, from a flounder before it was quite dead. The same appearance presented itself, if possible still more lively; and I found also, that it continued in many of the spicula, after exposure to the heat of boiling water.

Since that period, I have observed the same phænomena in the choroid of all the fishes which I have examined, in the cartilaginous as well as the bony.

The motion continues in a great many of the spicula even after the fluid containing them has become putrid; but it is then more slow. The addition of ardent spirit deadens, but does not destroy the motion. After exposure to a heat of boiling water, the number of spicula seems much diminished, and those which remain move less rapidly than before. The addition of vinegar, in a quantity equal to the fluid containing the spicula, suddenly causes a great diminution of the number of moving ones, probably from coagulating the albuminous matter, which had been washed from the eye along with the spicula,

cula, and entangling them in it. Many, however, continue their motion as before.

Whether these bodies really turn upon their axes, or whether they have the property of producing a rapid renewal and cessation of reflection of the rays of light, from their surfaces, so as to produce only the appearance of rotation, I cannot positively determine. In the larger spicula of the choroid of the herring, I have certainly, sometimes, been able to trace the opaque outline of an individual spiculum, after it had ceased its twinkling reflection ; but, in general, the appearance of rotation seems so distinct, as almost to preclude the supposition of its not really taking place ; and these bodies are not so minute as to admit of much optical deception ; for in those from some fishes, the herring in particular, the reflection, and apparent motion, are quite evident, in the sunshine, to the naked eye.

The spicula of the eye of the herring are jointed, being generally thus divided into three distinct portions, of which that which forms the centre is much larger than the two others. In common day-light, the entire spiculum is silvery ; but if it be observed in the sunshine, it will be found to reflect different rays, from the different jointed portions ; the end-joints being generally of a light straw colour, while the central one is steel-blue, like the main-spring of a watch, or of a red or light rose colour, sometimes silvery, green, or purple ; but never of the same colour as the extremities of the spiculum. The colours of the different joints do not shade into each other, but terminate abruptly by a well-defined line.

To account for the motion of these spicula is difficult. There seems no reason to suppose it to depend, either on electrical or galvanic influence. The motion of each spiculum is proper to itself, nothing like attraction, or repulsion, subsisting
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between it and any other, or between it and either the surface or bottom of the fluid.

Evaporation, causing an intestine motion in the particles of the fluid, cannot be the cause; for the addition of ardent spirit, which increases the evaporation, deadens the motion, and the motion continues when the liquid is covered over with almond oil, or inclosed in a glass tube.

The spicula are a little heavier than water; for, on standing, they slowly settle at the bottom; but the slow manner of their subsiding, and consequent turning, from side to side, is not the cause of the motion mentioned; for when a stratum is spread on a piece of glass with a hair-pencil, as thin as possible, the motion continues till the whole water is evaporated; and if a drop of oil is let fall on such a stratum of fluid containing the spicula, the motion continues under the oil without interruption for many hours.

The transmission of caloric will in no way account for it. The motion is totally different from that of particles of dust, &c. caused by the currents formed during the cooling or heating of alcohol or other fluids.

Phosphorescence has no connection with it; the reflection being apparent only when light falls on the surface of the fluid; and the stronger the light the more brilliant, as in other cases, is the reflection.

To suppose that these spicula are animated, would, for many reasons, seem a wild and improbable idea.

First, They resist a heat of 212° , which no animated being is known to do.

This alone might at first seem conclusive, yet, perhaps, it is not entirely so. The experiments of naturalists prove, that the ova of animalcula resist a boiling heat, as, in various vegetable decoctions, which, although poured hot into vessels,
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and immediately corked up or sealed over, yet are found, after some hours or days, to be replete with myriads of animalcules ; but I believe no experiment goes to shew, that any animalcule could itself withstand such a degree of heat. In these obscure departments of nature, however, there is no reasoning with certainty from mere analogy. Before TREMBLEY's discovery of the nature of the polypus, it could scarcely have been credited, that there existed any animal which might be multiplied almost *ad infinitum*, by cutting it into pieces ; and there are many other phænomena in the animal kingdom, which stand as it were insulated and independent of the laws which govern the chain of animation to which they belong. Thus vinegar proves an instantaneous poison to all animalcules found in other fluids, yet the *vibrio aceti* is found in vinegar, and in it alone. Some animalcules, after being dried up for years, as the eels in blighted wheat, revive upon the application of moisture ; and the insect named the *puceron*, or vine-fretter (as discovered by BONNET), contrary to all analogy, propagates without sexual intercourse down to the ninth generation. From these, and many other similar occurrences, it must be evident, that analogy, in our researches into the lowest classes of animal life, must be a fallacious guide. Perhaps, therefore, without too far transgressing the bounds of probability, we may admit the possibility of the existence of a being possessed of animation, and yet capable of resisting a heat as high as 212°.

Second, It appears very absurd to suppose, that any organ of a living body should be composed of a congeries of other minute animated beings or animalcules.

But, at one time, it would perhaps have seemed nearly as great an absurdity, to suppose that such beings existed in any of the secretions ; yet the discovery of LIEUWENHOECK, and the

observations of succeeding philosophers have proved, that in the seminal fluid animalcules do exist in the greatest abundance.

Third, These spicula, contrary to the nature of animalcules, have no power of progressive motion.

This is no argument whatever against their vitality ; for how many animals are fixed to one spot from the first moment of their existence till that of their dissolution. I need only mention some of the *testacea*, as the *lepas*, *anomia*, and *serpula* ; and the numerous zoophytes, the inhabitants of which remain for ever fixed, each to the cell which gave it birth. Even in the human body, we find the various species of hydatids under the same circumstances.

Fourth, Animalcules increase in number by long keeping and putrefaction ; on the contrary, these spicula, by the same means, become greatly diminished in number.

Here it may be observed, that when animalcula thus increase, they are in their natural and proper element ; but the spicula, when removed from the eye, are in the same circumstances as intestinal worms or hydatids, which, when removed from the body, soon die. Besides, the life of the animal which they infest, seems necessary to the continuance of their being ; for after the death of the animal, (as in the case of removal,) they soon die also. Hence, allowing these spicula to be animated, the wonder may rather be, how they retain their animation so long after being removed from their natural situation. It would, however, only be another instance of the extraordinary power by which some animals retain vitality, as is strongly evinced in the frog or turtle, which are said to leap or move about even twenty-four hours after the head has been taken off, or the heart cut out.

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With regard to the little effect which ardent spirit produces on the spicula, it may be remarked, that scarabæi, and other coleopterous insects, often remain a considerable time immersed in spirits before they become motionless, and, when taken out after a lapse of four or five hours, frequently recover.

Fifth, Are not these spicula formed and nourished by blood-vessels as the other parts of the fish are; and, if so, how can they be considered as distinct animals? This question, it must be confessed, is almost unanswerable. To prove that vessels cannot be traced into them, would be to prove nothing; for in many parts of the body, as the cartilages of the joints, vessels cannot, even by the finest injections, be detected. The spicula are chiefly abundant in the cellular substance which connects the outer layer of the choroid to the sclerotica, and there they seem to have little or no adhesion, at least not more than would seem to arise from their confinement among cellular substance. Hence, in merely separating the choroid from the sclerotica, they are obtained in thousands. When the choroid also is dissected off, and gently shaken in a phial with a little water, the liquid very soon becomes milky, from their dispersion through it.

This looseness, or want of connection, is, however, of little consequence with respect to the present argument, since the brain or the pulpy retina may be diffused through water with almost as much ease, yet both are perfectly vascular. The particles, however, into which the brain or retina is broken are quite irregular, and of different sizes or clusters, and of pulpy consistence, and exhibit no appearance of motion. The spicula, on the other hand, seem to be rigid, are always distinct, and of a constant determinate form, and keep up a perpetual motion and reflection of light.

Perhaps many other objections may be opposed to the supposition of animalcular life in these bodies ; and yet the strong *expression* of animation, if I may so term it, and air of seeming design, with which the varying motions, sometimes slow, and sometimes rapid, are performed, and the difficulty of otherwise accounting for their motion, whether real or apparent, lead, upon the whole, I think, to this supposition, not as one which we can admit with confidence, but as the *least improbable* conjecture, which, in the present limited state of our knowledge, we can venture to form.

In managing the microscope, the reflector must not be used ; for when a strong light is transmitted through the fluid, the spicula become invisible, or are only imperfectly seen. The fluid, therefore, containing them, should be placed upon something of a dark colour, as a piece of glass, with its underside blackened ; and, the stronger the light which can be thrown upon the surface, the better ; hence they appear uncommonly brilliant and distinct when placed in the sunshine ; and, in this situation, with a high magnifier, they present one of the most brilliant and lively microscopic objects that can be imagined ; each spiculum seems like a long bar of light, constantly twinkling, with a reflection almost too strong for the eye to sustain. They may be also well seen in a strong candle light, so managed, that it may fall upon the surface.

Perhaps this phænomenon may have been already pointed out ; but it is not noticed by ADAM, CUVIER, BLUMENBACH, or any author with whom I am acquainted.

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Since these observations were originally made by me on the spicula of the eye, I have been led to extend my inquiries to other parts of the fish ; and though I have not yet had time to vary my observations as fully and widely as with more leisure I would have done, I may state even now, that I have ascertained beyond a doubt, that the brilliant colours of the surface of this splendid tribe of animals are not owing, as CUVIER supposes, to a *mucous* * substance, but to bodies in every respect the same as the spicula of the choroid coat of the eye. The scales of fishes are pellucid ; and their brilliant appearance is owing to a thin film, which covers the underside of each scale, and is itself entirely formed of spicula, as is easily proved by scraping off a quantity of scales, and agitating them in water with a stick or other body, so as to detach the films. The water will then be found to contain thousands of moving spicula, which, in the sunshine, may be discerned with the utmost ease by the naked eye. The scales of the salmon answer best for this purpose, as they are large and easily detached.

* “ Of all vertebral animals,” says this illustrious physiologist, “ fishes are the most remarkable for the brilliant and metallic colours which their rete mucosum exhibits. We find in them gold, silver, and copper, tin, lead, and even all the tints which these metals assume in different degrees of oxydation. But as the description of these colours is the province of Natural History, properly so called, we wish merely to point out in this place, that they are produced by the mucous substance which adheres closely to the internal surface of the scales, and with which it is frequently renewed.” Sect. XIV.