On the existence and uses of cilioe in the young of the gasteropodous mollusca, and on the causes of the spiral turn of univalve shells / by R. E. Grant.

the Roy. Coll. of Physicians of Edin.

from the Author.

On the existence and uses of Ciliæ in the young of the Gasteropodous Mollusca, and on the causes of the spiral turn of Univalve Shells. * By R. E. Grant, M.D., F.R.S.E., Fellow of the Royal College of Physicians of Edinburgh, and formerly Lecturer on Comparative Anatomy.

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When we examine the surface of the minutest animalcules with a powerful microscope, we perceive that their quick locomotions are produced by the rapid vibration of very minute processes termed *ciliæ*, variously disposed on the surface of the body in the different species. In zoophytes, whose fixed and inert axis prevents them from swimming to and fro in search of prey like animalcules, we observe incessant currents of water directed to the mouths of the polypi, caused, not as is generally supposed by the motions of the tentacula, but by the quick vibration of *ciliæ* disposed either on the tentacula, or around the mouths of the polypi. I have already shown that the same minute vibratory organs exist on the surface of the reproductive gemmules, or so named *ova*, of a great variety of zoophytes, enabling these fixed and apparently inert animals to rise from the bottom of the sea, and swim rapidly from place to place during the first stage of their existence, separate from the body of the parent. Although the *ciliæ*, in the simplest orders of animals, might be considered as organs of motion destined to supply the place of the muscular system, a more extended application of the microscope will show that they are not confined to animals thus low in the scale, but are likewise of frequent occurrence in such as have the muscular and nervous systems highly developed, and probably that they have some influence in the first developement of the embryo of the most perfect animals. While watching the progress of the embryo of the *Buccinum undatum*, and of the

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Purpura lapillus, with the view of determining the influence exerted by the enormous pulsations of the heart of the testaceous gasteropodous *mollusca*, in causing the oblique spire of univalve shells to lie always on the side opposite to that organ, I was early struck with the rapid and incessant motion of the amniotic fluid towards the fore part of the body of these animals during every stage of their developement within the ovum, and it was easy to observe by the aid of the microscope that these currents were produced by *ciliæ* placed around the margins of two funnel-shaped projections on the fore part of the young animal. On examining the cells newly deposited by the female *Buccinum undatum*, whether in basons of sea water, or on the sea shore, we find in each cell about a thousand very small yellow opaque spheres, suspended in a transparent gelatinous fluid, which has a saline taste, and leaves dendritic crystals on evaporation. These yellow bodies do not effervesce in nitric acid, nor can we perceive any lime secreted in the shell of the young animal before it comes in contact with the sea water by the opening of the cell at maturity. The yellow spheres are observed to assume an arrangement in curved and convoluted rows, and at length they are found grouped together into about twenty small separate masses, where they are united by a gelatinous basis. Soon after the formation of these twenty round groups, we observe the gelatinous connecting matter form a transparent covering on each group, which is the rudiment of the future shell, and on one side the gelatinous matter is lengthened outwards, so as to form the margins of an internal cavity whose entrance is surrounded with vibrating *ciliæ*, and in the interior of which we perceive a constant revolution of the particles of some fluid. The vibration of the *ciliæ*, and the revolving current in the internal cavity, are perceived long before the pulsations of the heart, or any appearance of that organ are discernible, and are the first indications of life in the embryo. The yellow opaque bodies occupy the shut end of the spire like the testicle and ovarium of the adult. The heart is formed on the left side of the transparent anterior part, and its motions are so great, that at each diastole the whole projecting anterior half of the animal is forced considerably to the right side, causing that part of the

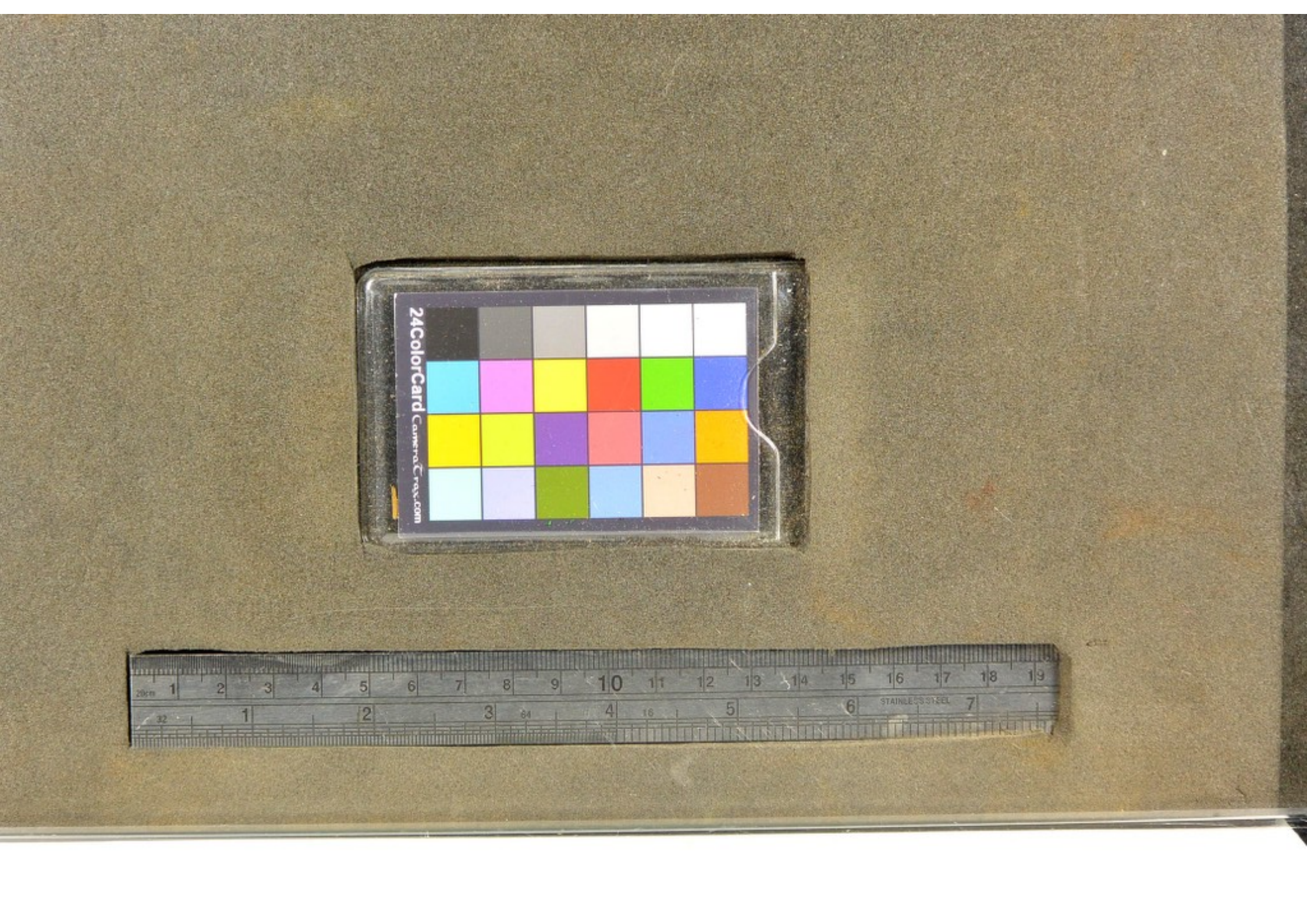
body, and consequently the shell, to assume a curved form, with the heart always on the convex side of the curve. The heart pulsates about twenty times in a minute, and the diastole of its cavities is much more sudden and remarkable than the systole. If the motions of the heart were the only powers which turned the body from a straight line, the spire of the *Buccinum* would revolve on the same plane round its shut extremity, like that of a *Spirorbis ;* but as the animal's foot requires continually to descend over the *columella* of the shell, before it can reach a solid surface to creep upon, the body and the shell are thus incessantly deflected from the original plane, and forced to assume the spiral form which we observe in the adult *Buccinum*, and in most univalve shells. In the *reverse* shells, where the cone lies on the left side of the animal, we likewise find the heart in a reverse situation, being then on the right side. The two wide projecting circles of *ciliæ* at the sides of the mouth continue visible for some time after the escape of the young *Buccinum* from the general cell, and they are of such length and size that their motions can be easily followed by the eye aided by the microscope. The young of the *Purpura lapillus* are also inclosed in a horny general capsule, like those of the *Buccinum*. The ovum of the *Purpura* is shaped like a grain of corn, while that of the *Buccinum* is flat like a split pea. When first deposited, the horny covering in both is white and soft, but soon becomes yellow and firm, and the transparent gelatinous matter enveloping the young becomes gradually thinner as the young advance to maturity. There are about fifty-five young in each cell of the *Purpura*, and they exhibit the same mode of developement as those of the *Buccinum;* the same revolution of particles within the transparent part of the embryo give the first indication of life, and the same wide ciliated opening is seen on each side of the head, the *ciliæ* continuing to vibrate for some time after the escape of the young from the cell or ovum, as in the *Buccinum*.

These circles of long vibrating *ciliæ* I have also met with in the young of other genera of testaceous mollusca, as the *Trochus, Nerita*, &c. which are not inclosed in a general horny cell, but are merely enveloped in a soft gelatinous matter, by

which they adhere to the leaves of *fuci* till they arrive at maturity. In such genera as have the *ova* enveloped only in a soft gelatinous matter, we find a delicate membrane surrounding each *fœtus*, and inclosing a thin amniotic fluid. In these the *ciliæ* are so long, and so rapid in their motions, that the young are seen within the *ova* revolving continually round their own axis, by striking the *ciliæ* against the inside of the containing membrane; and when they escape from the *ova*, they are carried with great velocity through the water by the vibrations of the *ciliæ*. I have observed the same appearances in the young of the naked gasteropoda as in the *ova* of different species of *Doris*, *Eolis*, &c. which are inclosed in a soft transparent gelatinous matter, and adhere by it to rocks or other solid marine bodies. The young in these genera are likewise surrounded, each by a thin membrane and amniotic fluid. They are seen almost continually revolving round their centre within the *ova*, and they swim rapidly forward by the action of their *ciliæ* when they escape from the *ova*. In those genera which deposit the young in a general horny cell, as those first described, we find no membrane or amniotic fluid surrounding each *fœtus*, but the horny covering is lined with a delicate membrane which incloses the whole of the embryos and the gelatinous fluid in which they are developed. The young of the *Buccinum*, when mature, escape from the cell, by a part of the horny covering separating on the inner concave side of the cell. The young of the *Purpura* escape by the falling off of a firm gelatinous plug from the free extremity of the cell. The portions of the outer covering which fall off are probably loosened by the motions of the young within; and as the young are still safely lodged in their cells when they first come in contact with the sea water by the formation of the aperture, we find the *ciliæ* in such genera much less developed than in the other genera without a horny covering. Their motions appear destined to bring a constant supply and renewal of pure sea water in contact with the young in the cells, in order to perfect the formation of the shell before their final departure from the now open cavity of the cell. In the *ova* which are enveloped in a gelatinous connecting matter without any horny covering, we observe

that connecting matter become very soft and loose, and separate into long flocculi when the young have arrived at maturity; and when the *ova* separate successively from the general mass by the action of the waves, the young in each *ovum* is so large as nearly to fill the whole of the vesicle which contains it. The *ciliæ* in these species are so long, and move with such rapidity, while the young gasteropod is incessantly revolving round its own centre, that probably the continued pulsations of the *ciliæ* against the sides of the containing vesicle tend to abrade or weaken it, and thus aid the escape of the young animal. After their escape from the vesicles, the rapid vibrations of these long *ciliæ* cause the young animals to swim with great velocity to and fro in the water, which will greatly accelerate their means of procuring food during their infant state; and as they have neither a *byssus* to fix themselves to rocks, nor a calcareous shell to protect them from the violence of the sea, the power of rapid locomotion which they possess by means of the *ciliæ* will add much to their safety in an element in constant agitation.

There is a remarkable similarity in the structure of the ciliated parts in the embryos of all the *gasteropodous mollusca* I have yet examined, and even in the general form of these animals, whether naked or testaceous, in their infant state. The existence of those singular minute vibrating organs termed *ciliæ*, appears not to have been hitherto noticed in animals so high in the scale; but from their general occurrence in this extensive class, it is highly probable that they are much more frequent and important organs in the economy of the lower animals than observation has hitherto shown.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