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March 6, 1879.

THE PRESIDENT in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

In pursuance of the Statutes, the names of the Candidates for election into the Society were read, as follows:—

Henry James Alderson, Lieut.-Col. R.A.

Thomas Clifford Allbutt, M.A., M.D.

John Anderson, M.D., F.R.S.E., F.L.S.

William Edward Ayrton, Assoc. Inst. C.E.

Henry Walter Bates, F.L.S., F.Z.S.

Rev. Miles Joseph Berkeley, F.L.S.

Henry Bessemer, Assoc. Inst. C.E.
Henry Francis Blanford, F.G.S.
George Stewardson Brady, M.D., F.L.S.
Prof. Alexander Crum Brown, D.Sc., M.D.
Walter Lawry Buller, D.Sc., F.L.S.
Charles Creighton, M.D.
William Sweetland Dallas, F.L.S.
George Howard Darwin, M.A.
Francis Stephen Bennet François de Chaumont, M.D.
John Dixon, C.E.
Sir George Duckett, Bart.
Prof. Joseph D. Everett, M.A., D.C.L.
William Galloway.
Henry Haversham Godwin-Austen, Lieut.-Col.
Prof. Thomas Minchin Goodeve, M.A.
Charles Alexander Gordon, M.D., C.B.
Charles Graves, Bishop of Limerick.
Townshend Monckton Hall, F.G.S.
John Harley, M.D., F.L.S.
John Deakin Heaton, M.D.
Henry M. Jeffery, M.A.
John Edward Lee, F.S.A., F.G.S.
Prof. George Downing Liveing, M.A.
George Matthey, F.C.S.
William Munro, General, C.B., F.L.S.
Charles Henry Owen, Col. R.A.
William Henry Preece, C.E.
Charles Bland Radcliffe, M.D., F.R.C.P.
John Rae, LL.D.
George Banks Rennie, C.E.
Prof. J. Emerson Reynolds, M.D.
George F. Rodwell, F.C.S.
George John Romanes, M.A.
Sir Sidney Smith Saunders, C.M.G.
Arthur Schuster, Ph.D., F.R.A.S.
Michael Scott, M.I.C.E.
Prof. Harry Govier Seeley, F.L.S.
John Spiller, F.C.S.
Bindon Blood Stoney, M.A., M.I.C.E.
Sir Henry Thompson, F.R.C.S.
William A. Tilden, D.Sc.
Alfred Tribe, F.C.S.
James Clifton Ward, F.G.S.
Benjamin Williamson, M.A.
Charles R. Alder Wright, D.Sc.
Prof. Edward Percival Wright, M.D., M.A., F.L.S.
Thomas Wright, M.D., F.R.S.E., F.G.S.

The following Papers were read:—

I. "Observations on the Physiology of the Nervous System of the Crayfish (*Astacus Fluviatilis*)." By James Ward, M.A., Fellow of Trinity College, Cambridge. Communicated by Michael Foster, M.D., F.R.S., Prælector of Trinity College, Cambridge. Received February 17, 1879.

I. *When one of the supra-œsophageal commissures is divided*, the whole body of the crayfish on the injured side is more or less enfeebled, with

the exception of the swimmerets and possibly the gnathites. The change is most marked in the antennæ and eye-stalks, which barely respond to considerable excitation; and after these perhaps in the abdomen, the power of swimming or turning over being generally entirely lost. The muscles connecting the abdominal segments on the injured side are relaxed, and the tail-fin appendages on that side are no longer spread out in the normal manner, but remain more or less overlapping and hang down like broken limbs. This leads to a want of symmetry which is most conspicuous during movement: it almost disappears when the nervous connexion with the abdomen is entirely severed by a cut between the first and second segments. No clear difference is discernible in the pinch of the two chelæ, but in prehension and locomotion all the limbs on the side of the injury are weakened. In consequence of this, when walking forward the course taken is towards the sound side, in backing the course is towards the injured side. The chelæ during progression show a bias towards the sound side; that is to say, when the right commissure is cut, they are both directed towards some position on the animal's left, and *vice versâ* when the left commissure is cut. There is a tendency when walking to flop suddenly forwards, and in some cases to "wabble" from side to side.

II. So long, however, as the other commissure remains intact, there is no lack of spontaneity and purpose in the movements of the crayfish; but when this too is severed, *that is, when both commissures connecting the supra- with the sub-œsophageal ganglion are divided*, everything of the kind disappears, save that occasionally the antennæ are waved about in the normal fashion, though much more feebly. The animal lies on its back, the maxillipedes, the chelæ, and the first three pair of legs, for the most part, swinging slowly to and fro in perfect *tempo;* not, however, as the swimmerets do, both sides synchronously, but with the movements of one side alternating with those of the other. On a very slight disturbance, and at intervals, without any obvious cause, this rhythmic swing gives place to feeding or "preening" movements, the last being chiefly confined to the fourth pair of legs, which take no part in the rhythmic swing. The feeding movements are a perfect mimicry of the movements made when food is actually seized. These last appear to be in all respects perfectly co-ordinated; so much so, indeed, that the chelate legs will wait their turn to pass their morsel to the mouth when scraps are placed in all of them at once. But neither they, nor the chelæ, nor the posterior maxillipedes, show any selective power, even the animal's own antennæ being seized: the first evidence of taste appears when the food gets within the gape of the mandibles.

When placed on a table, the ambulatory legs are straightened out so as to lift the body as if upon stilts, the half flexed abdomen barely

touching the ground with the tail-fin. In this position the animal will remain for a minute or so, one or more of the chelate legs engaging in feeding movements, while the last pair are doing their best to preen the abdomen. At length there is an attempt at locomotion, the limbs being moved slowly and in a tottering fashion, though with fair co-ordination, till after a few steps, having no power to recover its equilibrium, the animal rolls over helplessly on to its back. In some cases the chelæ were folded rigidly across each other so as to render locomotion impossible.

III. *When both commissures are divided behind the sub-œsophageal ganglion*, the antennæ are moved more frequently and more vigorously than in the last case: the eye-stalks too are oftener in motion. The rhythmic swing is not infrequent in the posterior maxillipedes, but very exceptional and of very short duration elsewhere. Preening movements are more common than under the last head, and in these all four pairs oftener take part; but feeding movements, save after external excitation, are quite exceptional. Then, however, they are vigorous enough, but the chelate legs are very uncertain in their aims at the mouth, do not loose their hold of the food when they get it there, and all of them attempt to crowd food into the mouth together. But the food is frequently rejected: in two cases out of three in which the experiment was tried, this "sulkiness" disappeared on dividing the supra-œsophageal commissures.

On the table these crayfish are unable to support themselves, the chelæ sprawl helplessly on either side and the legs are for the most part doubled up under the body. The posterior maxillipedes alone retain their wonted strength, and by means of these the cephalothorax is raised from the ground two or three times a minute till they are exhausted; the antennæ too being waved vigorously all the time.

IV. In three cases in which *a longitudinal division of the supra-œsophageal ganglion* was accomplished fairly satisfactorily, the animal assumed the stilted position above described, but the abdomen, instead of being bent sharply downwards, was alternately elevated to the utmost and then depressed and sometimes curved rigidly backwards for a minute or more: at which times, owing to the *rigor* of the chelæ, it was possible to make the animal stand upon its head. These animals had considerable power of maintaining equilibrium and were active in the water, making, however, very pronounced "circus-movements." Their ambulatory legs were always obedient to the impulse to walk, and never betook themselves to feeding or preening movements at such times.

From the foregoing it may perhaps, with more or less probability, be inferred:—

(*a.*) That there is no decussation of the longitudinal fibres in the nervous system of the crayfish.

(*b.*) That on the presence of the supra-œsophageal ganglion depend (1) the spontaneous activity of the animal as a whole, or what might be called its volitional activity; (2) the power to inhibit the aimless and wasteful mechanical activity of the lower centres; (3) the power to maintain equilibrium; and (4) the use of the abdomen in swimming.

(*c.*) That the sub-œsophageal ganglia are the centres for co-ordinating (1) the locomotive* and (2) the feeding movements, and (3) for the rhythmic swing described under II. (The stilted gait in II and the vigour of the posterior maxillipedes in III, the limbs connected with the other centres being then disabled for locomotion, seem to show that the sub-œsophageal ganglion is the source of a considerable amount of motor energy.)

(*d.*) That there is much less solidarity, a much less perfect *consensus*, among the nervous centres in the crayfish than in animals higher in the scale. The brainless frog, *e.g.*, is motionless except when stimulated, and even then does nothing to suggest that its members have a life on their own account; whereas the limbs of a crayfish deprived of its first two ganglia, are almost incessantly preening, and when feeding movements are started, the chelate legs rob, and play at cross purposes with, each other as well as four distinct individuals could do.

(*e.*) That some stimulus from other centres is more or less necessary to the activity of any given centre. This conclusion is rendered, at all events, probable (1) by a comparison of the activity of the antennæ and eye-stalks in I, II, and III; (2) by the diminution in the spontaneous feeding movements in III; and (3) by the simultaneous increase in the preening movements—the excitations from the tail-fin region having no longer a counterpoise.

(*f.*) The "natural" discharge of a ganglionic centre (not exhibiting "volition") appears to be of a rhythmic kind; the rhythmic movements becoming converted into varied movements by temporary augmentation or inhibition.†

It remains to mention one or two outlying points. There is much in the action and inaction of the mandibles, to suggest very considerable independence between the centre for their movements and that for the movements of the maxillipedes—which last is doubtless situated in the sub-œsophageal ganglion. Thus the mandibles in several cases lost the power to move while the maxillipedes continued unaffected, and

* In further proof of this position it may be added that, when the commissures are divided behind the second thoracic ganglia, the animal crawls with extreme difficulty by alternate advances of the chelæ alone; and that when they are divided behind the third it walks by alternate advances both of the chelæ and the first pair of legs: the other legs in each case being rucked together in confusion.

† Is there such a rhythm at the bottom of "volitional" movements?

they never, at any time, participated in the rhythmic swing or feeding movements of these last.

Gentle pressure on the anus or the sexual organs *excites or inhibits* the swimmerets, according as they are already at rest or in motion, and leads, where possible, to a folding of the abdomen. The feeding and preening movements are also, as a rule, brought to a complete standstill by slight irritation of the anus, the after movements being in all cases more violent. So long as the nervous connexion with the tail-fin remained intact, the swimmerets can be excited to considerable activity by touching this region, but when this connexion is destroyed, it is with difficulty they are made to move at all.

The experiments, of which the above is a brief and preliminary account, were carried on at the Physiological Laboratory, Cambridge.

II. "Preliminary Report upon the *Comatulæ* of the 'Challenger' Expedition." By P. Herbert Carpenter, M.A., Assistant Master at Eton College. Communicated by Sir Wyville Thomson, F.R.S. Received February 18, 1879. Published by permission of the Lords Commissioners of the Treasury.

The collection of *Comatulæ* made by the staff of the "Challenger" includes specimens from 45 different localities, but few of which are deep-water stations. *Comatulæ* were only obtained seven times from depths exceeding 1,000 fathoms, namely at:—

Station.	Depth.	Station.	Depth.
205	1,050 fathoms	158	1,800 fathoms.
218	1,070 ,,	160	2,600 ,,
175	1,350 ,,	244	2,900 ,,
147	1,600 ,,		

At lesser depths, 200—1,000 fathoms, *Comatulæ* were met with at 13 stations; but by far the greatest number both of species and of individuals were dredged at depths much less than 200 fathoms, and often less than 20 fathoms, at 26 widely distant stations.

No.	Station.	Locality.	Depth in fathoms.	Antedon.	Actinometra.	Promachocrinus.	Ophiocrinus.
1	48	.....	51	2			
2	..	St. Paul's Rocks.....	10—80	..	1		
3	122	.....	350	1			
4	..	Bahia.....	7—20	1	2		