moreover, long ciliated. Some degree of diœcism is however characteristic also of P. tetranthera and P. baccharoides, while pappus-bristlets in a single or in more than one row, and with various extent of denticulation or even ciliation, occur together in some other genera of Compositæ, for instance, in Senecio. The remarkable narrowness of the stigmata in our species, as well as their structure, are quite in accord with Pluchea, so also the sagittate base of the anthers, although the latter is reduced to extreme minuteness. This Pluchea, however, connects the genus evidently with the exclusively American Baccharis, and a section in Pluchea, as Natho-Baccharis might be established for it. The involucral bracts of P. conocephala arise all closely together from the exceedingly small receptacle; the corollas when dry are dull and dark-coloured towards the summit, but may be purplish when fresh; those of the staminate flowers being shorter than those of the others; the filaments are comparatively short; the terminal plate of the anthers is almost semi-lanceolar; the stigmas of the flowers with rudimentary anthers are fully exserted, those of the other kind of flower much enclosed and thicker than in many other species; the achenes are comparatively long. The pappus is almost that of Pterigeron. Additionally it may also here be noted, that Eurybia rudis is transferable to Erigeron, in which genus it should form a distinct section.

Art. XIII.—*Notes from the Biological Laboratory, Ormond College.*

I. *Observations on the Movements of Detached Gills, Mantle-lobes, Labial Palps, and Foot in Bivalve Mollusks.*

By D. McAlpine, Esq.

[Read October 13, 1887.]

The present paper will only deal with the results of these observations, without giving any detailed description.

It has long been known that the gills, for instance, of bivalve mollusks, exhibit ciliary motion in a very marked manner, but it has not hitherto been observed, that an entire gill, or portion of a gill, when detached from the body is capable of moving visibly and at a measurable rate of speed. It does seem strange, no doubt, that a large and important portion of the body, such as the gill, firmly fixed during life, and playing the part of a stationary engine, by creating currents in the water by means of its cilia, should become when detached, a locomotive engine, and the energy formerly spent in creating currents, now apparently utilized in driving the gill itself. And the wonder is not lessened, but increased, when we consider that the sea mussel, provided with such organs, capable when detached, of roaming about pretty actively, is one of the most inactive of animals in the adult state, even rooted to the spot where it lives by means of its byssus. Not only does the gill move thus, but other parts as well, all of them being richly provided with cilia. In fact there are four principal portions of the sea mussel which exhibit this independent movement when detached, viz., the mantle-lobes, the labial palps or tentacles, and the foot, as well as the gills.

It is generally known that cilia retain their activity even after the death of the animal, and that ciliary motion may be beautifully seen in detached pieces of any of the parts mentioned, but the point now to be insisted on is, that there is visible and measurable movement in these parts when detached. And there is at least a threefold interest attaching to an investigation of this sort.

There is first of all the peculiarity of detached portions of an animal comparatively high in the scale, retaining to a certain extent independent vitality, moving about and often rotating, as we shall see, in a certain definite manner and direction. Such an appearance is always interesting, whether it be the detached portion of a hydra, or of an earthworm, the wriggling tail of a lizard, or the detached leg of a spider.

Then there is a further interest when it is known that this movement in the mollusk is due, in whole or in part, to the action of cilia, for it may throw light upon the action of the ciliated epithelium of our own bodies, say of the lining membrane of the nose or of the windpipe.

And lastly, it will be interesting to determine the functions of the parts when attached to the body, judging from their behaviour when free, and see if such movements can throw any light upon their actions when in organic connection with other parts.

It was while examining the gills of the sea mussel in the ordinary course for medical students, at the Biological Laboratory, Ormond College, that a clue was obtained to the independent motion of the gills, and afterwards of the other parts as well. At first the movement was thought to be microscopic, only to be determined by a micrometer, but I soon found out that it required the largest of plates to allow free scope to the movements of translation and rotation.

For convenience, the subject will be considered under a fourfold heading, and in the order named :—

I.—Labial palps, inner and outer.

II.—Gills, inner and outer.

III.—Mantle-lobes.

IV.—Foot.

And a further division into four sections is necessary, each dealing with one special part of this particular enquiry :—

(*a*) Nature, direction, rate, and duration of movement in each of the above four parts when detached and free to move.

(*b*) Bearing of the observed movements on the probable functions of the parts concerned.

(*c*) Motive power employed in producing the movement.

(*d*) Effects of re-agents, &c., on movement.

Only the first section will be dealt with now.

Before proceeding a step further, it will be necessary to be agreed as to the position from which the moving parts are to be viewed, since it is impossible to have them detached and observed in motion in their natural position. If the valves of the shell are separated in the usual way, by inserting a knife at the ventral surface and passing it round the posterior end until the posterior adductor muscle is cut through, then if the two valves are spread out flat, with their pointed ends directed anteriorly, the right and left valves will be just reversed from our own right and left. This is the position from which our observations will be made as to the direction of movement. Further, in describing movements of rotation it will be found very convenient to use the terms *right-handed* and *left-handed*, as is done in connection with the rotation of the plane of polarization. So when rotation occurs in the direction of the hands of a watch, as seen by the observer, it will be called right-handed, and when in the opposite direction, left-handed; and the Labial Palp, for instance, according to its rotation, will be spoken of as right-handed or left-handed.

I.—Labial Palps.

1.—*Inner Palps.*

If a Palp is detached as near its base as possible, and laid on a plate with the liquid from the shell, then its motions are easily observed.

The movement is one of regular rotation, the palp revolving about one end in a steady manner, and in a definite direction. There may be forward, or backward, or lateral movement combined with this, but when once the palp has fairly become accustomed to its free condition of existence, rotation is its characteristic movement. This rotatory motion is probably due to the fact that the basal (cut) end is destitute of cilia, and so there is a tendency to turn round that spot as on a pivot. The palp, however, can also rotate upon its tip, and we can hardly account for making it the pivot on purely mechanical grounds.

The right and left inner palps detached turn *inwards*, the left turning to the left, while the right turns to the right. If there are obstacles in the way, such as dirt-particles in the water, or solid bodies of any kind, then the sensitive tip, ever, seemingly, on the alert, soon backs out and clears away from it, even although it should involve a change of course. Thus, I have seen a palp, when placed in a dirty liquid, turn backwards for a short distance, until it had shaken itself clear of adhering rubbish, and then go forward in its regular course, as if nothing had happened. If either palp is reversed, then it might be anticipated that the direction of movement would be also reversed, but as the result of several trials it was found that the direction was the same, the left inner being *right-handed* and the right inner *left-handed.*

Numerous continuous observations were made, over extended periods of time. It generally happened that the rate was slow at first, then gradually quickened, attained its maximum speed, and finally declined. The greatest speed attained was found to be a complete revolution in $1\frac{3}{4}$ minutes. *Left.*—For 15 recorded revolutions, the slowest was 17 minutes, the quickest $2\frac{1}{2}$ minutes, and the average 6 minutes. The first revolution took 11 minutes, and the last (recorded) 17 minutes. If a *partial* average be taken, including from the 4th to the 12th round, when the rate was comparatively regular, it would give 3 minutes per round. The left reversed, performed 12 revolutions at an average rate of 8 minutes. The motion was very steady, and after the first round, which took 16 minutes, the rate was either 7 or 8 minutes. A second specimen tried, performed 12 revolutions at an average rate of $6\frac{1}{3}$ minutes. The first round took $10\frac{1}{2}$ minutes, and afterwards they varied from $7\frac{1}{2}$ to 5 minutes. It is always to be understood that the palp continued revolving after the recorded observations. *Right.*—For 26 recorded revolutions, the slowest was 60 minutes, the quickest $1\frac{3}{4}$ minutes, and the average $8\frac{1}{3}$ minutes. It commenced with a revolution in 5 minutes, about the middle (14th) attained to the quickest in $1\frac{3}{4}$ minutes, and ended with the slowest in 60 minutes. A partial average for the more steady rounds, comprising from the 6th to the 19th inclusive, gave $2\frac{1}{2}$ minutes per round. The record was closed for the right after completing 26 rounds, when it became perfectly still, as if exhausted. It was still sensitive, however, as it quivered on being touched with a pin, and next morning it had shifted its position. The right reversed, moved very slowly, although it rotated in the usual manner by making the base the pivot. The first round occupied an hour, but deducting time stuck, it only took 28 minutes; the second round 22 minutes, and the third 20 minutes. Another specimen was tried, and in 12 revolutions gave an average rate of $5\frac{1}{6}$ minutes per round. The first round took $7\frac{1}{2}$ minutes, the last $8\frac{1}{2}$ minutes, and the intermediate rounds from 4 to $5\frac{1}{2}$ minutes.

2.—*Outer Palps.*

The movements generally resemble that of the inner palps. The outer palps appear to be capable of more sustained effort than the inner, as indicated by their more regular rotation for longer periods. The tip appears to be exceedingly sensitive. It might be thought from their general resemblance to the inner, that the direction of movement would be the same, but it is just the reverse of the inner of the same side. Thus the right rotated to the left, or outwardly, while the left rotated to the right, also outwardly. While this is the normal direction, I observed that it was occasionally reversed. This change might last for a few rounds, and then the original normal direction would be resumed. That the direction can be changed, and the original resumed again is rather an important observation, showing that the arrangement is not altogether a mechanical one, which causes the palps to move in a particular direction, like the hands of a clock.

The rate happened to be more regular than in the inner. This is evident from the fact that I was able to observe their movements over extended periods of time and through a number of rounds (50) without their movements becoming feeble or sluggish.

Left.—The left was observed for 20 rounds moving to the right with great regularity. The average was 7½ minutes to the round, the slowest being 9½ minutes, and the quickest 6 minutes. It commenced at the rate of 6 minutes per round, and with a steady pace, varying from 6 to 9 minutes. The 20th round was performed in 7½ minutes. The movement still continued when I ceased recording.

Right.—The right was observed continuously for 50 rounds, and for given periods of time the rate was pretty constant. The general average was 5 minutes to the round; the slowest record was at the commencement, with 25 minutes to the round, and the quickest was 2 minutes. The partial average for the 20 best continuous rounds, from the 13th to the 32nd inclusive, was 3 minutes, and the middle round of the whole (25th) was 2 minutes. The palp was going at the rate of 4 minutes to the round, when I left off observing, and the 51st round took 5½ minutes. Both left and right continued to move for some time afterwards, as I observed them for 25 minutes rotating as usual.

In this series of observations, extending over 4 hours, there was no variation in the direction, the left always revolving to the right, after being fairly started, and the right always to the left. But in a second continued series of observations, there was considerable variation in the rate and regularity, and a change in one of them once in the direction of movement.

An outer and inner palp were laid out at 11 p.m. to test how long they would retain movement, and next morning both were found moving. The morning after both again were found to have moved, and on the evening of the same day the inner palp moved visibly, while the outer was sensitive, but not motile. Hence one of the palps, at least, retained its power of movement for 48 hours, but this duration was afterwards completely eclipsed by the palp of the fresh water mussel (*Unio*), which actually continued to rotate for eight days.

A comparison may now be profitably instituted between the outer and inner palps as to direction and rate of movement, taking the partial average as a fair one.

TABLE I.

LEFT.	DIRECTION.	AVERAGE RATE.
Outer	Left-handed, outward	$7\frac{1}{2}$ mins. per round.
Inner	Right-handed, inward	3 „ „
RIGHT.		
Outer	Right-handed, outward	3 „ „
Inner	Left-handed, inward	$2\frac{1}{2}$ „ „

The outer rotate outward, the inner rotate inward, and this suggests a difference of function which we shall see actually exists. But it is also suggestive of some difference of structure or relative position, and the latter is found to be the case.

There is not any important difference in the rate of speed, except with the left outer, and its inherent slowness is borne out by two series of observations. No general conclusion can be drawn from the fact, but it remains that the left outer is fully twice as sluggish as the others when detached, and even regularly so, for each quarter round was frequently two minutes, thus completing a round in eight minutes.

II.—GILLS.

The gills will be named as in the following scheme :—

Gills
- Left
  - Inner.
  - Outer.
- Right
  - Inner.
  - Outer.

The left and right gills were first experimented on as a whole, *i.e.*, taking inner and outer of same side together. Next, inner and outer were observed separately, and lastly, small portions were taken.

As regards the power of movement possessed by the gills, perhaps, no more striking illustration could be given of it, than the fact, that either a single gill or a small portion of it, can travel along a moist surface even when held vertical, and if the plate is turned upside down, the gill still continues to move.

Dr. Carpenter, in his well-known work on the microscope, in referring to the ciliary motion exhibited by the gill of the sea mussel under the microscope, has remarked, " Few spectacles are more striking to the unprepared mind, than the exhibition of such wonderful activity as will then become apparent in a body, which to all ordinary observation, is so inert." But if he had only looked beyond his microscope, and applied ordinary observation, he would have seen the spectacle of the moving gill, the wonderful result of the lashing of the cilia.

It is also remarkable that in a sedentary animal like the mussel, more than one-half of its body by weight, when detached and free to move, is capable of independent motion. I took three mussels of average size, and after allowing them to drain sufficiently, weighed the entire body as taken from the shell. Then the gills, mantle-lobes, and labial palps were detached and weighed, and it was found that $\frac{7}{12}$ths of the soft body by weight could move about.

The movement is both translatory and rotatory. The former being a gliding movement, with the free ventral margin always behind. The direction is always that of the cut surface, and the rotation as a rule, takes place with the posterior end as a pivot.

As the result of numerous determinations at different times, I have found that the gills, both inner and outer, move at an average rate forward, of two minutes to the inch. They frequently cover an inch in 1 minute, and are sometimes much slower, but on the whole I have found them time after time, in succession, doing an inch in 2 minutes. The average rate for a small piece is the same as for the entire gill. The rate of the vertical ascent is more variable. The right inner gill ascended an inch three times in succession, respectively in 9, 10½, and 11 minutes, thus giving an average of 10 minutes to the inch. The left inner did the same in 14, 13, and 10 minutes respectively, thus giving an average rate of 12⅓ minutes to an inch. Both gills travelled horizontally at the regular rate of 2 minutes to the inch. The quickest vertical ascent was made by a right outer gill doing 1 inch in 7 minutes. The average rate when turned upside down was 2½ minutes to the inch. Left inner gill, detached on the evening of the 2nd, was found moving visibly with cilia in active movement on the evening of the 4th, so that in this instance, motion continued for at least 48 hours.

III.—Mantle-lobes.

The right and left mantle-lobes are just lateral expansions of the integument, arising dorsally from the body-wall, and attached ventrally to each valve of the shell by the thickened muscular margins, which are pigmented posteriorly and provided with tentacular processes. The inner surface only of the mantle is ciliated, and the direction of the ciliary current is outward and backward. On the thin membranous body of the mantle, the current is towards the exterior, while on the thick muscular margin it is towards the posterior end of the body. The movement is rotatory, for although there is a certain amount of forward movement, it only occurs, as it were, in the course of the rotation.

The entire left mantle-lobe was detached and placed in water, with its outer or non-ciliated surface uppermost. It began to glide away at once, but soon rotated upon its posterior end, turning towards the cut surface. It completed a round in 4 hours 20 minutes, and the quarter rounds were successively 1 hour 5 minutes, 1 hour 17 minutes, 1 hour 21 minutes, and the last in 37 minutes.

Right and left mantle-lobes were next taken and divided, each into two portions, the brown tentacular muscular margin being separated from the remainder. The brown marginal portion did not move just at first, but afterwards it travelled considerably. The whitish muscular margin, with the thin body of the mantle-lobe, moved visibly, the muscular margin taking the lead and dragging the rest along. The white and brown portions continued moving the day after being detached, and both were found to be sensitive, though not moving, 48 hours after being detached. The pigmented portion is particularly sensitive to stimulation, readily responding to the prick of a pin.

IV.—Foot.

The foot is a thick muscular brownish tongue-shaped body, ventrally situated, and its tip directed anteriorly. From the posterior end, which is comparatively uncoloured, the byssus for attachment is given off. By virtue of its secreting this byssus, the foot is the fixing organ of the mussel, but the free portion of the foot is capable of great expansion and contraction, and is really a very active member. When the valves gape a little it can protrude itself beyond the mouth and outside the shell, or it can turn itself round and project behind, or when the shell is firmly closed it may protrude on the ventral surface. The foot is richly ciliated, there is a slight notch at the free end, making the tip slightly bifid.

If the free portion of the foot is detached and laid in water sufficient to cover it, movement will take place. The movement is of two kinds—translatory and rotatory—the former being the normal one. The direction of translation is straight forward and away from the cut surface. The tip always led the way, and it might sometimes diverge a little to the right or left, but the general trend was a direct straight line. The direction of rotation, with the dorsal surface uppermost, was right-handed. The rate of rotation was, a complete round in 6 hours 47 minutes.

The rate of translation was fairly tested in a specimen, with dorsal surface uppermost, which moved 6 inches in 5 hours 55 minutes, or at the average rate of 1 inch per hour. With such a slow rate of movement, it is, of course, impossible to say exactly when movement ceases. Accordingly I have taken the safe plan of giving duration up to a time *after* which a little movement was known to occur. A specimen was thus known to retain its power of movement for at least 73 hours, or about 3 days.

Thus the wonderful result is arrived at, that in the common sea mussel, which has been known and studied for so long, there is a latent power of independent movement in detached parts, which has hitherto escaped notice.

It is one of the marvellous surprises of Natural History to see the seeming biological paradox of parts when attached to the living body apparently inert, but when detached from it, in active motion. The gliding gill and the rotating palp, the moving mantle-lobe and the creeping foot, show what a stock of vital energy must be stored up in the soft-bodied mollusc imprisoned within the walls of its shell.

Similar comparative observations have been made on the fresh water mussel and the oyster. Even detached portions of the frog have been found to move, and it will be a genuine surprise to physiologists to learn, that the heart of the frog, so long and so much investigated, has likewise a wonderful power hitherto unnoticed, that of travelling about when detached from the body, having covered a distance of half-an-inch in 10 minutes. These and other matters will, however, require separate treatment.

Art. XIV.—*Rainfall and Flood Discharge.*

By G. R. B. Steane.

[Read November 5, 1887.]

The subject of maximum Flood Discharge is one of considerable importance to the engineering profession, particularly to those upon whom falls the responsibility of constructing drainage outlets, culverts, bridges, &c. Though the subject has been practised for thousands of years and there have been millions of opportunities for observation, the bulk of the opportunities have been lost, owing to the fact that the surrounding circumstances have not been observed, and the information has not been published.

A few engineers have paid attention to the matter of river discharge and published the information, but on the whole, I think, the subject has been neglected. I know of very many instances where costly works have been constructed to answer certain purposes and have failed, causing damage to many times the value of a proper structure. As an evidence of the difference of opinion held by authorities, I cannot refrain from referring to evidence given at an