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NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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MEMOIRS.

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M = Memoirs. P = Proceedings.

[OVER.

I. On a new Binary Progression of the Planetary Distances, and on the Mutability of the Solar System.

By HENRY WILDE, D.Sc., D.C.L., F.R.S.

Received and read October 5th, 1909.

1. In the paper which I read before the Society in March last "On the Moving Force of Terrestrial and Celestial Bodies in relation to the Attraction of Gravitation,"* it was demonstrated that the moving force of celestial bodies is as the square of the velocity, in accordance with the experimental results obtained with moving bodies at the surface of the terrestrial globe. I further announced and demonstrated the new dynamical law that the moving force of celestial bodies is inversely proportional to the square of the distance, and correlatively equal to the static attraction of gravitation. For if the moving force were simply as the velocity, the attraction of gravitation would require to be in the like proportion, otherwise planetary bodies would either fall upon the central body, or be projected into outer space. But it has been demonstrated that the moving force and the attraction of gravitation are alike inversely proportional to the square of the distance to maintain and retain celestial bodies in their orbits during their revolutions round their primaries.

2. As some confusion of thought has arisen in the use of the term "gravitating force" by various writers, it cannot be too clearly stated that moving force and the static

**Manchester Memoirs*, vol. 53, 1909, *Phil. Mag.*, (6), vol. 18, p. 523, 1909.

October 25th, 1909.

attraction of gravitation, although strictly correlated, are as distinct properties of body as dynamic electricity is from the static force of magnetism, as each of these forces manifests itself and may be treated upon independently of the others.

3. As the moving and attractive forces of planetary bodies are correlatively equal, and are expressed by the same numbers, the radius vector of Mercury appeared to me the most natural, as well as the most convenient unit to which the other planetary distances should be referred. A further reason for this selection was the fact that the terrestrial unit is an obvious survival of the geocentric system of the universe which has dominated science for ages, and still retains its hold on ultra-anthropocentric writers on astronomy and astrophysics.

4. An apparently adverse feature, however, of the change of unit in the new table, was the excision of the binary progression of the planetary distances known as Bode's law, which, as Airy and Herschel have rightly said, "is not founded upon any theory which connects it either with Kepler's laws, the gravitating force, or any other known physical law."

5. Notwithstanding the brilliant results which followed the adoption of Bode's Law by independent thinkers, in the discoveries of the minor planets and of Neptune, the complete isolation of the law from all physical causes (which admits only of a teleological interpretation), appears to have created a strong prejudice, amounting to hostility, in the minds of eminent astronomical writers to disparage and obscure what they have been pleased to term Bode's "supposed" or "so called" law of planetary distances, ostensibly on account of minor differences from the observations, and its discordance with the distance of

Neptune. So accustomed have these writers been to viewing the more exact relations of Kepler's laws with the law of gravitation, and the extreme refinements involved in the measurement of these relations, that their power of forming a just estimate of probabilities becomes atrophied by disuse, to the great hindrance of the science which they endeavour to advance. This habit of mind is all the more deplorable in its consequences from the fact of its being unsuspected, and associated with attainments of the highest order in men occupying important positions in observatories and seats of learning, where the influence of their peculiar idiosyncracies makes itself felt through a long course of years.*

6. Bode's law, briefly stated, is as follows:—The *radii vectores*, or the relative planetary distances from the sun proceed in multiple proportions, each one after the second being double the one which precedes it, and, by adding the constant 0·4 to each progression, we obtain approximately the distances of the planets, as shown in Table 1.

7. The parallelism of the discovery of new planets through the law of multiple proportions of the distances, and the discovery of new elementary substances through the law of multiple proportions of the atomic weights, as shown in my former papers,† will not fail to be evident to serious investigators in the natural sciences.

8. The correlation of a series of nebular condensations, represented by the planetary distances on the one hand, and the further condensation of the nebular substance into

*The attacks made by astronomical writers on Bode's law have been discussed at greater length in my paper published in the *Manchester Memoirs*, vol. 39, 1895.

†*Manchester Memoirs*, vols. 30, 39, 40, 46, 48, 52, 1878-1907, *Chemical News*, vol. 38, pp. 66, 96, 107, 1878, *Phil. Mag.*, (6), vol. 16, p. 824, 1908.

well defined series of elements, with their like series of atomic weights and specific gravities, on the other, rendered it imperative that the binary progression of planetary distances should again appear in connexion with the Mercurian unit of distance.

9. The solution of this problem is shown in the same Table 1, in columns 4 and 5, parallel with 1 and 2, containing Bode's numbers, and expressed in astronomical units of the distance of Mercury from the sun.

10. Taking the unit distance of Mercury = 1·00, as a plus constant, instead of the empirical number 0·4, as in Bode's table, the binary progression now appears as,—

0·00	0·75	1·50	3	6	12	24	48	96;

and the value of each term of the new series becomes—

1·00	1·75	2·50	4	7	13	25	49	97.

11. The observation distances in column 2 are in close accordance with those derived from Kepler's third law, as will be seen by multiplying each of the terms in column 5 of the new table of distances from my former paper,* by the terrestrial unit distance of Mercury, 0·3871. The additional decimal place is brought in for greater accuracy not required in the general tables.

12. A comparison of the sums of all the distances in column 1 of Bode's table with those of the observation distances in column 2, shows that the difference between the two sums only amounts to one fortieth part of the whole.

13. By the like comparison of the sums of the new binary progression in column 4 with the distances from the new table in column 5 (which are in strict accordance with Kepler's third law), the difference between the two sums is only one hundredth part, or two and a half times

* *Manchester Memoirs*, vol. 53, 1909, *Phil. Mag.*, (6), vol. 18, p. 523, 1909.

less than that derived from Bode's table, and abundantly establishes the validity of the binary progression of the planetary distances of both tables as a law of nature.

14. The substitution of the Mercurian radius vector for the terrestrial unit of distance, brings out several variations in the tables, the most conspicuous of which is the minus difference, 0·417, of the distance of Uranus in Bode's table, and the plus difference, 0·550, in the new table for the same planet, the plus difference being accounted for by the attractive influence of Neptune.

15. The anomalous minus difference of Saturn, 0·360, column 6, between the plus differences of Jupiter and Uranus is interesting as indicating the large amount of attraction exercised by the enormous mass of the Jovian planet on the outer side, and by the plus differences of the Earth and Venus on the inside of his orbit from the same cause.

16. The plus difference of Jupiter in the new progression, 0·437, column 6, is remarkable as showing the attractive influence of the large planets, Saturn, Uranus and Neptune.

17. Other differences will also be seen between the observation and calculated distances in Bode's table and in the new progression, the final effect of which is to reverse the order of the plus and minus differences of the total sums of the distances shown in columns 1-2, and 4-5, of the table.

18. The smaller minus difference of Mars would appear to be caused by his proximity to the intra-Martian planets, together with the interruption of the binary progression of a major planet revolving in the orbit of the asteroids, of which Ceres is the chief representative.

19. It will be further observed that, while the plus and minus differences in the distances are irregular in amount, they are rectified by the mutual attraction of the planetary bodies among themselves, to effect an approximate ratio of equality between the binary progression of the distances, shown in columns 1 and 4, and those derived from observation.

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20. Turning now to the anomalous departure of the distance of Neptune from the binary progression of distances of the other members of the solar system; it will readily be admitted that, had the agreement between the numbers of the binary progression and the observation distances, as shown in the table, been absolute, the outstanding minus difference of the distance of Neptune, 19·410, would have still remained an exception to the law.

21. In my former paper on the multiple proportions of the atomic weights, it was laid down as a general principle of philosophic reasoning, that, when a number of recurring instances was sufficient to establish the relation of cause and effect, or, in other words, the general accuracy of a law, the road to further discovery was in the direction of explaining the anomalous departures from it, than in challenging the truth of the law itself.*

22. That the distance of Neptune, at the genesis of its history, was the first and exact term of the binary progression is an inference justly to be drawn from the like progression observable in the distances of the other planetary bodies, and it was on this same distance (38·4) that Adams, in 1845, based his first determination of the then unknown planet.

* *Manchester Memoirs*, vol. 39, p. 71, 1895.

23. The Astronomer Royal (Sir George B. Airy) in his historical review of the circumstances connected with the discovery of Neptune says that "if the mathematicians, whose labours I have described, had not adopted Bode's law of distances (a law for which no physical theory of the rudest kind has ever been suggested), they would never have arrived at the elements of the orbit,"* or, in other words, would never have discovered Neptune.

24. The most probable, as well as the most obvious, cause of the anomalous minus difference in the binary progression of the distance of Neptune is the outermost position of the planet in relation to the other members of the system, with the consequent conjoint attractions of all the planets, acting through every part of their orbits, to contract continuously and permanently his radius vector to the amount shown in the observations. The large amount of this contraction is strong presumptive evidence against the existence of a planetary body beyond the orbit of Neptune.

25. A further consequence of the outermost position of Neptune is the small amount of the eccentricity of his orbit, 0·009, or nearly six times less than the eccentricities of Uranus, Saturn and Jupiter, and, excepting Venus, 0·007, is the nearest approach to a circular orbit of any member of the system.

26. It is not a little remarkable that the inevitable effect of the outermost position of a planet, to contract continuously its radius vector, has never presented itself to Lagrange, Laplace and other writers on celestial mechanics, who have elaborated the doctrine of the absolute stability of the solar system. The conjoint attractions of all the

***Proc. Roy. Astron. Soc.*, Nov. 13, 1846, *Phil. Mag.*, (3), vol. 29, pp. 520, 537, 1846.

planets upon Neptune is easily demonstrated by the accompanying diagram, whereon, from the exigencies of space and clearness of definition, the intra-Jovian planets are not included in the demonstration.

27. Reverting to the small amount of the difference between the sums of the binary progression in column 4, Table 1, and the observation distances in column 5, it will be seen that the latter is a plus quantity, as 104·162 − 103·25 = 0·912. Now as the amount of the contraction of the radius vector of Neptune is 19·410 Mercurian units (696,000,000 miles), as shown in column 6, the plus difference, 0·912, between the two sums of the binary progression and the observation distances may well be accounted for as being the amount of the reciprocal attractions of all the planets upon Neptune in accordance with Newton's third law of motion, acting through periods of time too immense for calculation in the present state of our knowledge.

28. Assuming the future contraction of the orbit of Neptune to be continuous, his radius vector will ultimately coincide with that of Uranus, when the two bodies would either revolve together about their common centre of gravity in the same orbit, or coalesce to form a single self-luminous planet, when the same operation would be repeated in succession with other members of the system.

29. It is further postulated that all the planets would ultimately coalesce to form one or more self-luminous bodies revolving round the sun, as one of the binary or ternary systems of stars, of which upwards of ten thousand have been discovered and catalogued during the last century.

30. The probability that the ultimate transformation of

the solar system will be brought about by the means, and in the order herein set forth, derives further support from the fact that one of the stars of long recognised binary systems is itself a close double star, revolving about its common centre of gravity, as instanced in μ Herculis and γ Andromedæ.

31. *Recapitulation.*—(1) That the exact binary progression of the planetary distances is the primordial and fundamental law (shining forth alone in the formless void) from which the principal elements of the planetary orbits have been derived; (2) that the apparently irregular differences from the law are the direct consequence of the mutual attractions of the planetary bodies amongst themselves, but without affecting the validity of Kepler's laws, as the distances and periodic times are necessarily correlated; (3) that as planetary systems have been evolved in regular order from a nebular substance, so the transformation of these systems will proceed in like order to form the numerous binary and other revolving systems observed in the immensity of the stellar universe.

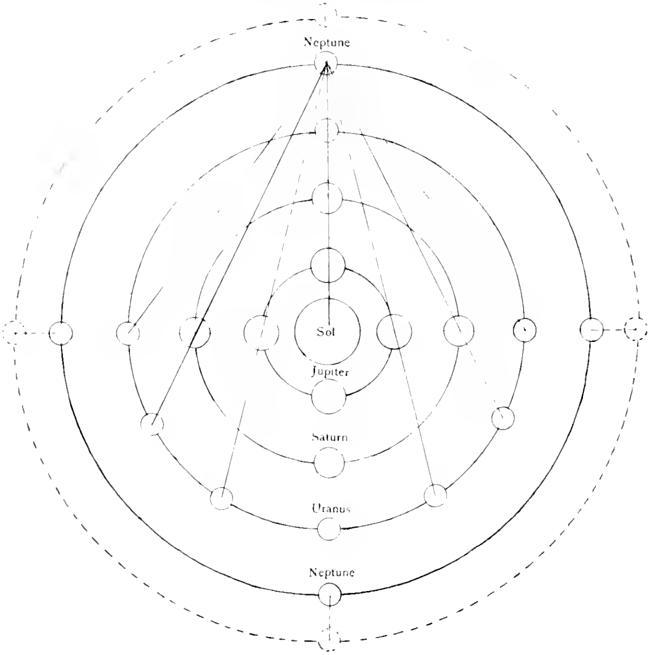
TABLE OF NEW BINARY PROGRESSION OF THE PLANETARY DISTANCES.

	1	2	3	4	5	6
	Bode's Law. Astronomical Units. Earth = 1·000.	Observation Distances.	Differences.	New Progression. Planetary Distances. Mercury = 1·000.	New Table of Distances. Kepler's Law.	Differences.
Mercury . . .	0·0 + ·4 = 0·400	0·387	0·013 −	0·00 + 1 = 1·000	1·000	0·000
Venus	0·3 + ·4 = 0·700	0·723	0·023 +	0·75 + 1 = 1·750	1·868	0·118 +
Earth	0·6 + ·4 = 1·000	1·000	0·000	1·50 + 1 = 2·500	2·583	0·083 +
Mars	1·2 + ·4 = 1·600	1·523	0·077 −	3·00 + 1 = 4·000	3·936	0·064 −
Ceres	2·4 + ·4 = 2·800	2·776	0·034 −	6·00 + 1 = 7·000	7·148	0·148 +
Jupiter	4·8 + ·4 = 5·200	5·202	0·002 +	12·00 + 1 = 13·000	13·437	0·437 +
Saturn	9·6 + ·4 = 10·000	9·539	0·461 −	24·00 + 1 = 25·000	24·640	0·360 −
Uranus	19·2 + ·4 = 19·600	19·183	0·417 −	48·00 + 1 = 49·000	49·550	0·550 +
	41·300	40·333		103·250	104·162	
Neptune . . .	38·4 + ·4 = 38·800	30·036	8·764 −	96·00 + 1 = 97·000	77·590	19·410 −

NEW TABLE OF ELEMENTS OF THE LUNAR AND PLANETARY ORBITS.

	Distances in Radii. Mercury = 1.		Squares of Times and Cubes of Distances.		Times. Astron. Units.		Time. Constant. 87·97.		Periodic Times. Days.	Moving and Attractive Forces. Squares of Radii. Mercury = 1.	Moving and Attractive Forces. Reciprocals.
Mercury . . .	1·000	=	. . . . 1·000	=	1·000	×	87·97	=	87·970	1·000	1·00000
Venus	1·868	=	. . . . 6·522	=	2·554	×	87·97	=	224·700	3·489	0·28661
Earth	2·583	=	. . . . 17·239	=	4·152	×	87·97	=	365·256	6·671	0·14990
Mars	3·936	=	. . . . 60·980	=	7·809	×	87·97	=	686·980	15·492	0·06455
Ceres	7·148	=	. . . 365·200	=	19·110	×	87·97	=	1681·400	51·094	0·01957
Jupiter . . .	13·437	=	. . 2426·000	=	49·250	×	87·97	=	4332·580	180·633	0·00553
Saturn . . .	24·640	=	. . 14957·000	=	122·300	×	87·97	=	10759·000	607·129	0·00165
Uranus . . .	49·550	=	121661·000	=	348·840	×	87·97	=	30687·000	2455·202	0·00041
Neptune . .	77·590	=	467142·000	=	683·494	×	87·97	=	60127·000	6020·208	0·00016
Moon	60·28	=	219038·000	=	468·000	×	84·07[m]	=	27·322	3634·000	0·00027

DIAGRAMMATIC REPRESENTATION OF THE CONTRACTION OF THE RADIUS VECTOR OF NEPTUNE.



Manchester Memoirs, Vol. liv. (1909), *No.* 2.

II. Some Notes on the Breeding Habits of the Common Mole.

By Lionel E. Adams, B.A.

Received July 10th, 1909. Read October 19th, 1909.

Since the researches of Henry Lecourt no one seems to have made any serious study of the life history of the Common Mole, and as many of Lecourt's conclusions have been incorrectly drawn, some from single instances and others from his imagination, there is a wide field for correction and research. But while thus criticising Lecourt, we must not forget to give him credit for furnishing most of the information found in the text-books; and the little work* by Cadet de Veau which embodies Lecourt's researches, may still be studied with profit by all interested in the subject.

Among the many remaining problems the following important ones are yet unsolved :—

1. The length of life of the Mole.
2. Whether the male and female pair for life, or for a season only, or if they couple promiscuously.
3. Whether the male and female inhabit the same nest during any part of the year.
4. The period of gestation.
5. The length of time the young spend in the nest, and their rate of growth.

With regard to the first, I believe the Mole lives at least four or five years. I have examined fortresses for three consecutive years, built on the same spot and closely

* "De la Taupe, de ses mœurs," &c. Paris, 1803.

on the same lines; and certainly the animal does not come to its full growth till its second year.

As to the second one can only surmise, my opinion being that they neither pair nor live together. It was Lecourt who pointed out the difference between the plan of the encampment of a male and that of a female, the male's encampment having a more or less straight main run, while that of the female is a mere network of runs without any apparent system. That this is so I have repeatedly found to be the case. Whether they occupy the same nest during the pairing season is uncertain, but, judging from the size of the dry nucleus of the nest, it is probable that only a single individual occupies it.

Number 4 seems very difficult of solution owing to the difficulty of observation and of keeping a captive the necessary length of time, which must be about four weeks.

The present notes contain some observations on the last of these problems.

Breeding nests. The females make special breeding nests shortly before the young are born. These nests though usually very slight and simple in construction, are sometimes as large and complicated as the winter fortresses. The slight, simpler nests are often mere excavations under the upheaved turf, and are, I think, the work of the young does; while the older and more experienced females make the more elaborate preparations. There is one almost constant difference between the winter fortress and the breeding nest, and that is the absence of a bolt run in the latter, and the persistence of it in the former. I have, however, found two examples of breeding nests with bolt runs; and, of course, circumstances sometimes prohibit the making of a bolt run in the winter fortress—as in the case of the soil being waterlogged. On one occasion I found two contiguous breeding nests in the

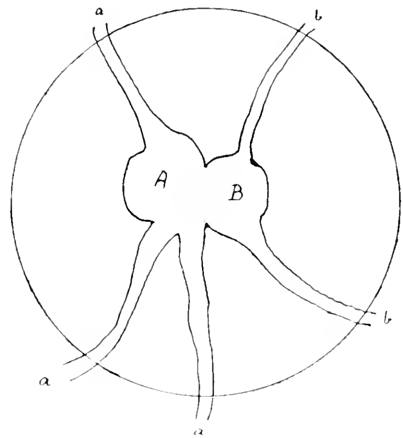
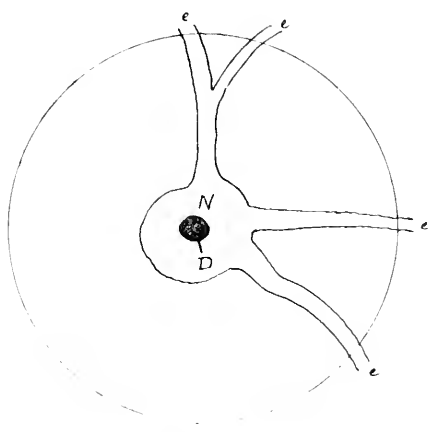


Fig. I.

A. Nest with 4 young.
B. Inhabited nest, but empty when found.
a, a, a, exits from *A.*
b, b, ,, ,, *B.*



(a.)

Fig. II. (*a*).

N. Nest with 4 young.
D. Entrance to Downshaft.
e, c, c, Exits from nest.

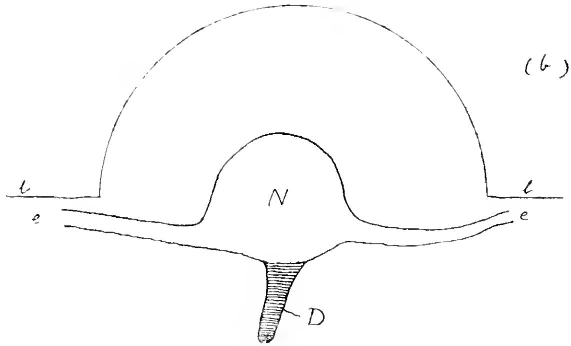


Fig. II. (*b*). Vertical section of same.

N. Nest.
D. Downshaft 9 inches deep.
e, e, e. Exits from nest.
l, l, Ground level.

same mound, resulting, I think, from a coincidence in the choice of a nesting place. On another occasion I found a down shaft leading from the cavity of a breeding nest.

Time of Breeding. The usual time for the young to be born is about the middle of May, but this year (1909) I have the evidence of a very reliable mole-catcher of a nest containing three young being dug up on April 24th, and I have myself found nests containing young on May 4th (young about seven days old), May 6th (about two days old), May 8th (about seven days old), and May 24th (about 21 days old); none since then. The latest time that I have seen young in the nest was June 25th, 1901. They were quite ready to leave the nest, and were at least three weeks old. I do not know if climatic changes have any influence on their pairing early or late,* but considering their subterranean existence, I should say less than might be the case with most animals; and I am convinced, though I cannot prove it, that the actual coupling takes place underground. During the pairing

* Lecourt asserts that this is the case.

season (March and early April) they may be heard to squeak in the runs, and during this period I have repeatedly trapped them, bearing evidence of quite recent coupling. Moreover, no one has ever recorded having witnessed the act.

One annual litter only. In my first paper* I have gone fully into the question of the number of litters produced annually by a single female, and I will only mention here that subsequent experience has fully confirmed the evidence then adduced to the fact that only one litter is produced per year. I have always found that in any given season all the litters have been born within a period of three weeks, and sometimes less, and as the young remain four weeks in the nest, there would not be time for two litters to be reared ; besides which, dissection shows that neither male nor female is in condition to continue breeding.

Rate of growth of the Young. In order to ascertain the rate of growth of the young and the time they spend in the nest I adopted the plan of taking one for measurement and reference from each of several litters, and, after replacing the nest as carefully as possible, repeating the process at intervals of a few days. I found this quite practicable, and it was an easy matter to calculate the daily increase and to tabulate the result.† I was particularly lucky in finding a litter that could only have been born the same day, of which fact I was satisfied from the size (head and body 42 mm.), from the state of the remnant of the umbilical cord, and from the extreme redness of the skin. I have examined embryos, which were upon the point of birth, measuring 37 mm., and allowing for those found in

* "A Contribution to our knowledge of the Mole," *Mem. and Proc. of the Manchester Lit. and Phil. Soc.*, vol. 47, No. 4.

† Table A, p. 8.

the nest being some hours old we may estimate that the young at birth measure 40 mm.

In the following summary I give the measurements of the head and body only as being the most useful; in Table B will be found other particulars.

	May 10.				*May 17.*		*May 21.*	
1.	Litter of 4.	Hd. & By.	95		Deserted.			
2.	„ 3.	„	105	2a.	Hd. & By.	118	Deserted.	
	May 11.							
3.	Litter of 4.	Hd. & By.	62		Deserted.			
4.	„ 4.	„	91	4a.	Hd. & By.	114	4b. Hd. & By.	117
5.	„ 3.	„	42	5a.	„	70	5b. „	88
	May 12.							
6.	Litter of 3.	Hd. & By.	76		Deserted.			
7.	„ 3.	„	80		Deserted.			
8.	„ 3.	„	47	8a.	Hd. & By.	71	Deserted.	

I regret being unable to carry the table further than the 22nd day, as I think that the young remain in the nest till the end of the fourth week, having found them in the nest on former occasions slightly more advanced than the oldest tabulated on pages 8 and 9, having the fur rather thicker and darker, and the eyes quite open. On May 24th I found two litters of four each in the same stage of development as the oldest mentioned in the tables, all eight individuals measuring 117 to 118 mm. At this limit the young all seem to stop for some weeks, for I have never found longer ones in the nests, and I have found young ones which had left the nest to measure little, if any, more. One of these, which I found dead in the road on June 7th, measured head and body 119, tail 30, hind foot 17½ mm., and though practically of the same length as those found in the nests, was more thick set, with the fur of the colour and length of that of an adult, and with a development of serviceable teeth, evidently capable of living an independent life. Leaving the nest is doubtless a gradual process, which, I think, takes place at the end of the fourth week, and ends about the end of the fifth week. The specimen in question was five weeks old.

Desertion or Removal. I have shown in the summary on the preceding page that on revisiting certain nests I found them empty and deserted, and I was puzzled as to what had become of the young, of which there were no traces. I think that if the mother had eaten them, as is the case when the young of many animals are disturbed, some traces would have been left, especially as in two instances the young were more than half grown and nearly fully furred. If the mothers had simply deserted them I think the young would have been found dead in the nests, as I have found nests containing dead young ones, whose mothers had, for some cause, failed to return. There remains the possibility of their removal by the mother, when she found that the nest had been disturbed, though a diligent search on my part failed to reveal their retreats. It is possible, however, that the mother had placed them in one of the many neighbouring tunnels leading from the nests.

Folklore. There is a legend current among the country people of Surrey to the effect that the mole has only one ear. An old mole-catcher, to whom I mentioned the legend, said he had often heard the story, but he had proved it wrong. He said it arose from the fact that when a mole is killed by knocking it on the head only one ear will bleed, but once a mole that he had so killed bled from both ears, and so he proved the story wrong.

TABLE A.*

Number of days old	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Young from nest 5 .	42						70				88											
,, ,, ,, 8...		47					71															
,, ,, ,, 4..											91						114				117	
,, ,, ,, 2..															105							118
Average Rate of increase....	—	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	3	2	1	1	1	1
Average lengths......	40	45	50	55	60	65	70	75	80	85	90	94	98	102	106	110	113	115	116	117	118	119

* Measurements in millimetres.

TABLE B.

Days.	Head and body.	Tail.	Hind Feet.	Colour.	Fur.	Remarks.
1	42	8	5	Very red		Umbilical cord recently severed
2	47	9	$5\frac{1}{2}$	Red		Cord still unhealed
3						
4						
5	62	10	8	Pink		
6						
7	{70 {71	12 15	9} 9}	Pink		
8	76	15	10	Pink		
9	80	15	11	Slightly lead colour on back		
10						
11	{88 {91	16 17	12} 13}	Lead colour above; belly pink		
12	95	16	14	Do. do.		
13						
14	105	17	16	Lead colour all over	Just visible	
15						
16						
17	114	23	16	{Covered all over with velvety lead-coloured fur		Ears open
18						
19						
20						
21	117	25	17	{Fur nearly normal black, not quite of normal length		Eyes beginning to open; spot of matter over eye
22	118	27	$16\frac{1}{2}$	Fur of normal length and colour		Eyes nearly open; spots of matter over eyes

Young Moles almost ready to leave the Nest.

Manchester Memoirs, Vol. liv. (1909), *No.* **3.**

III. A Note on the Staminal Mechanism of *Passiflora Caerulea*, L.

By T. G. B. Osborn, B.Sc.,

Lecturer in Economic Botany, The Victoria University, Manchester.

Received and read November 2nd, 1909.

The greenhouses at present occupied by the Department of Economic Botany, in the Victoria University, contain several Passion flower vines (*Passiflora caerulea*, var. *Constance Elliott*), so that I have been afforded an excellent opportunity of observing the flowers at all stages of their anthesis.

As my own observations do not agree in all respects with those quoted by Knuth in "The Handbook of Flower Pollination," it has seemed well to bring them together in this note.

Three references to observations on *Passiflora* are given by Knuth; Sprengel (1793), Herm. Müller (1883), and Warnstorf (1896).

According to Knuth the latter says: "When the bud opens the anthers have already dehisced, and are directed outwards, in a line with the thick stiff filaments. As the flower fully expands each anther rotates through an angle of 180° in the vertical plane of its filament, so as to bring its pollen-covered lobes towards the interior of the flower. There is next a second rotation of 90° into a horizontal plane cutting the first at right angles, so that the anther finally comes to be at right angles to the tip of its filament with the dehisced surface facing downwards."

December 7th, 1909.

It thus appears that there are two movements of the anthers recognised, and that they occur in the order given :—

(*a*) A radial one of the anther (and presumably its filament, for reasons given below) through 180°.

(β) A second of the anther alone, on its filament, of 90°, bringing the anther into a tangential plane.

The flower opens as follows. First, the sepals—which are white on their upper surface—expand, leaving the

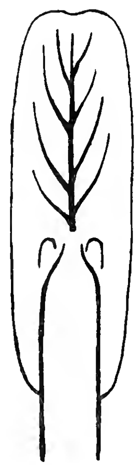


Fig. I. Diagrammatic view of stamen erect before the petals open. The stout filament is seen, and the short narrow connective which is attached to the anther between two projecting knobs of tissue. × 4.

still closed petals upright in the centre. If the petals be cut open at this stage the stamens are seen to be erect with their anthers introrse. Dehiscence of the anthers occurs shortly before the petals expand. Examined at this time the stamen presents the following features (*Fig.* I.). The filament has not yet attained its full development, and the cells at the distal end are in a state of growth. This end narrows bluntly to the connective, which is about ·5 mm. long. The connective joins the anther at a point on the major axis but below the middle, so that, in the bud, the greater part of the anther is above the connective. Just above this junction and on either side of it, a rounded knob projects from the back of the anther. The cells of these knobs are circular in

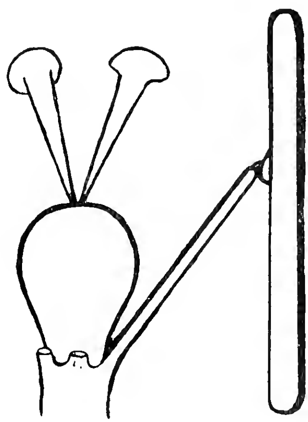


Fig. II. Diagram to show position of the stamen shortly after the opening of the petals. The filaments are no longer upright, but make an angle with the axis of the gynophore. The anther has become extrorse, and hangs vertically with power to swing about its point of suspension from the filament. × 4.

section and thick walled, forming a mechanical tissue, the function of which becomes apparent later.

The pressure of the petals on the anthers being removed as the former expand, the latter are left in an unstable condition and move outwards to hang perpendicularly downwards, thus becoming extrorse. As far as I understand his account, Warnstorf neglects this movement altogether, or, otherwise, I do not understand his statement that the anthers "are directed *outwards* (which I take to mean extrorse) in a line with the thick stiff filaments," when the flower first opens. The filaments have already begun to move outwards, forming an angle of about 30° with the axis of the gynophore, having by now completed their full growth. The end is blunt, and there is a tendency for the tissue on each side of the connective to expand, forming, as it were, two shoulders. The tissue of these has, also, thick-walled rounded cells. The anthers now hang in the position shown in *Fig.* II., the knobs on their backs impinging on the shoulders of the filament. This state of equilibrium is unstable, there being a tendency to swing laterally, the four projections serving as bearings. In the great majority of cases this is

Fig. III. Side view of anther showing the way in which the knobs of tissue on its back are clasped by the distal end of the filament. The distance between the anther and the filament is exaggerated to show the connective. ×4.

what happens, and the second movement described by Warnstorf occurs, viz., the anthers come into a tangential plane by moving through 90° about the connective. In this position the knobs interlock, as shown in *Fig.* III., the end of the filament curling laterally, and clasping the projections on the anthers. A very elementary knowledge of mechanics will show that the anther would not remain in this position but for the formation of the joint that directs it there. That this direction does actually occur can easily be proved by twisting an anther back into a line with the filament, when after a little while it will of itself resume the crosswise position. The swing of the anther may be in either direction, and is apparently determined by chance. It is rarely in the same direction on each of the five stamens in the same flower. I have also noticed that in some cases no such rotation occurs, especially in dull or cold weather. On those days in June and July upon which we had bright sunshine and a temperature of about 75°F. in the greenhouse, the movements above described from the opening of the petals took place in about a couple of hours, and during this time the filaments continued to move in a radial plane, so as to make an angle of 90° with the gynophore.

There appears to be a fairly obvious reason for the second movement of the anther. Pollen is transferred to the head of the insect visitor as it moves from ray to ray of the outer circlet of rays around the circular opening of the nectar chamber. Since the anthers are in a tangential positicn, it follows that the insect's head will come into contact with some portion of an anther at every stage throughout its progress. The function of the locking mechanism is also apparent, for, otherwise, the push of the insect's head would tend to replace the anther in the radial plane, but by the system of knobs, this must be prevented to a large extent, or, should it occur, the stamen would automatically return to the tangential position.

At the conclusion of the first stage of anthesis the stamens rapidly fall, thus completing a movement of 180° for the filament and anther together, and the styles move downwards, so that the receptive stigmas can dust the pollen from the heads of the insect visitors (Sprengel, Müller, and Knuth). It is this movement of the stamen as a whole through 180° in the vertical plane of its filament, that I take to be the first of the two movements described by Warnstorf. If he meant that movement by which the anthers become extrorse, I am at a loss to know what meaning to attach to the words "directed outwards." Moreover, it is certainly this movement of the stamen as a whole that brings the "pollen-covered lobes of the anther towards the interior of the flower." I am bound, however, to state that I have not had the opportunity of reading Warnstorf's paper, and have been obliged to interpret his meaning as well as I can from the reference in Knuth.

After this second stage the flower closes, and Knuth suggests the possibility of autogamy at this period, since the stigmas and anthers may be brought into contact in the closed flower. I am inclined to think that this must be rare, having examined a considerable number of closed flowers, I have found the styles between the ring of outer rays and the petals, the stamens inside the coronae, and no pollen on the stigmas.

SUMMARY.

The staminal movements to which I wish to draw attention and to place in the order of their sequence are :—

α. A radial movement of the anthers on the filament of 180°, which occurs as soon as the flower opens.

β. A second movement of the anther through 90° into a plane at right angles to the first, *i.e.*, into the tangential plane, in which position a special mechanism is called into play to retain it there.

γ. The radial movement in two stages of the stamen as a whole, so as to bring it from an erect to a drooping position; the first stage of this movement being, in part, concurrent with *β*, and coextensive with the first stage of anthesis.

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Manchester Memoirs, Vol. liv (1909), *No.* 4

IV. A Preliminary Note on two New Genera of Upper Liassic Plesiosaurs.

By D. M. S. WATSON, B.Sc.,

Late Beyer Fellow of the Victoria University of Manchester.

Received and read November 2nd, 1909.

In 1876 J. F. Blake gave in Tate and Blake's "Yorkshire Lias" a resumé of our knowledge of the reptilia of the Upper Lias known from Yorkshire. In it he records two Crocodiles, eight Plesiosaurs, and three Ichthyosaurs. No other Plesiosaurs have been described since.

Seven of these species are founded on more or less complete skeletons, two of which I have been unable to find

The species are :—

"*Plesiosaurus*" *homalospondylus*, Owen.

Founded on a complete skeleton in the British Museum, which, however, shows neither girdle. Also represented by a skeleton in the York Museum, and two in the Manchester Museum ; this species is described below, and made the type of the new genus *Microcleidus.*

Plesiosaurus macropterus, Seeley.

Type specimen, a skeleton in the Sedgwick Museum, Cambridge. Zone of D. commune, Lofthouse.

This species requires redescription, but the specimen gives no evidence of the structure of the girdles.

December 22nd, 1909.

Eretmosaurus dubius, Blake.

Founded on a complete skeleton which was in the possession of Mr. Brown Marshall, of Whitby. This specimen can no longer be found. Blake's description is quite inadequate, but he suggests that the species is identical with Seeley's *P. macropterus*. The pectoral girdle was well displayed from the ventral surface, and is certainly of the Eretmosaurus type, if Blake's figure is at all accurate.

"*Plesiosaurus*" *Cramptoni*, Carte and Baily.

Lyddeker regards this species as belonging to v. Meyer's genus *Thaumatosaurus*, which was founded on some imperfect teeth and vertebræ from the Lower Oolites. I think it is probably safer to use Seeley's genus *Rhomaleosaurus* for this species until more is known of the type of *Thaumatosaurus*.

The type specimen is a very large skeleton in the Dublin Museum. The description is inadequate, details of the vertebræ being wanting. The girdles are almost completely concealed, and the arrangement of the limbs is not natural, as Lyddeker has already recognised.

"*Plesiosaurus*" *propinquus*, Blake.

Type skeleton in the Whitby Museum.

Lyddeker regards this species as a *Thaumatosaurus* in his definition of that genus.

The vertebræ have not been described in detail, and are much obscured by matrix.

The girdles are only represented by fragments which are, I think, not in the positions in which they were found, the left fore limb is artificially arranged and the suppositious right humerus is the femur of another species. The arrangement of the ribs is conventional. This species is very different from *P. Cramptoni*, and I think cannot be included in the same genus.

"*Plesiosaurus*" *Zetlandi*, Phillips.

Type skeleton in the York Museum.

This species is quite unknown, no figures of it having ever been given ; as I have not yet examined it in detail, I do not wish to criticise Lyddeker's attribution of it to the genus *Thaumatosaurus*.

"*Plesiosaurus*" *longirostris*, Blake.

This species was described from a somewhat restored skeleton in the possession of Mr. Brown Marshall, of Whitby. I have not so far been successful in discovering its present whereabouts.

Blake's description is very slight, but he suggests that it is the same as Owen's *P. coelospondylus*.

It is possible that this species may include a somewhat fragmentary skeleton in the Manchester Museum, which is described below as the type of a new genus and species *Sthenarosaurus Dawkinsi*.

Plesiosaurus coelospondylus, Owen.

This species founded on a series of cervical vertebræ in the Whitby Museum, which can no longer be found, must rank as undefined, as it is quite impossible to recognise the type from Owen's description. Several other species do actually occur in the Upper Lias of Whitby, but are only represented by small sets of vertebræ sometimes associated with other bones. Such remains in the Manchester and Whitby Museums indicate at least three other very distinct species.

From the above account it will be seen that our knowledge of the Upper Liassic Sauropterygia is really very slight, and that this lack of knowledge does not depend on lack of material.

I hope shortly to redescribe all the Whitby reptiles, and the present paper is to be regarded in the light of a preliminary description of two interesting genera.

THE NEW GENUS, *Microcleidus*.

This genus is founded for *P. homalospondylus,* Owen, which is represented by three excellent specimens from the D. commune zone of the Yorkshire coast, and by a fourth not so complete, but entirely free from matrix, from the bifrons zone of Wellingborough, Northamptonshire. The available material is sufficient for a very detailed account of the osteology of the species; a naturally arranged hind limb being the only part lacking.

This species has been described by Owen, whose account of the vertebral column is sufficient to characterise it.

The Manchester Museum specimen, L. 7077, which was collected by W. H. Sutcliffe, Esq., F.G.S., from Whitby, and presented by him to the Museum, shows 40 cervicals, 5 "pectorals," 17 dorsals, and 15 caudals, the tail not being complete, as the Wellingborough specimen has 22 caudals, and that at York 26. The chief characters are:—

1. The elongation of the centra of the cervicals.

2. The narrowness of the cervicals across the zygapophyses, and the fore and aft direction of the latter.

3. The constricted centra of the dorsal region.

4. The great height of the neural spines of the dorsals.

5. The lowness of the centra of the three sacral vertebræ and the great strength of their zygapophyses.

6. The fact that the caudals retain a long rib tightly fused on down to the end of the tail, showing that there can have only been a very small fin, if any.

I shall discuss some interesting mechanical considerations presented by resemblances between the pectorals and sacrals in a complete osteology of the species.

Pectoral Girdle.

The Manchester Museum specimen, L. 7077, has a beautifully exposed pectoral girdle lacking only part of the right scapula and clavicle. The general plan of the girdle is that of the genus *Cryptocleidus*.

Coracoids. The coracoids are not completely exposed, and the shape of the postero-lateral angles is not shown.

The two coracoids meet in a very long symphysis. This is usually only about a centimetre deep, but between the glenoid ends becomes very thick, probably at least six centimetres. As the lower surface forms a uniform curve, this implies a great depression of the visceral surface of the coracoids behind the inter-glenoid bar.

The glenoid part of the coracoid is about six centimetres deep: the facet for the scapula is seven centimetres long, that for the head of the humerus being only five centimetres.

The position of the right coracoid with regard to the undisturbed dorsal vertebræ shows that it cannot have the postero-lateral corner extended into a process similar to that of *Cryptocleidus*, the width of the lower end given in the figure is, in fact, the maximum possible.

Scapula. The scapula is a triradiate bone, the posterior ramus of which articulates with the coracoid and forms part of the glenoid cavity. This ramus is triangular in transverse section, the upper surface being flat, and, where it joins the dorsal ramus, six centimetres across: it is here of nearly the same depth. The proximal end presents two triangular facets, both at their maximum six centimetres deep, the inner seven centimetres long for attachment to the coracoid, the other, which forms part of the glenoid cavity, only five centimetres. The dorsal ramus is a plate of bone 8·5 cm. long, 5 5 cm. wide in the middle, and having a maximum thickness of just under 2 cm. It rises from the joined posterior and anterior rami at their outer edge, and is directed dorsally, backward and outward, with its greatest breadth parallel to the axis of the animal.

The anterior ramus is confluent with the posterior and dorsal rami; it forms a broad plate of bone joining its fellow of the opposite side in the middle line, and passing backwards as a strong bar to meet the anterior projections of the coracoids; this bar, formed by the two coracoids and scapulæ, is of triangular section, the flat dorsal face being five centimetres wide, and the depth of the bar being some six centimetres. The anterior rami of the scapulæ, are not in the same plane as the corresponding coracoids, but are raised anteriorly so as to make the whole anterior part of the arch convex from front to back when viewed from below. The anterior rami, of course, meet at an angle so that the whole girdle is concave from side to side.

The two pre-coracoidal foramina are 10 cm. long by 6 cm. wide, and the plate of the anterior ramus of the scapula in front of them is at least 8 cm. from front to back.

Clavicles. The left clavicle is completely preserved with the exception of its anterior edge, which is slightly injured.

It is a thin bone with sharp edges, very tightly fitted on to the visceral surface of the anterior ramus of the scapula. In form it is roughly triangular, meeting its fellow of the opposite side in the middle line, and extending outward and backwards as a point towards the dorsal ramus of the scapula.

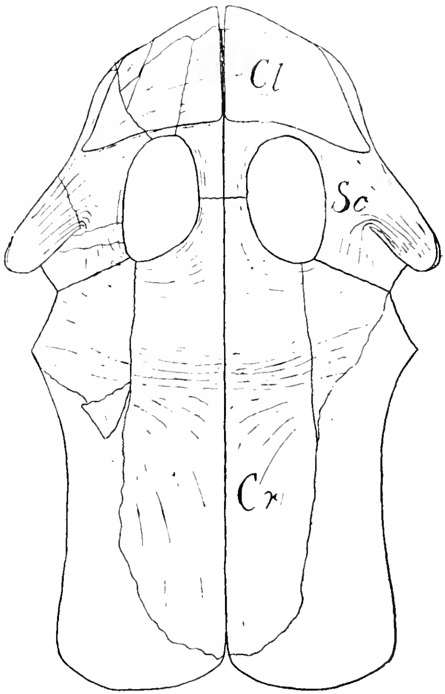


Fig. I. Pectoral Girdle of *Microcleidus homalospondylus*, viewed from the dorsal surface. × $\frac{1}{6}$. The right scapula and clavicle are restored. The broken lines in the coracoids and left scapula indicate fractures, and shew the amount of restoration. The posterior width of the coracoids is a maximum. *Vide* Text. Manchester Museum, L. 7077.

Its anterior end, as shown in *Text-fig* I., has a sharp bend where it reaches and crosses the anterior border of the scapula, beyond this point it is broken away but probably formed a narrow border to the scapula when viewed from below.

There is no trace whatever of an interclavicle.

This girdle at once shows that *P. homalospondylus* is not a *Plesiosaurus* but belongs to the " Elasmosauridae." The scapula and clavicular arch strongly resemble those of *Cryptocleidus*, they present, however, many differences in detail.

Viewed as a whole, the pectoral girdle of *Microcleidus* differs from that of *Cryptocleidus* and most other Sauropterygia in its great relative narrowness, which is rendered still more striking by the lack of any lateral processes at the hinder ends of the coracoid.

The only Liassic genus yet described with an Elasmosaurian type of pectoral girdle is *Eretmosaurus*, Seeley, founded on *Plesiosaurus rugosus* of the Lower Lias, and also including *E. dubius*, Blake, of the Upper Lias. In this genus the two pre-coracoidal foramina are very small, and the clavicular arch is unknown. *Microcleidus* is quite well distinguished from *Eretmosaurus* by the characters of the vertebral column, particularly by the elongated cervicals and the very long neural spines of the dorsal vertebræ.

PELVIC GIRDLE.

The material existing for the description of the pelvic girdle of *Microcleidus* consists of the displaced and somewhat mutilated pubes and ischia of the Manchester specimen, L. 7077, and the naturally associated and well-exposed girdle which belongs to the skeleton in the York Museum.

These two specimens present some marked differences in the pelvis; so far as I could examine the York skeleton, which, however, is fastened to the wall at the back of a glass case which cannot be opened, all the characters of the axial skeleton and of the pro-podial bones appear to be identical with those of the Manchester specimen.

I cannot believe that the two specimens belong to different species, and am inclined to attribute their differences to a difference in sex.

I propose to describe the girdle of the Manchester specimen first, and should state that the restoration here given was made before I had studied the York skeleton.

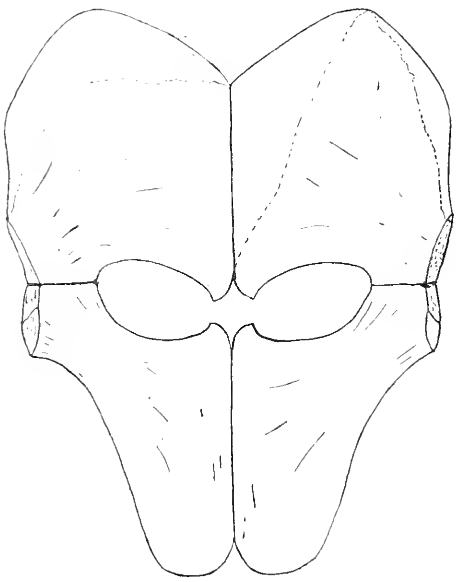


Fig. II. Pelvic Girdle of *Microcleidus homalospondylus*; lacking ilia. Viewed from the dorsal aspect. × $\frac{1}{6}$. Dotted lines shew the existing fragments of the pubes. L. 7077.

Pubis. The pubis is a thin plate of bone whose edges are not well preserved. It meets its fellow of the opposite side in a long median symphysis. It is thickest at the acetabular end, where at the maximum it reaches 5 cm. This end presents the usual two facets, which, however, are not very distinct, for articulation with the ischium and the femur. The contour of the bone in the figure (*Text-fig.* II.) is so arranged as to include the smallest possible area; the rough lines inside the bones show the shape of the existing fragments.

Ischia. The ischia are of the usual hatchet-shape, thick at the proximal end, and forming thin plates of bone where they join each other in a long median symphysis. The acetabular end is remarkable for its swollen character, it is not well exposed, but in one case the usual three facets for the pubis, acetabulum, and ilium are quite distinct. The neck of the bone is very slender. The head is set on obliquely, so as to suggest that the posterior ends of the ischia slope somewhat downwards, and are not in the same planes as the pubes.

The ischia and pubes do not meet in the middle line, so that there is only one obturator foramen.

Ilia. The ilia are not definitely recognisable; the only thing which might be one is a mutilated bone lying on the visceral surface of the coracoids. It is more than 15 cm. long, the shaft being round and about three centimetres in diameter; the lower end is more than 7 cm. across. Two fragments of a right ilium belonging to the Northamptonshire specimen in the Manchester Museum seem to agree closely with this bone. The shaft is at its narrowest 2·7 cm. in diameter, and is very nearly circular; the upper part of the bone is thin, and 7·5 cm. from back to front, and its upper border is at an oblique angle to the shaft of the bone. The lower end is expanded, and presents the usual two facets for the ischium and acetabulum.

This girdle reminds one strongly of the pectoral girdle of the same specimen in its great relative narrowness.

It differs markedly from that of *Cryptocleidus*, more resembling that of *Muræenosaurus*: I believe, however, that there is no anterior lateral process of the pubis as there is in the latter genus.

The pelvic girdles most similar to those of *Microcleidus* are those of *Elasmosaurus*, as described by Cope in *E. platyurus*, and by Williston in *E. ischiadiacus*; these two, especially the latter, are very like my restoration, although they are relatively wider.

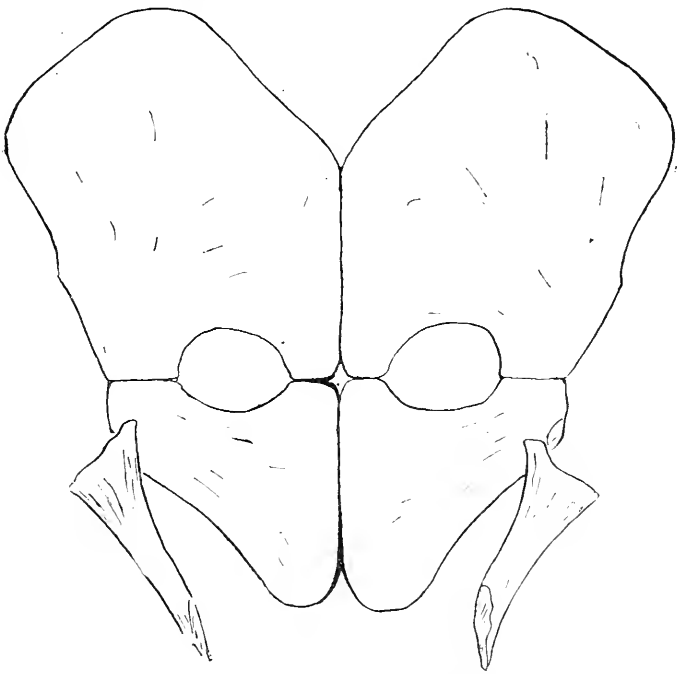


Fig. III. Pelvic girdle of *Microcleidus homalospondylus*, dorsal surface. × about $\frac{1}{5}$. From a photograph of the York skeleton.

The pelvis of the York specimen is well exposed from the visceral surface, and has all the bones with the exception of one ilium, naturally articulated. Its arrangement and the outlines of the various bones will be understood from the figure (*Text-fig.* III.), which is founded on a photograph.

There are many points of resemblance between the two girdles, but the York specimen differs from L. 7077 in the following ways:—

1st. It is relatively much broader.

2nd. The ischia are much shorter.

3rd. There are two obturatores foramina separated by a median union of the pubis and ischia. This character may only depend on age.

One character strongly brought out by the York skeleton is that there is an angle of nearly 30° between the pubis and ischium of the same side; this bend, the occurrence of which was a matter of inference in the case of the Manchester specimen, is to be seen at York.

The new genus *Microcleidus* may be defined as follows:—Sauropterygia with a very long neck and small skull. Cervical vertebræ elongated and narrow across the zygapophyses, which have a fore and aft direction. Dorsal vertebræ with constricted centra, transverse processes wholely supported by the arch, and very high neural spines.

Column composed of 40 cervicals, 5+17 pectorals and dorsals, 3 sacrals and 20+caudals. (These numbers are probably liable to individual variation.)

Cervical ribs double-headed and long, with a small anterior projection.

Pectoral girdle with reduced clavicular arch not containing an interclavicle. Scapulæ meeting each other and the coracoids in the middle line. Postero-lateral angles of the coracoids not produced. Pelvic girdle with long pubic and ischiac symphyses and the ilia articulating only with the ischia.

Pro-podial bones only articulating with two bones distally. Radius and ulna long when compared with their condition in later species.

Type species "*Plesiosaurus*" *homalospondylus*, Owen. Zone of D. commune, Whitby, and H. bifrons, Wellingborough.

Characters those of the genus, of which it is the only known species.

A set of six or seven cervical vertebræ of this type in the Jermyn Street Museum is said to have been obtained from the Lower Lias of Gloucestershire.

The New Genus and Species, *Sthenarosaurus Dawkinsi.*

The material on which this species is founded is in the Manchester Museum. It was collected by W. H. Sutcliffe, Esq., from the D. commune zone of the Upper Lias of Saltwick, some 10 feet above, and 100 yards away from, the specimen of *Microcleidus* described above.

The skeleton is scattered, although the girdles are still nearly naturally arranged ; the bones present are 18 cervical vertebræ, 11 dorsal vertebræ, 4 caudal vertebræ, complete pectoral and pelvic girdles, 2 humeri and 2 femora, both tibiæ and fibulæ and many tarsals and ribs.

The cervicals vary much in size, the smallest has a centrum measuring 3·5 cm. in height, 3·5 in length, and 4·5 in width ; the corresponding dimensions of the largest are 6 cm., 6 cm., and 7·5 cm. ; it is thus nearly twice the size of the smallest.

The vertebræ preserve a very uniform character throughout the neck. The anterior end of the centrum is rather deeply cupped, the posterior end, although not nearly flat, being much less so. The ends of the centra are somewhat heart-shaped. Viewed from below the centrum shows a very marked hæmal ridge, on each side of which is a deep depression in which and close to the median line lie the usual two foramina for nerves and blood vessels. There are two very distinct facets for the rib, these lie about half way up the side of the centrum.

The arch is fused on to the centrum, but its line of junction remains perfectly distinct. The arch is high and very robust, the width across its narrowest point between the præ- and post-zygapophyses being only slightly less than the width of the centrum. The neural canal is nearly circular in section; it is, however, slightly broader than it is high.

The præ- and post-zygapophyses are connected together to form a platform from which the short and comparatively feeble neural spine rises. The posterior edge of the neural spine is above the corresponding end of the same centrum, and its anterior end comes about half way to the front of the centrum. The præ-zygapophyses are short, projecting little, if at all, in front of the centrum; the post-zygapophyses project strongly backwards, and have a large articular facet. These facets are so directed that a horizontal line drawn on one is parallel to the long axis of the animal; they are inclined to one another at an angle of 105° in one of the posterior cervicals. Between each pair of zygapophyses in the middle line is a pit lying above the neural canal, and presumably lodging the attachment of an intervertebral ligament.

The most marked difference between the anterior and posterior vertebræ, apart from size, is that in the smaller specimens there is a very marked ridge running from the præ-zygapophysis to the posterior point of junction of the arch and centrum. This ridge becomes almost obsolete in the posterior cervicals.

Dorsal vertebræ. The two well-preserved dorsals which are free from matrix belong to the anterior part of the back, and probably differ in some respects from the typical dorsals.

One of the most conspicuous characters of these vertebræ is that the centra are very short, in one case only 5 cm., where the breadth across the anterior face is 9 cm., and the height 7·5 cm.

The most striking character of the more anterior of these two is that the neural spine leans so much back that its summit is over the posterior surface of the centrum of the succeeding vertebra. The spine is thick and narrows at the top, where, however, it is much swollen laterally its posterior surface has a deep groove for ligaments.

There is still a trace of the table joining the zygapophyses, but this is now contracted just before the post-zygapophysis. The præ-zygapophyses are low and amazingly solid; they do not project before the centra. The post-zygapophyses project entirely behind the centra: they are very slim and deeply cupped.

The facet for the rib is single, placed high up and largely carried by the arch; below it is a pit, excavated in the centrum, which is a centimetre wide and rather more deep. There is no marked hæmal ridge. The ends of the centrum are nearly flat.

The caudals are only noticeable for a pit below the facet for the rib, which is not fused on to the centrum.

The cervical ribs are very distinctly double-headed, and show only faint traces of the characteristic hatchet-shape; they are long, slender, triangular bars.

The dorsal ribs are single-headed and slender, as are also some abdominal ribs.

PECTORAL GIRDLE.

The pectoral girdle is well preserved, although the scapulæ are slightly separated from the coracoids and the clavicular arch lies below one of the coracoids. (See *Text-fig.* III.).

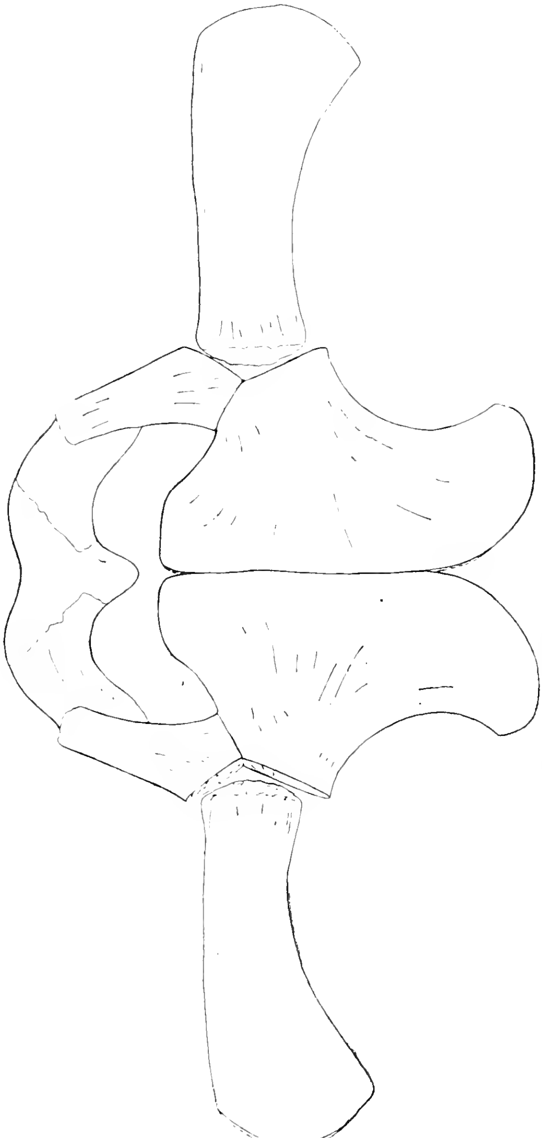


Fig. IV. Pectoral Girdle of *Sthenarosaurus Dawkinsi.* Ventral aspect. $\times \frac{1}{8}$. Restored from the type specimen in the Manchester Museum.

Coracoids. The coracoids are short and very thick. They are united in a long, median symphysis, which forms a marked ridge when the girdle is viewed as a whole. This symphysis is at least 6 cm. deep between the glenoid cavities. The posterior portion of the coracoid is small, but the bone is never much less than 2 cm. thick. The glenoid part of the coracoid is very thick, and presents the usual two facets, one 6 cm. long facing the scapula, and the other 11 cm. long forming part of the glenoid cavity.

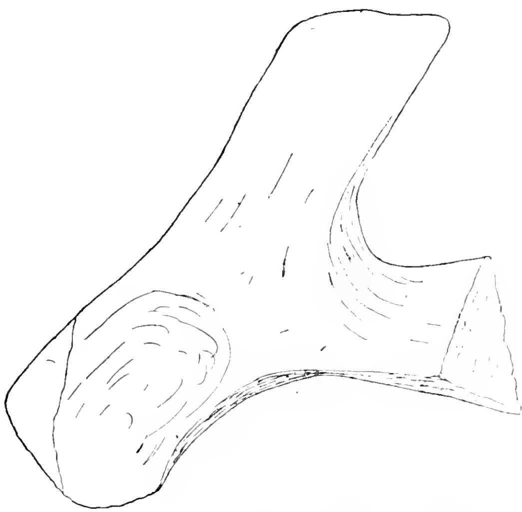


Fig. V. Right Scapula of *Sthenarosaurus Dawkinsi*, type specimen. × $\frac{1}{4}$. Viewed horizontally from within. This view shews the downward projection of the anterior ramus and the dorsal ramus.

Scapula. The scapula is a trihedral bar with one of the faces directed ventrally; the dorsal ridge is produced into the dorsal ramus, which is directed dorsally and to the back.

The ventral surface is very strongly curved, so that in side view the anterior ends of the scapulæ project downwards below the level of the coracoids.

The posterior ramus is broad, 10 cm. across at its widest, and nearly 7 cm. thick; in section it is triangular, the broadest face being directed downwards, the other two faces are of nearly equal size, the outer being somewhat smaller than the other. The outer border of the bone is a marked ridge, owing to the concavity of the corresponding face.

The anterior ramus is a direct continuation of the posterior one; it also is of triangular section, but here the ventral face is the smallest. The outer of the other faces is nearly flat, whilst the inner is scooped out into a roughened elliptical cup for reception of the clavicle. The greatest height of the bar is over 6 cm., and its breadth about 5 cm.

From the dorsal ridge of the anterior and posterior branches rises the dorsal ramus; this is some 10 centimetres long, 6 wide, and 2 thick; it is of oval section, and is directed upwards and backwards, its length making an angle of about 60° with the under surface of the posterior ramus. Its breadth faces laterally.

Clavicular Arch. The clavicular arch is seen from below, and part of its right side is missing; there is, however, evidence for everything shown in the restoration, including the width.

The whole forms a large arc of a circle, probably nearly a semi-circle, when complete.

The interclavicle is a **T**-shaped bone, of which nearly the whole stalk is bordered by the clavicles. Its anterior border has a broad but shallow notch, and its posterior border forms a rounded tag.

The clavicle is suturally united to the external edge of the interclavicle. Its general form will be seen from the figure, but the most interesting character is a dorsally-directed portion which fits into the depressed area on the

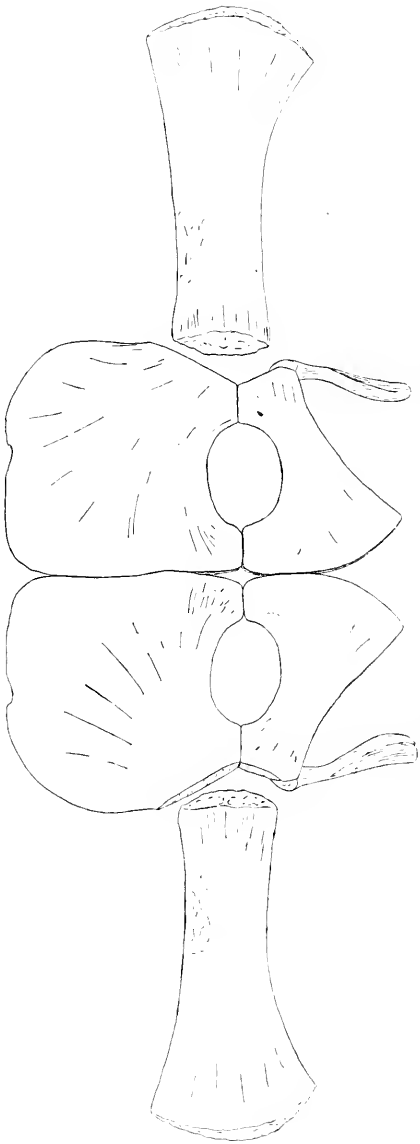


Fig. VI. Pelvic Girdle of *Sthenarosaurus Dawkinsi.* Ventral aspect. $\times \frac{1}{8}$. Restored from the type specimen. The ilia are much foreshortened and reversed, the left being represented on the right.

inner side of the scapula. This tag is more than a centimetre thick; of the thickness of the rest of the bone nothing can be said.

PELVIS.

With the exception of the ilia the pelvis is naturally articulated; it is exposed from the ventral surface.

It is remarkably broad and sturdy.

Pubis. The pubis is a squarish plate of bone whose thickness cannot generally be determined; it meets its fellow of the opposite side in a long symphysis. In the region between the acetabula the symphysial face must be very deep; for there is in this region a pronounced ridge across the bone.

The anterior edge is thin and shows a small notch, of a type which is quite common in the Sauropterygia and is apparently associated with some attachment of the plastron.

The exterior border of the bone is not well shown but cannot differ more than a few centimetres from that given in the figure (*Text-fig.* VI.). The acetabular face is large, some 10 cm. long and 5 cm. wide, the face opposed to the ischium is however very small, being less than 5 cm. long. The posterior border presents the usual concavity to the obturator foramen, and at the median end is in contact with the ischium.

Ischium. The ischium is of the usual hatchet-shape. The head is obliquely set on so that the posterior end of the bone must have pointed down during the life of the animal. It has the usual three facets, that for the ilium being somewhat obscurely marked off from the acetabular face.

The blade of the bone is thin and there is no long median symphysis in the middle line. Although the animal was apparently quite adult at death the ischia are noticeably short.

Ilia. Both ilia are preserved although no longer attached to the ischia.

The ilium, although really quite large, appears small and weak when compared with the other bones of the pelvis.

The acetabular end is of nearly circular transverse section, it bears two faces, the larger for the acetabulum and the other for the ischium.

This end passes imperceptibly into the blade of the bone, which is flattened, some 10 or 12 cm. across at the top and at the maximum 2 cm. thick. The lower edge is straight, and formed by a sharp ridge, the upper is smooth and strongly concave. The crest is flat and pitted for a cartilaginous extension. The inner face of the bone is flat or almost concave; the outer side is convex.

In the diagram the ilia are represented as much foreshortened and are accidentally reversed.

Discussion of the Determination of the Specimen.

Only two Upper Liassic species have been described to which the specimen I have just discussed could belong; these are *P. longirostris* and *P. coelospondylus.*

There are no materials extant for determining what Owen meant by the latter species, which must be dropped.

The only parts of *P. longirostris* which can be compared with my specimen are: the cervical vertebræ, the length of the dorsal centra, and the relative and actual sizes of the pro-podials.

Blake's description suggests that in *P. longirostris* the cervicals are of similar size throughout the neck.

Blake gives a figure of a vertebra which, if really a cervical, differs greatly from those of my animal ; it does, however, present some slight resemblance to the more anterior of the dorsals of the Manchester specimen. His description states that the neural spines of the cervical vertebræ lean back, so that their tips lie above the posterior surface of the succeeding vertebræ, and thus agrees with his figure.

Blake states that in *P. longirostris*, 25 dorsal centra fill a length of 80 in., giving at least 3 in. for the length of an average dorsal centrum. None of my dorsals, which represent all parts of the back, approach this length.

In actual size and in relative length the pro-podials of our specimen agree fairly closely with those of *P. longirostris*, but the humerus has the anterior edge convex, and not concave, as in the latter species. It is thus impossible to refer our specimen to any known species. It appears to be allied to the Longirostrate group of Plesiosaurs, typically represented by *P. rostratus*, and also including, *fide* Lyddeker, *P. longirostris.*

The vertebral column shows many points of resemblance to that of *P. rostratus*, the cervical centra being very similar, although relatively somewhat longer. They also resemble those of " *Thaumatosaurus*" *carinatus*, of the Kimmeridge clay.

The pro-podials are also very similar to those of *P. rostratus.*

Of the girdles of *P. rostratus* nothing is really known. If Lyddeker is right in referring R. 1315 of the British Museum to an allied species, it differed considerably from ours in the pectoral arch. The clavicular arch of our specimen presents many resemblances to that of " *Thaumatosaurus* " *arcuatus*, although it differs in having the posterior border convex instead of concave.

Our type also resembles in its pectoral girdle *P. Conybeari*, as restored by Sollas.

The scapula of our specimen is, however, quite unique in its fore and aft direction and its downwards slope in front.

The characters of the vertebral column separate our type from *Plesiosaurus* as typified by *P. dolichodeirus* and from the reptiles placed in *Thaumatosaurus* by Lyddeker.

There is no resemblance to any genus with the Elasmosaurian type of pectoral girdle.

There is, in fact, no described genus which will hold the species. I therefore propose to call it *Sthenarosaurus Dawkinsi* from σθεναρός (strong) and Prof. Wm. Boyd Dawkins.

Sthenarosaurus may be defined as follows:—

Plesiosaurs with the neck tapering from back to front. Cervical vertebræ with concave anterior face to the centra, præ- and post-zygapophyses united, forming a table from which the neural spine rises abruptly in the anterior, and more gradually in the posterior cervicals; anterior neural spines weak and placed far back.

"Pectorals" with short stout neural spines leaning far back.

Cervical ribs double-headed.

Pectoral girdle with short coracoids, strong scapulæ very widely separated anteriorally and pointing downwards. Clavicular arch robust containing an interclavicle, with a wide anterior notch and a small posterior tag.

Pelvic girdle with large square pubes and short ischia meeting medially so as to leave two obturatores foramina.

Type species *Sthenarosaurus Dawkinsi*, nov. sp.
Zone of D. Commune,
Saltwick near Whitby,
Manchester Museum L. 8023.

NOTE added Dec. 7th, 1909.

Dames in 1895 described an excellent skeleton of a Plesiosaur from the Upper Lias of Germany. This species *Plesiosaurus Guilelmi Imperatoris*, he refers to Lyddeker's typical group of the genus *Plesiosaurus*, *i.e.*, to *Plesiosaurus* sensu strictu.

From his description and figures I much doubt the propriety of this reference ; the animal presents many striking resemblances to *Microcleidus* ; although it certainly cannot be included in that genus.

The resemblances are as follows :—

1. The head of *P. Guilelmi Imperatoris* is small, and, although damaged, appears to closely resemble that of *Microcleidus*.

2. Both species have long necks. *Microcleidus* having 40 cervicals, the other species 35.

3. The shape of the posterior cervicals shewn in Dames' small but very clear figure is very similar to that of similiarly situated bones in the British genus.

4. The very high neural spines of the dorsal vertebrae of *P. Guilelmi Imperatoris* are unparalleled in *Plesiosaurus* sensu strictu, and are only to be matched in *Microcleidus*.

This character is, however, less pronounced in the German species, in which, however, the neural spines of the posterior cervicals are relatively longer than in *Microcleidus*.

5. The constricted dorsal centra are also similar in the two species. The two types, however, differ in the following characters :—

The cervical centra of the *P. Guilelmi Imperatoris* are shorter than those of *Microcleidus*. It is, however, noticeable that the anterior cervicals of the latter genus are not much elongated, the 6th or 7th being the first in which this character becomes conspicuous. In the pectoral girdle of Dames' specimen the scapulæ do not meet in the middle line, and there is a "furculum." Of this furculum only the right half is preserved, it shews no trace of an interclavicle, and Dames suggests that the latter bone may have been connected by loose suture.

The shape of the clavicle reminds one of *Microcleidus*, particularly in the way in which the lateral angle fits into the anterior ramus of the scapula. So far as I know, in all Plesiosaurs except such Elasmosaurids as *Microcleidus* and *Cryptocleidus*, the whole clavicular arch is fused into one solid bone, and Dames' suggestion of an open suture in the clavicular arch of *P. Guilelmi Imperatoris* confirms me in the idea that it is on the way to become an Elasmosaurid, or more probably has separated from a stock some members of which will become Elasmosaurians.

The pubis of Dames' species is similar to that of the York skeleton of *Microcleidus homalospondylus.*

A specimen in the Manchester Museum which shews cervical, dorsal, sacral and caudal vertebrae, a pubis, femur, and some other bones of the hind leg, resembles *P. Guilelmi Imperatoris*, in having somewhat shorter cervicals than *Microcleidus homalospondylus*, and in their having rather longer spines. I have regarded this specimen as representing an undescribed species of *Microcleidus*, but it is possibly identical with the German species.

This latter species appears to me to have some genetic connection with *Microcleidus*; it is probably a conservative branch from the *Microcleidus* stock which separated off after the high dorsal neural spines had been acquired, but before the elongated cervicals and Elasmosaurid arch were developed.

I do not think that it ought to be included in *Plesiosaurus* s.s., for it is undoubtedly very different from such species as *P. dolichodeirus* and *P. Hawkinsi.*

It cannot be included in *Microcleidus*, because that genus is intended to include Plesiosaurs in this line of descent which are sufficiently advanced to have the scapulae meeting in the middle line. It therefore should have a new genus founded for it. I refrain from suggesting a name until I have seen the specimen.

The set of caudal vertebrae figured in the same paper as *P. suevicus*, resemble fairly closely the anterior caudals of *M. homalospondylus.* Many plesiosaur caudals are much alike, but it is probable that *P. suevicus* is a member of the group which includes *Microcleidus* and *P. Guilelmi Imperatoris.*

The vertebrae figured by Dames as the type of *P. bavaricus*, appear to me to be not definitely referable to the same species.

Fig. 1 is very like a cervical of my *Sthenarosaurus Dawkinsi*, but I do not believe that an isolated centrum of this type is really identifiable: there is, moreover, no indication in Dames' figure of the ridge, connecting the anterior zygapophysis with the posterior edge of the arch, which, in a cervical of *Sthenarosaurus* of the same size, is quite conspicuous.

The smaller and more perfect cervical represented in Fig. 2, differs from the original of Fig. 1, in that the ridge along the haemal surface does not widen out posteriorly into a flat surface,

The arch represented in Fig. 2 differs from that of a similar sized cervical of *Sthenarosaurus*, in having a larger neural spine, much shorter posterior zygapophyses, and in having the zygapophysial table contracted before the postzygapophyses.

These vertebrae, however, appear to belong to the group of Plesiosaurs, which includes *Sthenarosaurus*.

PLATE.

A late cervical vertebra of *Sthenarosaurus Dawkinsi.* Founded on one almost perfect specimen, but some details slightly restored by comparison with neighbouring vertebrae.

1. Left lateral aspect.
2. Anterior aspect.
3. Posterior ,,
4. Superior ,,
5. Inferior ,,

All ½ natural size.

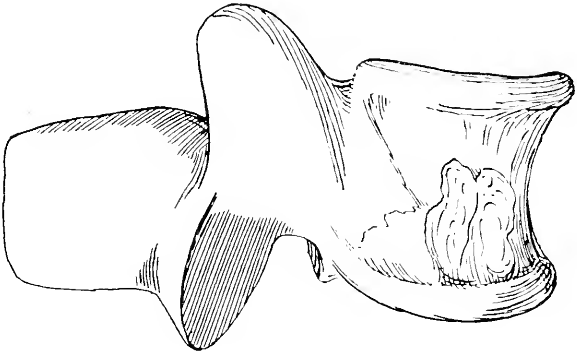


Fig. 1.

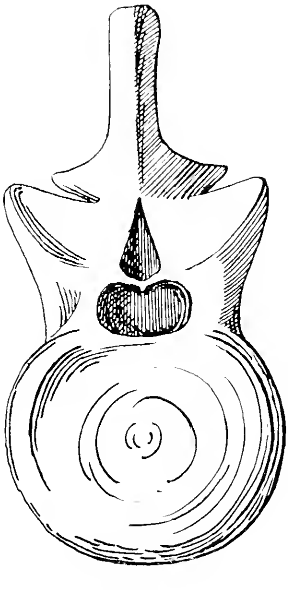


Fig. 2.

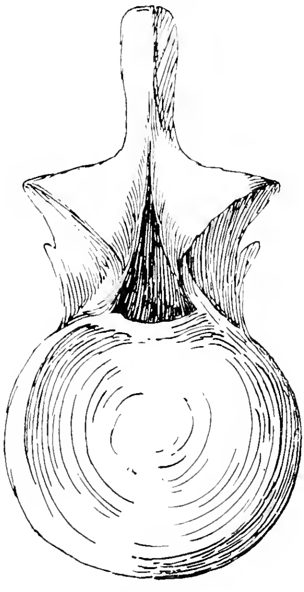


Fig. 3.

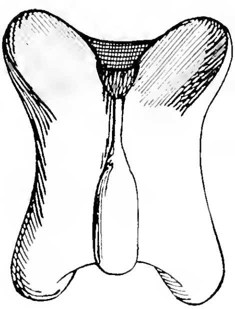


Fig. 4.

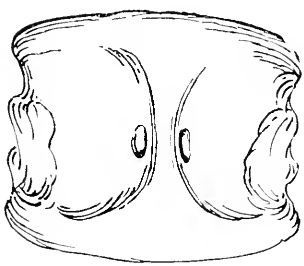


Fig. 5.

V. The Action of the α Rays on Glass.

By Professor E. RUTHERFORD, F.R.S.

Received and read November 30th, 1909.

It has been shown by Joly that the pleochroic halos observed in mica are to be ascribed to the action on the mica of the α rays emitted by small inclusions of radio-active material. The radius of the halo (about ·04 mm.) indicates that the effect is due in large part to the rays from radium. I have recently reproduced the conditions under which such halos would be formed by enclosing a large quantity of radium emanation in a fine capillary tube of soda glass. After the emanation had decayed, the inner wall of the capillary was seen under the microscope to be surrounded by an area of distinct colouration extending about ·04 millimetre from the walls. The outer boundary of the coloured region was sharply defined, and the depth of the colouration was equivalent to the maximum distance of the most penetrating α particle from the active matter. This result strongly confirms the correctness of the explanation of halos given by Joly.

December 24th, 1909.

Manchester Memoirs, Vol. liv. (1909), *No.* 6.

VI. "Production of Helium by Radium."

By Professor E. RUTHERFORD, F.R.S.,

AND

Dr. B. B. BOLTWOOD.

Received and read November 30th, 1909.

Since the demonstration by Ramsay and Soddy of the production of helium by radium, it has been of great importance to determine accurately the amount of helium produced by a known quantity of radium. It has been shown by Rutherford, Geiger, and Royds that the *a* particle emitted by radium and its products is an atom of helium. In addition Rutherford and Geiger have calculated by counting the *a* particles and determining their charge that one gram of radium in equilibrium should produce 158 cubic mms. of helium per year. The first systematic measurements of the production of helium by radium were made last year by Sir James Dewar.* His experiments indicate that radium in equilibrium produces helium at a constant rate equivalent to 135 cubic mms. per gram per year—a result in fair agreement with the calculated quantity.

Another determination has recently been made by the writers using a barium-radium salt containing about 200 milligrams of radium, loaned by the Vienna Academy of Sciences. The salt, chemically treated to remove polonium and radium D, was placed in a platinum capsule which was in turn sealed in an exhausted tube of hard glass. At the end of 83 days, the

* *Proc. Roy. Soc.*, A. 81, 280 (1908).

gases were completely removed by heating and exposed to charcoal cooled in liquid air. The unabsorbed gases were pumped out and repeatedly exposed to fresh cooled charcoal. The residual gas consisting of essentially pure helium was found to have a volume corresponding to the production of helium at the rate of 163 cubic mms. per gram of radium per year.

With the experience gained in these preliminary experiments, it is hoped ultimately to determine the value of this constant with considerable precision.

Other experiments which have been made to test whether helium is produced by polonium have shown conclusively that such is the case.

Manchester Memoirs, Vol. liv. (1910), *No.* 7.

VII. The Development of the Atomic Theory: (1) Berthollet's Doctrine of Variable Proportions.

By Andrew Norman Meldrum, D.Sc.
(Carnegie Research Fellow).

(Communicated by Professor H. B. Dixon, M.A., F.R.S.)
Received and read November 30th, 1909.

Two of the burning questions in science, between the years 1800 and 1810, were the theory of "mixed gases," and the fixed or the variable composition of chemical substances. On each of these questions Claude Louis Berthollet and John Dalton were leaders of thought on opposite sides, and in each case Dalton's ideas were ultimately triumphant. Yet his rights in these directions have never received full attention, the subjects having been treated in an inadequate manner by the historians of science. The present paper shows in outline how the doctrine of constant proportions developed.

The doctrine that chemical compounds have a constant composition is not a discovery made in the XVIIIth century by a certain man. Lavoisier, Wenzel, and Richter were outstanding workers on the subject, and other workers in the same field, and to much the same general effect, were Cavendish, Bergman, Klaproth, Vauquelin, and Kirwan. Many more might be named, for practically all chemists towards the end of the century seem to have judged the doctrine to be a satisfactory account of the facts of chemistry.

But no doctrine can be regarded as established, or even as rightly understood, until it has been called in question and successfully defended. The challenge puts the defenders on their mettle and compels them to con-

February 1st, 1910.

sider, perhaps to realise for the first time, precisely what their position is. Such was the case of the doctrine of constant proportion. It seems to have arisen naturally and been taken for granted, assumed as a matter of course, rather than considered and carefully defined. Suddenly, about the beginning of the XIXth century, it was called in question by Berthollet.

Primarily his teaching was concerned with the problems of chemical affinity. He had ample leisure to meditate on the subject during his stay in Egypt, where he had gone as an honoured member of the famous Napoleonic expedition. The first fruits of that leisure appeared in papers, read in Cairo before the shortlived Institute of Egypt in June of the year 1799, in which he propounded the valuable and original ideas of "mass-action" and chemical equilibrium. Berthollet was thus the founder of *chemical statics.* Resuming the subject on his return to France, he developed his ideas into a system of chemistry, which is explained in various Memoirs[1] and above all in his "Essai de Statique Chimique," (2 vols., 1803).

His teaching aroused interest everywhere, witness the appearance of English and German translations of his works, and the extent to which his ideas permeated the scientific dissertations[2] and books of the period. His main contention that chemical change was very largely a matter of two factors, affinity and mass-action, could hardly be denied. The tables of affinity which in the course of the XVIIIth century had become more and

[1] "Recherches sur les lois de l'Affinité," *Mém. de l'Institut*, vol. 3, pp. 1, 207, 228, 1801; vol. 7, 229, 1806.

[2] Memoirs, in which Proust, Thénard, Gay-Lussac, Avogadro, Berzelius, and Dalton take Berthollet's ideas into consideration will be cited as occasion requires. A supplementary list of memoirs not specially referred to in this paper, will be found in an appendix.

more elaborate, were now seen to be obsolete, for they had been drawn up in ignorance of the effects of mass-action. Torbern Bergman, in particular, had prepared more numerous and more elaborate tables than any that had previously appeared, and had also endeavoured to extend the theory of affinity to the reactions of acids, bases, and salts. Berthollet showed that affinity had nothing to do with these reactions, which are governed by mechanical considerations, such as the insolubility and volatility of a substance. Von Meyer, in his "History of Chemistry," advances the opinion that Berthollet's teaching was neglected. "His principles were held to be totally erroneous. . . . . It was thus that Bergman's doctrine, although based upon wrong assumptions, and therefore leading its author to false conclusions, kept for so long a time the upper hand."[3] Ladenburg is much nearer the mark when he remarks that "tables of affinity disappear soon after the appearance of Berthollet's 'Statique Chimique.'"[4] The truth is that Berthollet's ideas supplanted Bergman's with an ease almost unparalleled in the history of science. Karsten remarked in 1803 that not a trace was to be found of our previous ideas on affinity,[5] and as early as 1801, Fischer, who translated Berthollet's "Recherches" into German, declared that the new view of chemical phenomena was so convincing that it was impossible to uphold the old theory.[6]

[3] "Hist. of Chem.," Eng. trans., p. 551, 1906.

[4] "Hist. of Chem.," Eng. trans., p. 41, 1900.

[5] *Allg. J. Chem.*, (Scherer), vol. 10, p. 137.

[6] *Allg. J. Chem.*, (Scherer), vol. 7, pp. 507, 517. It is difficult here to avoid overstating the truth, one way or the other. Of course the disappearance of tables of affinity from the text-books of chemistry, in consequence of Berthollet's teaching, was not absolute. Objections to his teaching were urged by Pfaff in 1811 (see Appendix) and by Davy, "Elements of Chemical Philosophy," pp. 117—124, 1812 (see also Henry, "Elements of Experimental Chemistry," vol. 1, pp. 66—67, 1829). Nevertheless, Berthollet's doctrine of chemical affinity, in its main features, was never seriously challenged.

The time was ripe for a new theory of affinity. That is the explanation of how Berthollet's ideas were taken up so eagerly as was the case. Chemical reactions had been studied in the light of the old theory so thoroughly that numerous anomalies had been discovered, which only the new theory could explain. Even the effect of mass in chemical change had been noted by Bergman. In his "Dissertation on Elective Attractions" (§ 10, 1785) he discusses the reaction, $Ad+c=Ac+d$, where Ac is precipitated. "It now remains to be examined, whether the whole of d can be dislodged by a sufficient quantity of c from its former union. It should be carefully noted in general, that there is occasion for twice, thrice, nay sometimes six times the quantity of the decomponent c, than is necessary for saturating A when uncombined." Bergman noted the effect, but could not explain the principle, of mass-action. That principle, leading straight as it does to the doctrine of chemical equilibrium, was quite foreign to the theory of chemical affinity to which he always adhered.

It seemed to be a necessary consequence of Berthollet's principles that chemical combination takes place in indefinite proportion. He had obliterated the distinction between chemical and physical forces, and regarded solution as produced by affinity between solvent and solute. Hence solutions were compounds.[7] In the next place, indefinite proportion seemed to be an obvious corollary of his "mass-action" theorem. In any chemical system the state of equilibrium depends on the quantity present of each of the re-agents involved. Hence the larger the amount of a given constituent that might be present, so much the more of this should enter into the composition

[7] "Essai de Statique chimique," §§ 36, 39.

of the product. So he reasoned. For instance, if hydrochloric acid is added to a solution of copper sulphate in water, the copper is divided between the two acids. It was natural to think that all the hydrochloric acid was combined with its share of the copper, and all the sulphuric acid with its share.[8]

Berthollet's attitude is easily misunderstood. He did not so much contradict as transcend the XVIIIth century view. He did not assert that cases of constant composition were non-existent. He admitted, for instance, those of water and ammonia and the oxides of mercury, and was inclined to think that gases combine in constant proportion.[9] But he thought these instances arose from exceptional circumstances, which he was perfectly prepared to discuss. His standpoint was that constant composition was the exception, and variable composition the rule.[10]

On this matter his great opponent was Joseph Louis Proust. The battle waged chiefly round the oxides of the metals. In the case of a metal which forms more than one oxide, Berthollet held that the oxide at minimum can gradually increase its oxygen without sudden change, till the oxide at maximum is reached. Proust, on his part, while not denying that a metal might yield more than two oxides, directed all his efforts to the study of the two extreme oxides,[11] and showed that material of intermediate composition usually consisted of a mere mixture of these two,[12] and

8 *Op. cit.*, § 52. But the instance given above is not Berthollet's.

9 *Op. cit.*, §§ 206, 207.

10 *Jour. de Phys.*, vol. 60, p. 347, 1805.

11 *Op. cit.*, vol 63, pp. 438—440, 1806.

12 *Op. cit.*, vol. 55, p. 331, 1802.

he maintained his point with great conviction and persistence.[13]

The historians of chemistry have not been well inspired in their estimates of the meaning and the result of this controversy.[14] They convey the impression that Berthollet was a person who had "preposterous notions" about the chemical composition of substances and was "deservedly annihilated"[15] by Proust. Ladenburg[16] says the controversy was settled by the year 1809, Kopp[17] and Clarke[18] in 1808,

[13] Proust's principal memoirs on the subject are:

(1) Recherches sur le cuivre. *Ann. de Chim.*, vol. 32, pp. 26—54, 1799.
(2) Sur quelques sulfures métalliques. *Jour. de Phys.*, vol. 53, pp. 89—97, 1801.
(3) Mémoir pour servir à l'histoire de l'antimoine. *Op. cit.*, vol. 55, pp. 325—344, 1802.
(4) Sur les sulfures métalliques. *Op. cit.*, vol. 59, pp. 260—265, 1804.
(5) Sur les sulfures alcalins. *Op. cit.*, vol. 59, pp. 265—273, 1804.
(6) Sur les oxidations métalliques. *Op. cit.*, vol. 59, pp. 321—343, 1804.
(7) Sur les muriates de cuivre verd et blanc. *Op. cit.*, vol. 59, pp. 350—354, 1804.
(8) Faits pour l'histoire du cobalt. *Op. cit.*, vol. 63, pp. 421—442, 1806.

In all probability Berthollet's ideas on affinity and chemical composition were first made known through his lectures at the *École Normale* and the *École Polytechnique*. In 1799, before the "Recherches sur les lois de l'affinité" had appeared, Thénard published a paper in support of Berthollet, and Proust one against him. For Berthollet in reply to Proust, see the "Recherches" and the "Statique Chimique," and also "Observations relatives à differens mémoires de Proust," *Jour. de Phys.*, vol. 60, pp. 284—290, 347—351, 1805; vol. 61, pp. 352—362, 1805.

[14] From these strictures I must except P. J. Hartog, who has given in brief a perfectly just statement of the question at issue, see *Nature*, vol. 50, p. 149, 1894, and also *Brit. Ass. Rep.*, p. 618, 1894.

[15] See Huxley on Descartes and Newton.

[16] "Hist. of Chem.," Eng. trans., p. 45, 1900.

[17] "Geschichte der Chem.," vol. 2, p. 369, 1844.

[18] *Manchester Memoirs*, vol. 47, No. 11, p. 9, 1903.

and E. von Meyer[19] in 1807. A. Wurtz, putting the date even earlier, says "the truth of the fixity of chemical proportion was definitely established in the year 1806."[20]

These writers do not adduce any evidence in support of their statements. They seem to consider their case so probable that proof is unnecessary. On the contrary their case is not even probable. It depends on a fatal under-estimate of the influence of Berthollet. He occupied a commanding position in the world of science, so that his ideas could not fail to receive consideration in full. Not only were his main ideas of the highest intrinsic value but his teaching on the very subject of constant proportion, in the light of the knowledge which was then available, was extremely plausible. There are two reasons for this. First, chemists in the XVIIIth century had concentrated their attention on the outstanding compound of each pair of elements, and on this insufficient basis the doctrine of constant composition had been founded. Berthollet raised a new problem by studying the relation between the different compounds of the same elements. It has already been suggested that his teaching did not so much contradict Lavoisier's and Wenzel's and Richter's as go beyond it. While holding in general that affinity tends to unite substances in all proportions, he pointed out that this tendency could be limited by physical factors such as cohesion and insolubility and elasticity, in which case the compounds would be produced on which the supposition of fixed proportion had been based.

In the second place the wretched state of chemical analysis only too easily afforded data in support of variable proportion. Berthollet's theory suited the existence of discordant analyses of the same substance by

19 "Hist. of Chem.," Eng. trans., p. 194, 1906.

20 "The Atomic Theory," Eng. trans., p. 9, 1880.

different workers and even by the same worker. He was able to maintain his teaching by quoting able chemists such as Vauquelin and Klaproth, whose results *a priori* were as probable as Proust's.[21]

Proust had to maintain his own analyses in the face of Berthollet's teaching and of the analyses of other chemists. It is quite a mistake to suppose that his results were specially accurate. E. von Meyer surmises that if he had only "calculated the result of his experiments on the composition of binary compounds otherwise than he did, he would have discovered the law of multiple proportions."[22] As a matter of fact he frequently expressed his results in a way that must have revealed the law in question, supposing that he had known what to look for, and that his data were approximately correct. For the composition of black oxide of copper he gives copper 100 and oxygen 25, and this is correct, and for the composition of the red oxide copper 100, and oxygen 17—18 instead of 12·5.[23] These figures prove that for the determination of the composition of chemical substances it is not sufficient to have good intentions and a strong conviction that substances are formed in invariable proportions.

In truth the odds against Proust were heavy. He had no principle of the same calibre as the doctrines of mass-action and chemical equilibrium with which to encounter Berthollet. He had to trust to the purely empirical method, and there is no reason to think that it was by means of this method that the doctrine of constant proportion was ultimately established.

[21] *Jour. de Phys.*, vol. 60, p. 349, 1805.

[22] *Op. cit.*, pp. 195—196; see also Arrhenius to the same effect, "Theories of Chemistry," Eng. Trans., p. 16, 1907.

[23] *Journ. de Phys.*, vol. 65, p. 80, 1807.

E. von Meyer says that "none of the other leading chemists of the day raised any objections."[24] This puts the matter too strongly, for Thénard, who had previously been on Berthollet's side, showed signs of veering round in 1805. "I am quite persuaded that the number of oxides of the metals is much greater than the majority of chemists allow, . . . but I declare that I am not yet convinced that there are as many oxides as there are possible degrees of oxidation; and if theory allows of them, experience seems to reject them."[25] In this paper he maintains that there are not two oxides of iron (as Proust said) but three.[26] Proust must have had some adherents, but I do not know of any, unless Thomas Thomson be one,[27] who gave him open support. Thénard does not mention him. There is extremely little sign that he was considered to have made out his case. Further, there is every reason to think that the change of opinion, when it came, was due to quite another influence than Proust. What was effective was the working hypothesis which the atomic theory supplied.

The influence of Dalton began to permeate chemistry about the year 1808. For some years he had been making endeavours, not very successful ones, to arouse interest in his theory of chemical combination. In particular, Humphrey Davy,[28] with all his powers of imagination, had failed to see anything in it. A much less

[24] "Hist. of Chem.," Eng. trans., p. 194, 1906.

[25] *Ann. de Chim.*, vol. 56, p. 62, 1805.

[26] *Op. cit.*, pp. 66, 77.

[27] See *Nicholson's Journ.*, vol. 8, pp. 280—281, 1804.

[28] Davy must surely have heard of the atomic theory when Dalton was lecturing at the Royal Institution of London in 1803—1804 (see Henry's "Life of Dalton," pp. 47—50, and Dalton's "New System of Chemical Philosophy," p. v., 1808). He certainly discussed it with Thomas Thomson in 1807 and poured ridicule on it then. (See Thomson's "History of Chemistry," vol. 2, p. 293.)

brilliant man than Davy, Thomas Thomson by name, happening to get an account of the theory from Dalton himself in the year 1804, was wise enough to see its immense importance, and in the year 1807 gave an admirable sketch of it in the 3rd edition of his "System of Chemistry." Then in 1808 Dalton gave his own version of it in the first instalment of his "New System of Chemical Philosophy." Confirmation of the theory had already appeared. At the beginning of the year Thomson had published work on the oxalates of strontium, and William Hyde Wollaston on the carbonates and oxalates of potassium, which they each regarded as exemplifying and justifying Dalton's teaching. This work was of great importance at the moment. As Wollaston remarked afterwards, "Chemists were by no means duly impressed with the importance of this observation of Dalton, until they were in possession of other facts observed by Mr. Thomson and myself."[29] The historians of chemistry have failed to perceive the full significance of this work. It refuted Berthollet in a specially telling way, for, in illustrating his doctrine, he had made much use of acid salts of the kind that Thomson and Wollaston examined. He had found them to be of variable composition,[30] and now, in the light of Dalton's theory, they were found to be perfectly definite substances.

[29] *Phil. Trans.*, p. 6, 1814.

[30] "Essai de Statique Chimique," §§ 201—203; *Mém. de l'Institut*, vol. 7, pp. 230—252, 297, 1806. Not only so, but Torbern Bergman ("Dissertation on Elective Attractions," § 9) and J. B. Richter (see report by Karsten of a conversation with Richter, *Allg. J. Chemie*, (Scherer), **10**, 138—143, 1803) thought that in many cases salts could be formed with a decided superfluity of either ingredient. Further, it has been shown recently (Joh. D'Ans, *Zeitsch. anorg. Chem.*, 63, 225—229, 1909) that there are four acid sulphates of potassium; hence Berthollet might well think that these salts justified his belief in variable proportion: (see his Introduction to Riffault's translation of Thomson's "System of Chemistry," vol. 1, p. 24.)

That Berthollet felt the weight of this refutation of his teaching is shown by the fact that he thought it necessary to repeat Wollaston's experiments.[31]

Further, Gay-Lussac's Memoir on the combining volumes of gases, published in 1809, afforded numerous examples amongst gases of combination in fixed proportion. Berthollet, however, had declared that this was likely to occur amongst gases, a fact which greatly discounted the possible effect on chemists of Gay-Lussac's discovery—of tending to lessen their confidence in Berthollet's doctrine of variable proportion. Besides, at that stage of chemistry, Gay-Lussac was himself reluctant to abandon this doctrine, and still held that, in general, mass-action must produce compounds in all proportions. He maintains the "great chemical law, that whenever two substances are in presence of one another, they act in their sphere of activity according to their masses, and give rise in general to compounds with very variable proportions, unless these proportions are determined by special circumstances."[32]

Indeed, Dalton's doctrine of combination in definite and multiple proportions was victorious only in process of time and in consequence of the efforts of J. J. Berzelius. Yet it is worth noticing how much less complete Proust's answer to Berthollet was, than the answer tacitly conveyed by Dalton's doctrine. Berthollet held that affinity tends to combine elements in all proportions, and that the composition of the oxides of a metal at maximum and minimum depended on accidental factors, physical conditions opposed to affinity, such as cohesion and elasticity. Dalton showed that a beautifully simple relation exists between the composition of one oxide and another, so

[31] *Mém. d'Arceuil*, vol. 2, p. 470, 1809.

[32] *Op. cit.*, pp. 232—233.

that the composition is not in the least a matter of chance. Proust had no conception of the law which regulates multiple proportions. Again, Berthollet believed that one oxide could change into the other by continuous variation in composition, while Dalton's theory not only allowed for the existence of definite intermediate oxides, but could even predict their composition with a considerable degree of certainty.

The view taken here, that Berthollet's teaching on the subject of chemical composition easily survived Proust's criticism, and received a serious check from Dalton, can be amply illustrated from the literature of the time. William Henry treats the subject of chemical proportion in that sense. "In opposition to the theory that chemical affinity has a strong tendency to unite bodies in unlimited proportions, an hypothesis has lately been proposed by Mr. Dalton, which appears more consonant to the general simplicity of nature."[33] John Murray pits the two doctrines against one another, and actually, as late as the year 1809, expresses a strong preference for Berthollet's.[34] Indeed, Berthollet felt the challenge to himself implied in Dalton's Atomic Theory, and showed this by criticising it in the Introduction which he contributed to the French translation of Thomson's "System of Chemistry,"[35] in which, it will be remembered, the theory is sketched.

If anyone, inclining to hold to the view of von Meyer and Wurtz that Proust was successful against Berthollet, should doubt whether the prestige of the latter was so great as has been indicated in this paper, he might do well to consider the chemical literature of the time. In

[33] "Elements of Experimental Chemistry," 6th ed., vol. 1, p. 81, 1810.

[34] "System of Chemistry," 2nd ed., vol. 1, p. 627.

[35] Riffault's translation, vol. 1. pp. 21—27, 1809.

addition to Gay-Lussac and Murray, who, as already explained, adhered in the year 1809 to the doctrine of combination in variable proportion, Friedrich Stromeyer[36] in 1808, and Amadeo Avogadro[37] in 1811, showed themselves under the sway and influence of Berthollet. What is more, even after Dalton's doctrine of definite proportion had become the foundation of chemistry, Berthollet's main ideas were still held by chemists in the greatest respect. The very opposite of this might be inferred from E. von Meyer's statement that "his principles were held to be totally erroneous . . . . . the revival of his principles was reserved for quite modern times,"[38] and Sir William Ramsay's conjectural remark that the "Essai de Statique Chimique" was soon forgotten."[39]

Berzelius's "Essai sur la Théorie des Proportions Chimiques," published in 1819, contains an exposition of mass-action and chemical equilibrium,[40] and is dedicated "a l'auteur de 'L'essai de statique chimique.'" Perhaps the most interesting testimony of this kind is borne by J. B. Dumas, who in his lectures on chemical philosophy, delivered in the year 1836, expressed the highest admiration for the "Statique Chimique." "It engrossed my whole time for three or four years; from the age of 17 to 21 I read it, re-read it, and pondered it. . . . . I read it pen in hand, making extracts and reflections and comments; these efforts have been of the highest value to me. As a student of chemistry I formed myself on Berthollet . . . . and whatever right I have to raise

36 "Grundriss der Theoretischen Chemie," pp. 66, 80.

37 *Jour. ae Phys.*, vol. 73, p. 76.

38 *Op. cit.*, p. 551.

39 "Introduction to the Study of Phys'cal Chemistry," p. 43, 1904.

40 *Op. cit.*, pp 7—11, 106—109.

my voice in this hall . . . . I owe it to the study I made of Berthollet's 'Statics.'"[41]

Finally, on the establishment of these two doctrines, which seemed to be incompatible with one another—Dalton's of invariable proportions and Berthollet's of mass-action—there remained the problem of reconciling the one with the other. That the necessity of doing this was present in the minds of the leaders of chemistry is proved by Berzelius's "Essay on the cause of Chemical Proportions," etc., which begins with a section "on the relation between Berthollet's theory of affinities and the laws of chemical proportions." He remarks that "some chemists have affirmed that the existence of chemical proportions is contrary to the principles of the theory of affinities with which the illustrious Berthollet has enriched chemistry," and proceeds to show that this is really not the case. He takes the case of solution in water of copper sulphate to which hydrochloric acid is added; ". . . . the part of the acid really combined with the oxide is neutralised according to the laws of chemical proportions. . . . . This single example is sufficient to show that the principles of Berthollet's theory are not inconsistent with the laws of chemical proportions."[42]

Dalton, in his comments on this Essay, expresses his full concurrence with the verdict. "The first division of Dr. Berzelius's essay contains an admirable exposition of those facts which Berthollet brought forward in so conspicuous a point of view in his chemical theory, and which his zealous followers have magnified in a still greater degree. A better explanation could, I think, be scarcely given in fewer words."[43]

41 "Leçons sur la Philosophie Chimique," pp. 379—380

42 *Ann. of Phil.*, vol. 2, p. 443, 1813.

43 *Ann. of Phil.*, vol. 3, p. 174, 1814.

APPENDIX.

List of Memoirs, in addition to those mentioned in the paper, which show Berthollet's influence.

1799.

L. J. Thénard, "Les différents états de l'oxide de l'antimoine et ses combinaisons avec l'hydrogène sulfuré," *Ann. de Chim.*, vol. 32, pp. 257-269.

1800.

(A note drawing attention to Berthollet's work on the causes of error in tables of affinity.) *Allg. J. Chemie* (Scherer), vol. 4, pp. 669-670.

1801.

"Ueber den Einfluss einiger unbeachteten Umstände bei der Wirkung der Wahlverwandschaften," *Chem. Ann.* (Crell), vol. 1, pp. 111-114.

1802.

L. J. Thénard, "Sur les différentes combinaisons du cobalt avec l'oxygène, etc," *Ann. de Chim.*, vol. 42, pp. 210-219.

1803.

A. B. Berthollet, "Observations sur les précipités des dissolutions métalliques," in "Essai de Statique Chimique," note 22.

E. G. Fischer, "Vermischte Bemerkungen über die brennbaren Grundstoffe, mit Rücksicht auf Berthollets Theorie der Verwandschaft," *Allg. J. Chem.* (Scherer), vol. 10, pp. 171-184.

L. W. Gilbert, *Ann. der Phys.*, vol. 13, pp. 158-159.

C. J. B. Karsten, "Revision der Chemischen Affinitätslehre mit beständiger Rücksicht auf Berthollets neuer Theorie," Leipzig, pp. 278.

L. Schnaubert, "Untersuchung der Verwandschaft der Metalloxyde zu den Säuren. Nach einer Prüfung der neuen Bertholletschen Theorie," Erfurt (for Berthollet's comments on this, see *Ann. de Chim.*, vol. 49, pp. 5-20, 1804).

1804.

Gay-Lussac, "Sur les précipitations mutuelles des oxides métalliques," *Ann. de Chim.*, vol. 49, pp. 21-35.

1805.

J.-M. HAUSMANN, "Sur l'oxidation," *Ann. de Chim.*, vol. 56, pp. 5-14.

1807.

C. F. BUCHOLZ, "Die Verhältnissmengen der Bestandtheile im salzsauren Silber, und den salzsauren Neutralsalzen," *J. für Chem.* (Gehlen), vol. 3, pp. 328-335.

A. F. GEHLEN [notes accompanying his translation into German of Berthollet's "Troisieme Suite de Recherches sur les lois de l'affinité."] *J. für Chem.* (Gehlen), vol. 3, pp. 248-322.

H. F. LINK, "Ueber Berthollet's Theorie der Chemischen Verwandschaft," *J. für Chem.* (Gehlen), vol. 3, pp. 232-247.

ROSE, "Die Verhältnissmengen der Bestandtheile des Schwefelsauren Baryts," *J. für Chem.* (Gehlen), vol. 3, pp. 322-328.

1808.

H. F. LINK, "Einige Bemerkungen über Anziehung und Verwandschaft," *Ann. der Phys.*, vol. 30, pp. 12-22.

1811.

L. W. GILBERT, "Historische-Critische Untersuchung über die festen Mischungs-Verhältnisse in der Chemischen Verbindung, etc.," *Ann. der Phys.*, vol. 39, pp. 361-428.

C. H. PFAFF, "Expériences et observations relatives au nouveau principe d'action de l'affinité établie par M. Berthollet," *Ann. de Chim.*, vol. 77, pp. 259-288 (for Berthollet's comments on this, see *op. cit.*, 288-296).

G. K. L. SIGWART, "Ueber Berthollet's Chemische Masse," *J. für Chem.* (Schweigger), vol. 1, pp. 352-357.

1812.

P. L. DULONG, "Recherches sur la décomposition mutuelle des sels solubles et des sels insolubles," *Ann. de Chim.*, vol. 82, pp. 273-308.

1815.

H. F. LINK, "Ueber die Chemische Wirkung beim Zusammenreiben der Körper," *J. für Chem.* (Schweigger), vol. 14, pp. 193-199.

Manchester Memoirs, Vol. liv. (1910), *No.* 8.

VIII. Note on Radio-active Recoil.

By Sidney Russ, D.Sc.

Read December 14th, 1909. Received for printing December 18th, 1909.

It has been shown that when Radium Emanation is condensed at the bottom of a tube, and the space above it evacuated, particles of the Active Deposit are radiated up the tube.*

This phenomenon has been attributed to the recoil of the atom when an alpha particle is emitted from it.

If the emanation be allowed to remain condensed for a time sufficient for it to attain radio-active equilibrium with its products, it might be expected that Radium A and Radium B would be projected up the tube in equal numbers as the result of the expulsion of α particles by the emanation and Radium A. The change from Radium B to Radium C is only accompanied by the emission of β particles, the recoil due to which is much less energetic than in the above cases. Under certain conditions, however, the recoil of Radium C has been shown to take place, but in the phenomena under examination it will be seen that its effect is hardly appreciable. A disc suspended above the condensed emanation will be the recipient of active deposit particles, which adhere to it. After an exposure for a suitable time the disc may be removed, and the decay curve of its activity tested with the aid of an electrometer by means of the alpha rays emitted from it. The object of the present investigation

* Russ and Makower, *Proc. Roy. Soc.*, A., vol. 82, 1909.

has been to find the relative numbers of Radium A, Radium B, and Radium C particles radiated away from the condensed Emanation, by an analysis of the decay curves of the active deposit collected on the aforesaid disc for different times of exposure.

The method of experiment consisted in condensing the Emanation from a few milligrammes of Radium at the bottom of a glass tube by means of liquid air. After waiting three hours, by which time the Emanation is in equilibrium with its products Radium A, Radium B, and Radium C, a disc was suspended about 7 cms. above the condensed Emanation, and the system evacuated to a pressure of about 1/100 mm. After a suitable exposure the disc was removed and the decay of its activity tested by means of an electrometer. During the course of these experiments, a short account of which is given in the paper referred to, the times of exposure of the disc were 10 minutes, 40 minutes, and 3 hours respectively, but for the purposes of this analysis attention will be confined to the 10 minutes and the 3 hours exposures. This selection has been made owing to the comparative simplicity of the analytical expressions under these conditions, at the expense of no essential features of the phenomena.

The decay curve obtained for an exposure of 10 minutes is marked I in *Fig.* 1, and it may at once be seen, by inspection of its marked variation from curve IA, which is the well-known curve due to 10 minutes' exposure to the Emanation, that a considerable amount of Radium B was projected on to the disc as well as Radium A, a result which might have been anticipated.

Curve II shows the decay curve obtained when the exposure was 3 hours, and its deviation from the ordinary 3 hours exposure curve IIA is still more marked than for the shorter exposure.

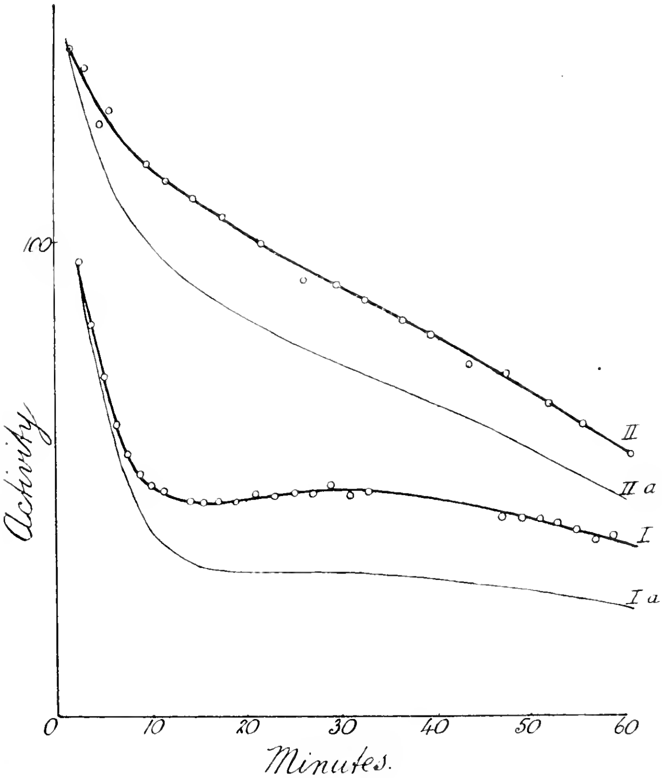


Fig. 1.

The question at once occurs in what proportions do Radium A and Radium B exist on the disc?

Consider the supply of Radium B to the disc due to the disintegration of Radium A.

If n = number of particles of Radium A at the bottom of the tube, then

$$\frac{dQ}{dt} = \lambda_1 n - \lambda_2 Q,$$

$$\therefore Q_t = \frac{\lambda_1}{\lambda_2} n(1 - e^{-\lambda_2 t})$$

where Q_t = number of Radium B particles produced after a time t, λ_1 and λ_2 being the radio-active constants of Radium A and Radium B respectively, and n being considered constant during the time of exposure.

The number of Radium B particles supplied to the disc will be a fraction of this, depending on the solid angle subtended by the disc, which will be considered later.

At any time T after removal

$$Q_t = \frac{\lambda_1}{\lambda_2} n(1 - e^{-\lambda_2 t}) e^{-\lambda} \quad .$$

As Radium B is supplied to the disc it immediately begins to form Radium C, the rate of increase of which may be denoted thus :—

$$\frac{dR}{dt} = \lambda_2 Q - \lambda_3 R$$

$$= \lambda_1 n (1 - e^{-\lambda_2 t}) - \lambda_3 R$$

$$\therefore R_t = \frac{\lambda_1}{\lambda_3} n \{ 1 - ae^{-\lambda_2 t} + be^{-\lambda_3 t} \}$$

where $a = \dfrac{\lambda_3}{\lambda_3 - \lambda_2}$ and $b = \dfrac{\lambda_2}{\lambda_3 - \lambda_2}$.

For a definite time of exposure the quantity within the brackets is determinate, and may be replaced by M, whence

$$R_t = \frac{\lambda_1}{\lambda_3} . n \quad M.$$

Since the decay curves were measured by means of the alpha rays, we require to know the quantity of Radium C on the disc at any time T after removal.

The quantity of C may be considered as made of two parts—

(1) That actually on the disc at the moment of removal, which at any subsequent time T will be

$$\frac{\lambda_1}{\lambda_3} n Me^{-\lambda_3 T}.$$

(2) That produced by the Radium B which was on the disc at the moment of removal.

Let R' be the quantity of Radium C due to this cause at any time T.

Then, by analogy with the case considered by Rutherford*—

$$\frac{dR'}{dt} = \lambda_2 Q - \lambda_3 R'$$

$$= \lambda_2 Q_t e^{-\lambda_2 T} - \lambda_3 R'$$

$$\therefore R' = \frac{\lambda_2 Q_t}{\lambda_2 - \lambda_3}(e^{-\lambda_3 T} - e^{-\lambda_2 T}).$$

Hence the total quantity of Radium C present at any time T after removal of the disc is $R_t + R'$, due to the Radium B projected from the Radium A at the bottom of the tube.

There will, however, be some Radium C due to the Radium A projected from the Emanation itself, and this quantity may be calculated; the *change* of activity with time due to the Radium A and Radium C together may, however, be read off from the well-known decay curve for the particular time of exposure.

This has been done for the exposures of 10 minutes and 3 hours under consideration here.

Let n = number of Radium A particles at the bottom of the tube.

Then the number obtained on the disc after a time t will be proportional to $n(1 - e^{-\lambda_1 t})$. The factor of proportionality depends, as already stated, on the solid angle subtended by the disc, and also, perhaps, on the nature of the surface upon which the Emanation is condensed, for it has been shown† that only about one-eleventh part of

* "Radio-activity," p. 331.

† *loc. cit.*

the particles breaking up per second actually leave the surface.

Since the factor due to the first cause will be the same whether Radium A or Radium B is projected, and probably also due to the second, we may for simplicity take it unity.

After 10 minutes exposure the number of Radium A particles on the disc will be $\cdot 9n$, and that of Radium C $\cdot 13n$.

Hence at the instant of removal of the disc the initial alpha ray activity will be these numbers multiplied by the radio-active constants λ_1, λ_3 of Radium A and Radium C respectively.

It has previously been shown that the activity at the instant of removal of the disc, due to the Radium C on it which has been produced from the Radium B directly fired on to the disc is given by R, where

$$R = \frac{\lambda_1}{\lambda_3} n(1 - ae^{-\lambda_2 t} + be^{-\lambda_3 t}).$$

The evaluation of this expression shows that the number of Radium C particles on the disc at the moment of removal after an exposure of 10 minutes is $\cdot 34n$, and consequently its alpha ray activity will be $\cdot 34n\lambda_3$.

We have then at the instant of removal of the disc after 10 minutes exposure :—

(1) Due to the radiation of radium A an alpha ray activity given by $\cdot 9n\lambda_1$ Radium A particles and $\cdot 13n\lambda_3$ Radium C particles, breaking up per second.

The variation of this activity with time may be read from the graph referred to.

(2) Due to the radiation of Radium B an alpha ray activity given by $\cdot 34n\lambda_3$ Radium C particles breaking up per second.

TABLE I.

CALCULATED ACTIVITY.

Time in Mins.	Due to Radiation of Radium A.	Due to Radiation of Radium B.	Combined Activity.	Reduced to fit experimental curve at time 30 mins.
1	100	5·68	105·7	136
2	81	6·44	87·4	113
3	66	7·00	73·0	94·5
4	58	7·96	66·0	85·4
5	53	8·43	61·4	79·6
7	39·5	9·46	49·0	63·4
10	29	10·8	39·8	51·6
15	24	12·3	36·3	47·1
20	23	13·2	36·2	46·9
25	23	13·6	36·6	47·4
30	23	13·6	36·6	47·4
35	22	13·4	35·4	45·8
40	22	12·9	34·9	45·2
45	21	12·3	33·3	43·2
50	20	11·7	31·7	41·1
55	19	10·9	29·9	38·7
60	17	10·2	27·2	35·2

The variation of this activity with time may be calculated from the expressions $R_t + R'$.

If Radium A and Radium B are projected up the tube in equal quantities, the decay curve of the active matter on the disc would be that obtained by adding the activities due to (1) and (2) in the ratio in which they stand, namely :—

$$\frac{\cdot 9 n\lambda_1 + \cdot 13 n\lambda_3}{\cdot 34 n\lambda_3} = 17\cdot 6$$

where $\lambda_1 = 3\cdot 85 \times 10^{-3}$ and $\lambda_3 = 5\cdot 93 \times 10^{-4}$.

This has been done and the results tabulated in Table I. and reproduced graphically in the full line curve in *Fig.* 2. It will be seen that the experimental points,

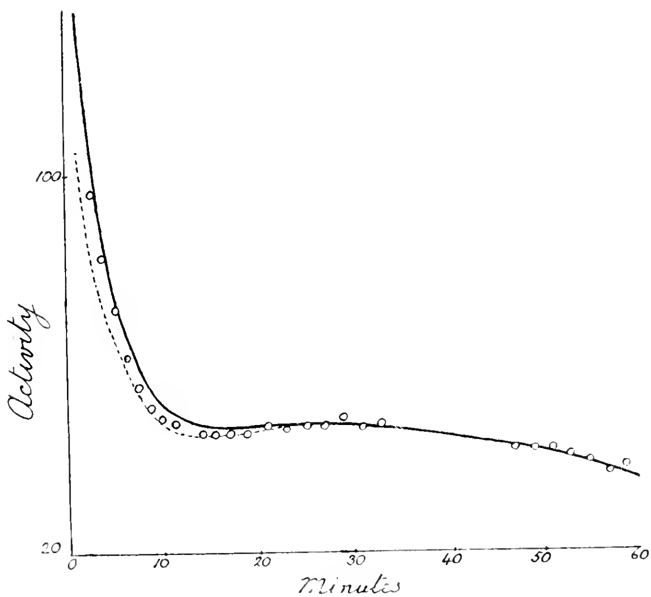


Fig. 2.

which are represented by small circles, do not lie exactly on this curve. Bearing in mind the possibility that Radium A and Radium B may not be radiated up the tube in equal quantities, the limits of any such an equality can be found by varying the proportion in which the quantities (1) and (2) are added together.

The dotted line in *Fig.* 2 shows the decay curve that would be obtained if twice as much Radium B had been projected as Radium A. Inspection shows that the experimental points lie within the limits defined by the two curves drawn.

Hence from the analysis corresponding to an exposure of 10 minutes, it may be pretty confidently stated that Radium A and Radium B are projected up the tube in nearly equal proportions.

The case of an exposure lasting three hours admits of comparatively simple treatment, for in this case Rutherford has shown that a state of equilibrium exists between the different short lived products obtained from the Emanation.

Hence, owing to the direct firing of Radium A, we have at the moment of removal the same number of Radium C particles breaking up per second as Radium A particles. If Radium B is radiated up the tube in an equal proportion to Radium A, then a similar number of Radium C particles will be breaking up per second on the disc at the instant of removal due to this cause as when the radiation is due to Radium A.

Hence the initial alpha ray activity due to the first cause will be twice that due to the second.

The variation in the alpha ray activity of the disc due to the Radium A radiated on to it corresponds to the well known decay curve for an exposure of three hours. This variation is tabulated in Table II., Column 2.

TABLE II.

CALCULATED ACTIVITY.

Time in mins.	Due to Radiation of Radium A.	Due to Radiation of Radium B.	Combined Activity.
1	100	50	150
2	93	50	143
3	88	49·9	137·9
4	84	49·7	133·7
5	80	49·5	129·5
7	75	49·2	124·2
10	69	48·3	117·3
15	63	46·7	109·7
20	59	44·2	103·2
25	55	41·8	96·8
30	52	39·4	91·4
35	49	36·4	85·4
40	46	33·2	79·2
45	43	30·7	73·7
50	39	28·1	67·1
55	35·7	25·7	61·4
60	32	23·4	55·4

The variation in the alpha ray activity due to the Radium B radiated to the disc has been calculated from the expression $R_t + R'$, where

$$R_t = \frac{\lambda_1}{\lambda_3} n (1 - ae^{-\lambda_2 t} + be^{-\lambda_3 t}) e^{-\lambda_3 T}$$

and $R' = \frac{\lambda_2}{\lambda_2 - \lambda_3} Q_t (e^{-\lambda_3 T} - e^{-\lambda_2 T})$ where $Q_t = \frac{\lambda_1}{\lambda_2} n (1 - e^{-\lambda_2 t})$.

These numbers will be found in Column 3, and the result of adding Columns 2 and 3 is reproduced as the full line curve in *Fig.* 3.

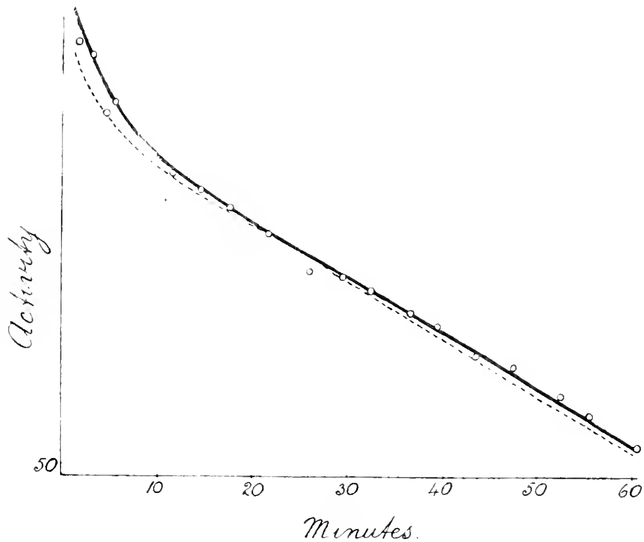


Fig. 3.

It will be seen that the experimental points, indicated by small circles, do not lie exactly on the curve.

Following the same procedure as for the short exposure, and assuming that twice as much Radium B is radiated up the tube as Radium A, we obtain the dotted curve in *Fig.* 3.

Inspection again shows that the experimental points lie within the limits imposed by the two cases considered.

This result confirms the impression already obtained that the numbers of Radium A and Radium B particles projected up the tube are not very different.

It was thought unnecessary in the analysis to allow for the difference in the ionisation produced by the α particles from Radium A and Radium C.

CONCLUSION.

It has been seen that the experimental results obtained may be explained on the supposition that Radium A and Radium B particles are projected in about equal proportions from the Radium Emanation when it is condensed at the bottom of a tube from which the air has been removed.

If Radium C were radiated in anything like the same proportion the experimental decay curves would be markedly different. Some recent experiments by Dr. Makower and the Author have shown that the number of Radium C particles which effectively recoil as the result of the ejection of beta particles from Radium B is a very small fraction of the number of Radium A and Radium B particles which do so as a result of the ejection of alpha particles from Radium Emanation and Radium A respectively.

MATTHEW NICHOLSON,
OF RICHMOND ROW.
1746–1819.
From a water-colour drawing in the possession of Mr. Albert Nicholson.

Manchester Memoirs, Vol. liv. (1910), *No.* 9.

IX. Correspondence between Mrs. Hemans and Matthew Nicholson, an early member of this Society.

By FRANCIS NICHOLSON, F.Z.S.

Received and read November 16th, 1909.

By virtue of my relationship with the recipient, I am possessed of a number of letters addressed by Felicia Dorothea Browne and her mother and sister, to Matthew Nicholson, of Richmond Row, near Liverpool. Mr. Nicholson preserved these letters carefully, and also drafts of many of his replies. In the course of the ninety years that have elapsed since his death some of the letters have been lost, but enough remain to throw much light on the personal and literary history of Mrs. Hemans for several years prior to her marriage.

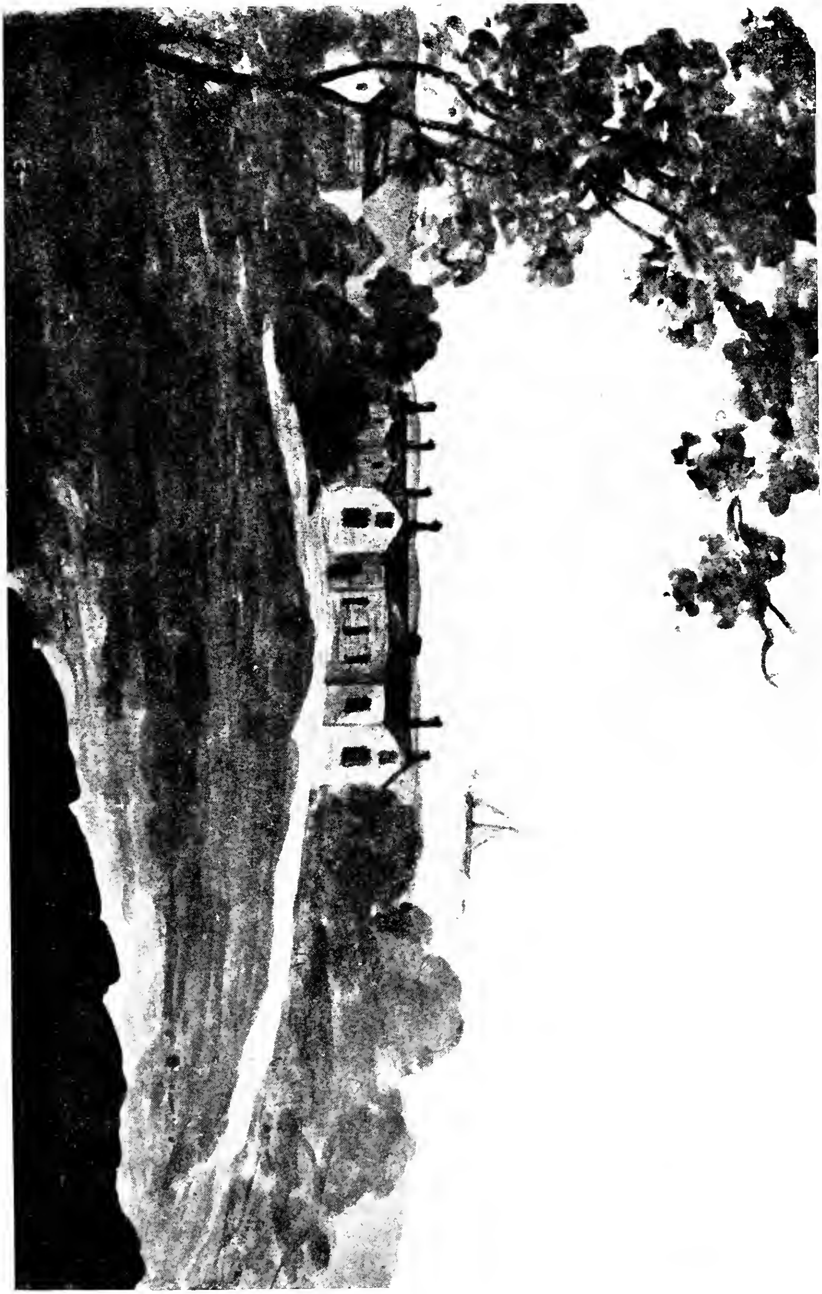
Felicia Dorothea Browne, better known as Mrs Hemans, though not considered one of our greatest poets is recognised as one of the most distinguished natives of Lancashire. She is acknowledged to have had the "true poet's gifts of grace, sweetness, and tenderness." A few of her poems are well known to everyone by reason of their appearance in hymn books and school books, or from having had the fortune to be set to good tunes. The writer of "Casabianca," "The Better Land," and "The Graves of a Household," is not likely to be consigned to oblivion.

Felicia Dorothea Browne was the elder daughter of George Browne, who was for some time a merchant in Liverpool, but failed in 1793. He must have been in a considerable way of business, as it took ten years to wind up the estate, the fourth and final dividend being paid in 1804. Felicia was born on the 25th September, 1793,* six months after her father's failure, in Duke Street, Liverpool. The house has been identified by Mr. G. T. Shaw† as that formerly numbered 65, but in 1896 numbered 118.

Mr. Browne's failure reduced the family from affluence to genteel poverty. They left Liverpool in 1800, and went to live at Gwrych, near Abergele, where Felicia spent a happy childhood amidst surroundings of great natural beauty, which undoubtedly had their effect on her imagination. Naturally enough, considering the straitened circumstances of the family, the girls (for Felicia had a younger sister) were educated at home. Their mother, who had been a Miss Wagner, and was a woman of considerable culture, trained her daughters herself. They were both precocious children, much given to rhyming, and their juvenile efforts, circulated in manuscript, had met with the praise of many friends. One of those to whom Felicia's poems had been submitted was Lady Kirkwall. She expressed her "high and flattering approval" of them, and caused the shabby manuscript to be most elegantly bound before she returned it to the author. At one time Mrs. Browne wished to send Felicia to a boarding school to finish her education, but was prevented from doing so by want of means. In this difficulty it occurred to Mrs. Browne that the means for Felicia's education might be provided by the publication of the child's poems. Her reasoning seems to have been that as the poems had obtained the approval of the

* This date appears in the mother's autograph, and I therefore think it correct, although all the authorities do not accept it: H. F. Chorley, for instance, gives it as 1794.

† Liverpool homes of Mrs. Hemans (*Hist. Soc. of L. & C.* xlviii. 123; liv. 207).



GWRYCH

From a drawing by Jonathan Hatfield.

Face p. 2.

aristocratic Lady Kirkwall they were good enough to print, and that if printed they were certain to sell. Subscriptions were solicited and the poems were sent to press. The forthcoming book of poems, written by a juvenile prodigy of Liverpool birth, was naturally a subject of conversation in literary circles in Liverpool. Moving in those circles, and intimate with William Roscoe and other friends of the Brownes, was Mr. Matthew Nicholson. Becoming interested in the young poetess, Mr. Nicholson entered into correspondence with Mrs. Browne, and a close friendship followed.

Matthew Nicholson, who was the first cousin of my grandfather of the same name, was born at Liverpool in June, 1746. He was educated at the then celebrated school of the Rev. Philip Holland, at Bolton, and in 1762 became a student at the Warrington Academy, which filled amongst the dissenters of those days the place of the universities, which were closed to them. Probably no seat of learning had so large a proportion of distinguished men on its teaching staff as had the Warrington Academy. Amongst the tutors in Mr. Nicholson's time, or of his acquaintance, were Joseph Priestley, F.R.S. (in whose house he boarded), Dr. Aikin, John Holt, the mathematician, Dr. Nicholas Clayton (Mr. Nicholson's brother-in-law), Dr. John Taylor, author of the "Hebrew Concordance" (to which all the English and Welsh archbishops and bishops, with four exceptions, subscribed), and George Walker, F.R.S., sometime President of this Society. In 1773 Mr. Nicholson became a partner in a mercantile firm founded in Liverpool by his grandfather early in the 18th century. In 1785 the business of the firm was divided, the junior partner (my grandfather) remaining in Liverpool, while the two other partners (Matthew Nicholson and his brother Thomas) removed to Manchester as being a better centre for carrying on the business of cotton and linen merchants, in which they were engaged. Though Matthew Nicholson was successful in business, it does not seem to have been congenial to him. Having sufficient means to supply his simple and inexpensive tastes, and being a bachelor, he had none of the usual inducements to continue in business, and being also subject to severe headaches, he retired at the age of 43, and settled on a small property he had inherited at Richmond Row, then a rural locality near Liverpool. There he spent the remainder of his long life, following his favourite hobbies of gardening and reading, drawing and writing, nursing himself during frequent illnesses, and occasionally taking tours to Wales or Scotland. During his residence in Manchester he had joined this Society, having been elected a member on 14th December, 1785. Doubtless he owed his introduction to the Society to its founder, Dr. Percival, between whose family and the Nicholsons there had existed for three generations a friendship, which had been further cemented by Dr. Percival's marriage with a connection of the Nicholsons. Matthew Nicholson contributed one or two papers to the Memoirs of the Society.

Mr. Matthew Nicholson was 61 years of age, when, in 1807, he became interested in the works of the young poetess, Felicia Browne, then aged 13.

At one of the literary gatherings already mentioned the discussion turned on the difficulty of writing a preface to Felicia's forthcoming book. Mr. Nicholson, who was one of the party, was tempted to try his hand at this literary performance. So pleased was he with the result that he submitted his preface to Mrs. Browne, modestly hiding his identity under the pseudonym, "One of the Subscribers." Availing herself of the privilege her anonymous correspondent had allowed her, Mrs. Browne made several alterations in the preface. Amongst these was the omission of some of Mr. Nicholson's poetry. "Your beautiful lines in the preface," writes Mrs. Browne, "are justly entitled to high admiration, and have my warmest thanks; but my little votary of the muse has so great an objection to *any poetry* in this part of the work, that I hope your liberality will forgive my not adopting them—she says it might be imagined that they were her own production."

Several letters passed between Mrs. Browne and the anonymous subscriber while the preface was being drafted, and agreement as to details seemed to be unattainable. One of Mrs. Browne's anxieties was that the preface should bear witness to Lady Kirkwall's interest in the publication. Her Ladyship was to have honoured it by accepting the dedication, but an even more exalted personage had expressed his willingness to do so. To us George IV. may seem a strange patron for a young girl's first book of poems, but in his own day the following passage in the preface probably sounded quite appropriate: "The distinguished and gratifying patronage of His Royal Highness the Prince of Wales, and the favours of the highly dignified and very respectable subscribers in the annexed list, will naturally excite gratitude and rouse to new exertion in the pursuits of literature and virtue." Mrs. Browne was also desirous of adding to the name of Mrs. Barbauld, who alone was mentioned as having influenced the young writer, the names of Mrs. Trimmer and Hannah More, "as I am a great lover of their works, and as they have all been equally in the hands of my girls." The correspondents were still far from agreement as to the exact wording of the preface when a way out was found. William Roscoe undertook to write the preface. In favour of so great a star in the literary firmament, Mr. Nicholson promptly withdrew his proffered preface.

"Since Mr. William Roscoe had taken in hand the writing of the preface," he says, "I was so satisfied that it would be so much better done, that I was only desirous that my effort should be buried in oblivion." Nevertheless, he seems to have been rather proud of his own production, and in the same letter he includes a final copy of the meditated preface, "which I hope you will find so altered that you could have had no objection to have suffered the introduction of the second tetrastich amongst the others. I myself would have chosen to leave out the parenthesis respecting the ages of the young ladies. These comments are now needless, and I have much confidence that you will be perfectly satisfied with any preface written by Mr. William Roscoe." In the spring of 1807, Harriett Mary Browne*, Felicia's younger sister, then aged 8½, wrote a little story of the Pleasures of Willow-dale, and this and some poetical effusions were shown to Matthew Nicholson by one of the girl's aunts. The approbation he expressed, and the interest he took in securing the publication of Willow-dale, reached the young lady's ears, and brought forth a letter of grateful acknowledgment (dated 28th January, 1808), and a very pressing invitation to Gwrych. Though he did not avail himself of the invitation, Mr. Nicholson now thought it necessary to reveal his identity, which had probably been known all along to Mrs. Browne. Early in 1808 Harriett visited her relations in St. Ann Street, Liverpool, and while there was taken ill. She met Mr. Nicholson, and there grew up a fondness

* Harriett always spelled her name thus, but her mother and sister often omitted the last letter. We have followed her own spelling throughout.

between the sexagenarian bachelor and the little girl such as one sometimes sees between a grandfather and grandchild. The friendship continued for many years. On the child's return to Gwrych her mother wrote—"I should be very ungrateful indeed, my dear sir, if I did not endeavor again by *words* to express to you how very deeply I am impressed by your repeated *acts* of kindness to my two girls, and to convince you that I am not unmindful of them; though *words* are all I have to offer in return—but I am sure you have your reward *most amply* in your own gratification, for I know from experience how much more delightful it is to oblige, than to be obliged. My little Harriett is all gratitude to you for your constant goodness to her, and she has represented to me in her own enthusiastic language, what unmerited attention you have bestowed upon her, during her late disorder, and how liberally the first fruits of your sweet garden were devoted to cool her little heated mouth." In the same letter Mrs. Browne pressed Mr. Nicholson to visit Gwrych, and as he had apparently declined a previous invitation because he was an invalid subsisting on a milk diet, countered the excuse very smartly. "Be assured," she writes, "that a cordial welcome would receive you, and we would endeavour to make up in sincerity, what we want in splendor—the most liberal abundance prevails in the Dairy and I find it *very convenient* to put all my friends upon a milk diet, from the *kind plea* of it being so conducive to health and at the same time so suitable to an exhausted pocket. Do not you think I am very considerate to my friends?" In the same letter (June 28th, 1808) she says "I anticipate the pleasure of your sincere congratulations on the appearance of Felicia's book, under such flattering auspices; and here again I am at a loss how to tell you of my sensations of pleasure and respect, in the reflection of the great obligations which this publication has to your friendly zeal and to the interest you have so long taken in its success, of which I have been constantly informed,—but I believe the less I say, the more grateful it will be to you, for true goodness does not delight in a parade of words, therefore I will say no more of obligation."

There was much work for Mr. Nicholson in connection with Felicia's first book. Prior to its publication he was often asked for advice and afterwards Mrs. Browne depended on him to get things done in a business-like manner. And truly there was need for a business man to get things straight. A change of publishers had been made after printing, but before publication, subscriptions had been booked twice over, and no proper record had been kept of subscriptions paid. Moreover Mrs. Browne seems to have been annoyed by the lukewarmness of Messrs. Cadell and Davies, the publishers. She would only correspond with them through Mr. Roscoe and he seems to have been too much occupied to attend promptly to this business, so that eventually business arrangements were made in a very roundabout fashion, Mrs. Browne writing to Mr. Nicholson who saw Mr. Roscoe who wrote to Cadell and Davies. The subscribers to the book were so numerous that it ought to have paid well but some of the subscribers were dilatory in paying and the sale otherwise was disappointing. The criticisms were neither numerous nor favorable.

The young poetess was not spoiled by the honour of seeing herself in print. In June 1808 her mother wrote "Felicia is most assiduously devoting herself to reading, for the sole purpose of improvement, and I think her mental powers improve every day—she has composed many beautiful pieces lately, which appear to my *partial* *mind* to exhibit great progressive elegance and show that her genius is not likely to lie dormant." In September Felicia read and admired Roscoe's poem on the Park Dingle and about the same time seems to have become acquainted with the works of Burns, a copy in four volumes having been lent to her by Miss McAdam, a Liverpool friend. In October, 1808, she was on a visit to Denbigh.

Felicia Browne had about this time an attack of patriotism. It was excusable in her case. Her country had all her lifetime been engaged in a great Continental struggle. All her brothers were or were hoping to be in the army. In August, 1808, one of these brothers, Tom, was on duty at Halifax, Nova Scotia, and another, George, was embarking at Cork, in the fourth expedition for Spain or Portugal, with Sir David Baird, "the service," writes his mother, "which I am most pleased that he should be sent upon." The young poetess had military news not only in the newspapers, but in letters from her brothers at the seat of war. During this period also Mrs. Browne read aloud to her children Robertson's "History of Charles V." The result of all this exciting reading is to be found in Felicia's second book, which followed the first within a few months, and bore the topical title, "England and Spain." While the elder sister was writing patriotic poetry for publication, the younger one was writing poems not for publication, and making herself useful. Writing to Mr. Nicholson, she says, "I must tell you that I made two excellent apple dumplings the other day, which is more than Felicia ever has done, but she desires me to say, that she would be very happy to make her first attempt on one for you."

Throughout 1808, Mrs. Browne was making full use of Mr. Nicholson, very apologetically it is true. "I really feel," she says (Oct. 31st), "great repugnance at giving you such a continuation of trouble respecting this business, but I have already said so much of the deep sense I have of the kind interest you have taken to promote the success of the cause, that I will not weary you with a repetition of my obligations, but will only say, once for all, that your philanthropy and incessant efforts in the cause of infantile genius, are indelibly engraven on the minds of myself and your highly favored young friends."

Soon after completing "England and Spain," Felicia was ill. Referring to her illness and to her poem, Matthew Nicholson wrote to Harriett on 5th January, 1809, "we have all been saved much anxiety by not knowing till we can rejoice on her recovery, that your dear sister has been so very ill. She must be particularly careful of herself this winter. I cannot help suspecting that her fever may have been occasioned by too much exertion, and some anxiety respecting the charming poem she has lately written. I find the manuscript was dispatched to London the same day it came to the hands of Mr. Wm. Roscoe, and it was as quickly printed; but the motion of the French Emperor was quicker still! The poem, however, will sustain its own fame whatever may become of Emperors and their Thrones! And the freedom of the mind is beyond the reach of the former and more exalted than the latter! Or, to *prosify* the fair poet's words—it is in vain to restrain the *Soul* of Freedom." He followed with some very kindly criticism and with a final verse of his own, and continued, "I am not afraid that the author is in danger of being spoil'd by any praise which may be bestow'd—such a mind must be well poised as it is well stored!" This letter to Harriett and some previous criticisms drew a letter from Felicia herself, the first she had sent to her elderly critic, who has numbered it (1) and written on it the date of receipt. It is dated,

"Gwrych, 9th Jany., 1809.

MY DEAR SIR,

Though I have hitherto delayed to express my sense of the kindness you have shewn me, be assured I have ever felt most truly indebted to your friendship, and flatter myself you will do me the justice to believe, that my gratitude will be as permanent as it is sincere. I do not share with Harriett the honor of your correspondence, yet I hope a few lines from your *unknown* young friend, will not be unacceptable, as they are the genuine dictates of a heart, which has been so highly gratified by your approbation. Surely nothing can impart a more exquisite pleasure, than to receive esteem and commendation from the truly virtuous, may it ever be my aim to *deserve* their praise, by the constant practice of every moral excellence! The encomiums you have so liberally bestowed upon my last poem, are delightful, *because* I am persuaded they are sincere; I am convinced that *flattery* destroys the germ and blights the promise of infant merit, but you will agree with me that praise is calculated to rouse emulation, to inspire the most noble enthusiasm, and to fix

'The gen'rous purpose in the glowing breast.'

Harriett is, I believe, fearful lest I should supplant her in your regard, but she must allow me to become a Candidate for a portion of your favour, as I cannot expect to *rival* her, before I have the pleasure of your acquaintance. She has informed you of our regret at the prospect of leaving this dear retreat, but neither her pen nor mine could express the sentiments with which I shall bid adieu to the scenes of my infantine pleasures. The seclusion I have here enjoyed has afforded me leisure to pursue my favorite studies; the wild and romantic prospects of the surrounding country, have inspired me with that adoration for the beauties of nature, which I shall ever retain; and I have here imbibed a taste for the genuine pleasures of rural and domestic life. I need not therefore attempt to describe the impressions with which I shall leave a place endeared to me by every recollection. A town-residence would at all times be unpleasant, but the contrast of its hurry and gaiety, with this sweet retirement, will render it almost insupportable. I am quite delighted with the recent victory of my hero, the gallant Palafox, and shall certainly attempt to celebrate it in a song of triumph by way of a supplement to 'England and Spain.' Accept my best thanks for the additional lines you have favored me with; they are very appropriate, but from a tenacity which I hope you will think pardonable, I cannot admit into the poem any idea or even *word* that is not my own. Do not imagine that this is the effect of my presumption, as I am sensible how much might be improved, how much is to be pardoned; it is dictated by that Candour, which I should wish to be ever my guide. As I am certain that I have nearly exhausted your patience by this long letter, I will only entreat your farther indulgence, whilst I beg you to accept, my dear Sir, the good wishes and grateful esteem of your unknown, but sincere,

and much-obliged young friend,

FELICIA D. BROWNE."

A few days later Mr. Nicholson received a batch of letters from the Brownes enclosing a copy of one from the soldier brother in Spain. Mrs. Browne writes

"the approbation you have bestowed upon my dear Felicia's last production is truly grateful to her and to me and all the praises she receives stimulate her most ardently to the improvement of her talents that she may attain *real excellence.* She is most *zealously* devoting herself to *solid* reading and she says that her 'England and Spain' shall soon be no more to be compared with what she is now meditating than her first publication is to that. I pray God most fervently, that she may ever preserve that simplicity of mind and manner and singleness of heart, which are now the chief ornaments of her character, and that the commendations she daily receives may only prompt her to devote her talents and genius to His glory and the cause of virtue."

In her letter, Harriett, referring to Felicia having herself written to thank Mr. Nicholson, writes, "I must express a hope, that she will not supplant me in your regard, or that her writing to you, will not be the means of depriving me of so valuable a correspondent." Of public events she says, "We, who are so much interested in *every* account from that country (Spain), open every newspaper almost in fear and trembling, and read the intelligence of *every victorious* battle with peculiar pleasure. Felicia is particularly delighted that her hero, Palafox, has gained *another* victory, and added another *laurel* to his wreath." On February 1, Mrs. Browne sent a very long letter relating entirely to her son George, whose regiment had suffered much at Corunna, and during the retreat which preceded that victory. "He is in most miserable plight, for he has lost all he possessed in the world, and is worn to a skeleton." The delicate task she imposed on Mr. Nicholson was to use his influence with her mother, the wealthy, but evidently stingy, Mrs. Wagner, to provide the money for the fresh equipment of the soldier grandson. "Forgive my entreating you to take the trouble of applying to her," she says, "but I think she cannot refuse you." The old lady did refuse, however, "but," writes Mrs. Browne, in a later letter, "I am as much indebted to your exertions as if they had been successful."

In March, 1809, the Brownes removed from Gwrych to Bronwhilfa. "I have taken," says Mrs. Browne, "a little cottage in the neighbourhood of St. Asaph, where it would give me and my daughters the highest gratification to see you. It is pleasantly situated on the banks of the Clwyd, and is ten miles nearer Liverpool than where we now are, so that the journey would not be so serious an undertaking, and your society would be an invaluable acquisition to my two girls." In the same letter (4th March, 1809) Mrs. Browne writes: "Felicia was much gratified by the letter you had the kindness to write her, and she bids me say that it made her heart glow with pleasure, as she was convinced the sentiments of friendship you profess for her, are sincere. She will write to you herself after we are settled in our new habitation." The promised letter was dated 18th April, and with it was sent a copy of a letter from her eldest brother giving an account of the taking of Martinique. The brother had been wounded, but his spirit and enthusiasm were unaffected :—

"Bronwhilfa, 18th April, 1809.

MY DEAR SIR,—

The letter which my Mother has transcribed for your perusal on the other side, we received yesterday from my eldest Brother. You may easily imagine what blended emotions of tenderness, *pride*, and affection, it excited in our Bosoms. Deeply as I feel for the sufferings my dearest Brother must have endured, still I can hardly regret that he has received a wound in so glorious a cause, and as a trophy of so brilliant a victory; it will ever be his pride that he has bled in the service of his Country, and, like the Soldier described in the 'Pleasures of Memory,' who 'counts o'er his scars, and tells what deeds were done,' he will ever triumph in a recollection of the perils to which he has been exposed. If, however, he had not written *himself* to inform us of his convalescence, or if we had imagined he was in any danger from his wound, how different would our feelings have been! I agree with you that my poetic visions of Spanish Freedom are not likely at present to be realized; and I regret that the ardent enthusiasm the cause excited, led my fancy to paint the Spanish people, in colours, which (except in a few instances), have proved only *rainbow illusions.* I feel highly indebted to you, my dear Sir, for suggesting to my Muse, a subject which might well exercise the highest powers; but I fear it requires more knowledge of the *world* than a youthful, unsuspecting heart, can pretend to have acquired; indeed, if Experience only serves to blight the visions of imagination, and display the depravity of which human Nature is said to be capable, I should prefer to remain in total ignorance of life, and the manners of the world. For this reason, therefore, I must, *at present*, decline a theme, which perhaps my Judgment, when more matured, may select, for its variety and excellence. I hope I need not assure you, my dear Sir, what delight we should have in seeing you at our new abode; it certainly has more resemblance to a *Cottage* than a Palace, but you know Poets make *Cottages* the dwellings of peace and Content; Hospitality would give you a most cordial welcome, and *Gratitude* would certainly meet you in the person of your unknown

though affectionate young friend,

FELICIA D. BROWNE.

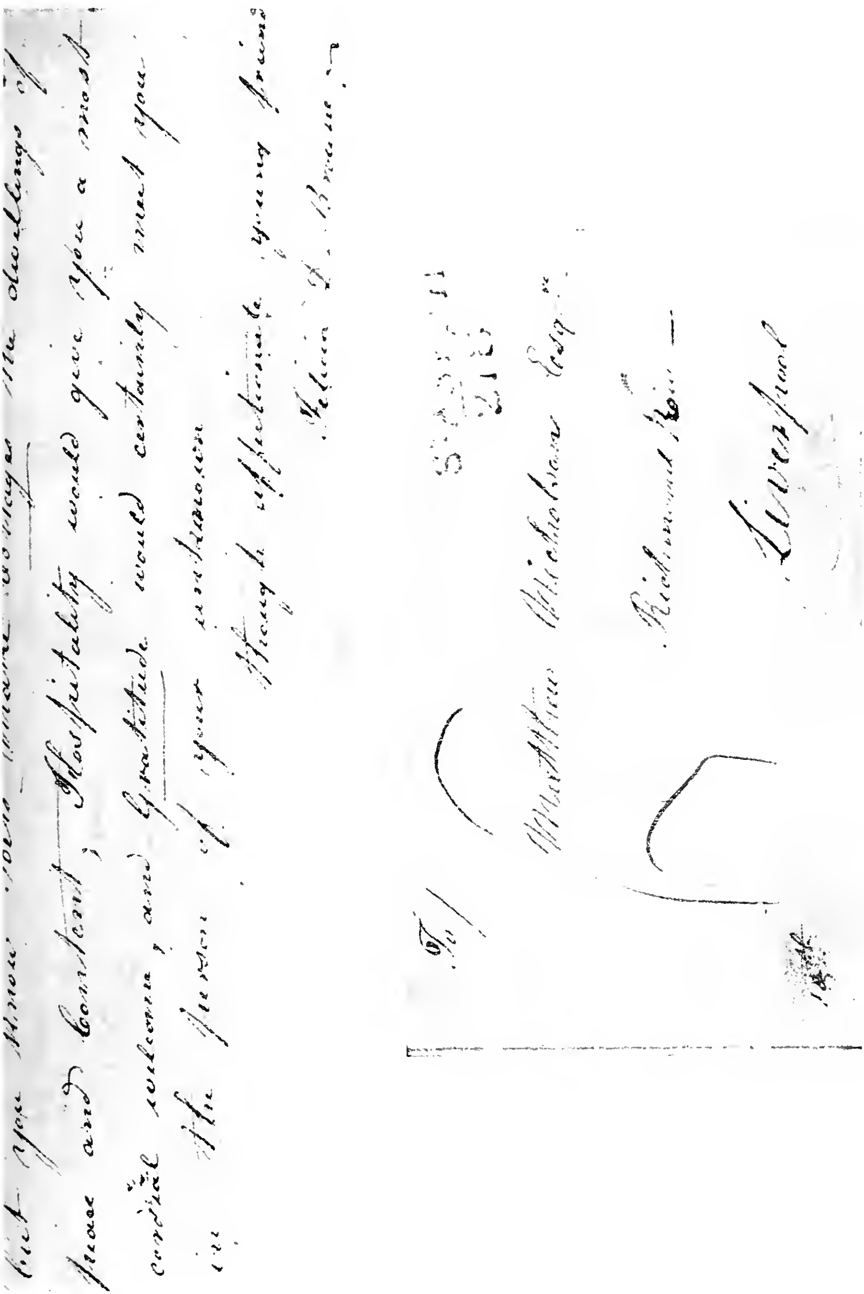
Harriett unites with us in affectionate regards; she will not forgive me if I intrude any more upon her privilege of corresponding with you, which she has reason to value as such a prerogative deserves!"

In May, 1809, Felicia again wrote to Mr. Nicholson and this, like her previous letter, shows how an almost first hand acquaintance with war and the Spaniards had toned down her enthusiasm.

"Bronwhilfa, 4th May, 1809.

MY DEAR SIR,—

I regret that you should imagine my 'hint for closing correspondence,' had proceeded from any reluctance on my part; as I assure you it has hitherto afforded me very high gratification, and I have no doubt, would continue to be productive of both pleasure and improvement. I was fearful that you might consider my letters as



FACSIMILE OF MRS. HEMANS'S HANDWRITING.

Face p. 14.

trespassing upon that time, which might be so much better devoted than in either reading or answering them. If I thought they could be in the least interesting to you, I should feel myself highly honoured by being admitted into the number of your regular Correspondents. Most ungrateful should I indeed be, if I did not consider myself greatly indebted for the notice of one whom I have so much reason to esteem. I am happy to find that you have not given up the cause of Spain as desperate; had every Leader of the Spanish people acted like the *illustrious Palafox*, and the brave defenders of Saragossa, they would have deserved the praises and enthusiasm, their energies *at first* excited, and Spain might have been called the Land of patriot-heroes. Have you read Mr. Heber's poem lately published, on the subject of the present war? It appears to me imbued with much of the true Spirit of Poetry; and, though it is certainly inferior to his noble production, 'Palestine,' yet it is highly animated, and bestows the most glowing encomiums upon the exertions of the Spaniards, in the Cause of Liberty. If you have met with it, I should like to know your opinion of its merits, and hope it will coincide with my own. We are at length comfortably settled in our new habitation, but the surrounding Country, tho' rich in the beauties of Cultivation, appears very uninteresting after the wild mountain-walks, and rude, romantic scenery of our former abode. The Sea, too, that constant picture either of the Sublime, or the Beautiful, is far distant, and I regret the privation *daily*. I thank you, my dear Sir, for your kind wishes respecting my dear Brothers; they are echoed by my own heart, and I hope the anxiety and suspense we have endured on their account, will never again be experienced. Nothing but a firm reliance on the mercies of Providence, could sustain our spirits in such a situation, and I hope that humble resignation to all its dispensations, will ever attend your

Affectionate and sincere young friend,

FELICIA BROWNE."

At the same time Mrs. Browne writes :—

"I receive all the assurances of the friendly interest you take in the success of Felicia's two publications, with peculiar gratification, because you have evinced by *deeds* the sincerity of your words,— and though, from her total indifference to all pecuniary objects, she never bestows a thought upon the emolument which *might* have been expected to be derived from these juvenile productions; yet I cannot entirely divest myself of anxiety on the subject, from the circumstances in which I am placed by providence which make it an object of importance to me and my children."

It appears that though "England and Spain" was on a topical subject, the edition of 500 copies remained unsold and unnoticed. Mrs. Browne thought the sale of the copyright was the only way to induce the publishers to push it, and Mr. Nicholson was requested to get an offer from them. "I fear I am trespassing too much on your time," she says, "by making you such a participator in my concerns; but it is natural for us to expatiate where we find we are attended to." Mr. Nicholson's health was then worse than usual, and he had just lost two old friends, Mr. Kennion, the artist, and Mr. Rathbone. A letter of June 3 from Mrs. Browne enclosed a copy of Felicia's stirring poem, "The Call of Liberty," afterwards printed in "Domestic Affections." In the next letter from Bronwhilfa, 25th July, 1809, Mrs. Browne has much to say about Felicia.

> "Felicia would have availed herself of this opportunity to tell you how much she admired the virtuous and grateful sentiments expressed in the lines of Mr. Rushton, which you were so attentive as to send her, but she is assiduously occupied in copying, or rather writing out *fairly*, a poem ['War and Peace'] she has lately composed, and which I shall have the pleasure of sending to Mr. W. Roscoe, by a private conveyance, the latter end of this week, when you may, perhaps, take the trouble of perusing it. She was taken ill of the scarlet fever (which has been very prevalent in this neighborhood) about a month ago, and whilst she was confined by it, she planned and executed this poem, which was but the work of thirteen days, though I believe it contains more than eight hundred lines. It appears to me a very spirited performance, but I will make no further comments upon it, till I hear your sentiments and those of Mr. W. Roscoe. When you read it, I am sure it will be with that candor which is due to the work of a girl, who still wants two months to complete her sixteenth year. She is every day more and more devoted to study, and her mind certainly makes astonishing progress in the path of literature; so that I hope she may one day be an ornament to her circle and have an influence in society in the cause of virtue and truth."

A fortnight later Mr. Nicholson was desired to enquire if Mr. Roscoe had received the poem. In her next letter Mrs. Browne enclosed two others from one of her soldier sons, which she wanted her mother and sisters to read: "I entrust them to you," she says, "as they may lose them, and I wish to have them returned." On September 22nd she wrote to Mr. Nicholson:—

> "As you always express an interest in Felicia's compositions, I have copied for you a piece she lately made ('The Angel of the Sun') which is one of her great favorites. The subject is quite original and I am sure its sentiments will accord with your own. Your approbation of 'War and Peace' is most grateful to its Authoress. I certainly must think it a wonderful production, and I am anxious to hear from Mr. W. Roscoe respecting its publication as he promised to take upon himself the measures for that purpose."

In December, 1809, Mr. Nicholson had a visit from George Browne, who had returned from the wars wounded and disillusioned, and being temporarily out of conceit with a military life, was looking for civil employment. This gave Mr. Nicholson an opportunity of trying to check Felicia's military ardour, or rather her expression of it in poetry.

> "What our young heroine will say [to her brother's change of career], I cannot tell. But I think his measures and her own disappointed hopes of victory will operate more powerfully than any preaching to convince her that politicks are unworthy of her Muse. I will explain my meaning. The 'England and Spain,' 'The Call of Liberty,' 'The Wreath of Loyalty,' and the 'War and Peace' are all wonderful Poems, and especially in the first and last there are most interesting passages which will always be admired and enjoyed; but I must own my fears that many of the personal and temporary allusions will not add to their interest when the passing scenes are faded and the charming Author is more known. In my opinion 'tis on the cultivation and expression of the tender sensibilities of innocence and nature—the sympathetic feelings and descriptions of afflicted virtue,—and the conscious possession and glowing raptures of Affection and Piety that her talents will still shine brightest and that her own delight will be secure. 'The Silver Locks,' 'The Lamenting Mother and Daughter' in the 'War and Peace'—and above all 'The Angel of the Sun' affect and interest me. There are very great beauties of invention which happily introduce the finest ideas in most melodious language. 'The Invocation to Futurity,'—'The Address of Celestial Mercy and Angelic Love' and that of 'The Angel of the Sun' with all the delicate moral and pious applications which result, will one day meet with their deserved admiration. But 'tis as well perhaps that

this for the present should be postponed. Meanwhile perhaps she will think it best to avoid rousing the passions by declamation and to persevere in interesting descriptions and undisputed Morals and in captivating appeals to the heart and affections. She must make us better before we can admire as we ought her best works. I don't know whether I should allow any young man to say these things to herself; yet she has deceived an old one if she is not out of the reach of Injury."

At the same time Mr. Nicholson replied to one of Felicia's letters which has not been preserved :—

"I rejoice with you, my dear Miss Browne, that your brother George is safe and well here, and that your anxiety on his account in future is likely to be lessen'd. It was my intention when first I saw him to write to you by him a long letter; but the pleasures of his society and other matters have put it out of my power. Not that I perceive any irregular luxuriance 'to be temper'd in the wild enthusiasm of fifteen' now happily *attained to sixteen!* or any 'improvement' that it is in my power to bestow. I have had a rich feast in your letter and the productions of your Muse. Heber's Poems which you mention I have not yet got to see; and Mrs. Carter's Life I feel fresh desire to read because of your warm admiration of her character."

Then he goes on to tell that he had recently read 'Coelebs', "a jumble of good things," though he deplored the author's "degraded idea of human nature." Writing to Harriett at the same time, Mr. Nicholson says :—

"As I have let your Brother into some of my secrets I may as well tell you and get you on my side to plead forgiveness from your Sister for having copied some of her Poems into a book of the same size of her printed Works. I shall not suffer them out of my sight, and if you do not gain forgiveness for me, I must some time lay the sacrifice at the Author's feet."

The book to which Mr. Nicholson refers is now in my possession.

When George Browne went to Bronwhilfa after seeing Mr. Nicholson, he had fully resolved to break with his military life. His mother reported to Mr. Nicholson that "Our young heroine is amongst the first to rejoice in his resolution, to avail himself of an opening for something more advantageous, than even the highest rank in the army could promise, and her thoughts are now occupied upon subjects very remote from the passing events of the day." Mrs. Browne was of opinion that Cadell and Davies were keeping back the sale of "England and Spain," as "it does not appear that they have disposed of a single copy," and she urges Mr. Nicholson to help her in disposing of the copyright of some of Felicia's poems, and she also desires him to buy her the 16th of a lottery ticket. Felicia, she says, "will tell you herself . . . . how much she is gratified by your good opinion of her, and how highly you honor her effusions by thinking them worth taking the trouble of transcribing. The more candid you are in your remarks, the more valuable to her will be your correspondence, and I only wish we were so situated, that your young friends would be able to avail themselves of your preceptive and practical lessons in morality and all goodness, to a greater extent than can now be the case." Felicia's promised letter is missing, but there is one from Mrs. Browne, congratulating herself that George Browne had, after all, decided to remain in the army. "I have such a dread of mercantile undertakings, from having experienced the horrors of a failure in them, that I own I should feel less anxiety from his continuing in the army, than from his entering into large engagements. These are my sentiments from conviction, though I own I was, at first, a little dazzled by the offers made him." On 15th January, 1810, Mrs. Browne thanks Mr. Nicholson for sending her a copy of a criticism of one of Felicia's works, and in March she was again asking his services in connection with the sale of copyrights. There followed an "obstinate silence" on Mr. Nicholson's part, probably he was ill, which Mrs Browne tried to break by sending him a short letter on 15th July, enclosing a copy of Felicia's poem on "The Statue of the Dying Gladiator."

Shortly afterwards followed a personal meeting between Felicia Browne and Matthew Nicholson. Mr. Nicholson had neglected many invitations to visit the Brownes, but in 1810 he made up his mind to visit North Wales again, and to call on the Brownes.

That he should so far depart from his accustomed routine of life was due to the fact that his niece, Bessy Hatfield, of Manchester, was ill, and was ordered to Abergele. Mr. Nicholson escorted the invalid. The visit was a long one. The journey from Manchester to Abergele took four days. On the way to Abergele the party called at Bronwhilfa, and found only Miss Wagner at home. Early in August, Mr. Nicholson again went there, "and found Mrs. Browne and Harriett got home, but was again disappointed in not seeing Miss Felicia, nor have I since heard if she be returned from her excursion." Writing to his brother, he says, "It will be a great mortification to leave the Principality without seeing its greatest ornament! Her situation at Gwrych was highly favorable for the cultivation of the imagination, as well as the mind and understanding. I have frequently walked round it, almost with the devotion of a lover—nor have I ever seen the windows of her study without painting on my mind the ideal image of her person, old as I am!" He was not, however, to be disappointed. On August 13th he visited the Brownes, and saw Felicia. The quotation just given will indicate the spirit in which Mr. Nicholson was prepared to meet the poetess, although he had not then seen her. When he had made her acquaintance he seems to have fallen in love with Felicia, but it was love tempered by more common sense than one usually finds when an old man falls in love with a girl in her teens. Whether he told his love to Felicia I do not know, but he told his sister later that if he had been twenty years younger he would have married Felicia. Of his own impressions of Felicia we have no contemporary record, but his niece paid a visit to Bronwhilfa, and has left the following account :—

"We were shewn into Mrs. B's Tea room which was ornamented with drawings, there was a pedal Harp, and a Piano Forte, which was open. Mrs. B—. first appear'd and received us in a very friendly manner. Next came Miss W. and Miss Harriett B. and last of all the lovely and interesting object of our visit, Miss F.D.B., came into the room, and with perfect ease engaged in the conversation, which was supported in a most lively strain by her Mother. Having heard of Miss Browne's musical powers, we requested to participate in the gratification our friends had received when they visited Br—a and after my Brothers had arrived and Mrs. B. had tuned the Harp,—her daughter F. vibrated its strings and accompanied by her sister on the Piano, played delightfully. She complied with our request to sing, in a voice remarkably sweet and powerful. Her countenance glowed with an expression the most heavenly ; and to be in the presence of a figure altogether *Angelic* seemed like a vision of fancy rather than reality,—for it is impossible for the imagination to picture an *earthly* being half so lovely. After having passed two delightful hours with this engaging family we quitted Br—a with true regret, taking a friendly farewell of all."

After Matthew Nicholson's visit to Bronwhilfa, there was a break in the correspondence, which was reopened by Felicia.

"Bronwhilfa, 4th Dec., 1810.

My Dear Sir,—

I know not whether I ought to begin in so affectionate a manner, considering the reason I have to be justly offended at your neglect of the promise you made respecting our future correspondence. I had the vanity to flatter myself, after the few, but agreeable and instructive hours I had the pleasure of passing in your society, that you would not soon forget me ; but, alas ! I have the mortification of perceiving this is not the case, and can only regret my want of power to make a stronger impression on your *faithless memory*. However, I am determined to make one effort at least, to refresh your imagination and my wishes will be fulfilled, if these lines recall to your mind one whom you have honoured with your friendship. You may be assured, my dear Sir, that if I do not hear from you in a *very* short time, I shall set you down in the list of *inconstant swains:* and I think if this terrible *anathema* has no effect, I must give up all hopes of success, so I will say no more upon this subject.

I believe I must remind you of the eagle's quill you promised me; I have long expected it with impatience, and my Muse having been rather languid for some time past, it would certainly be very à propos at present, and I will send you the first poem I write with the *pen of Inspiration.* I believe it is since your visit at Bronwhilfa, that I have been delighted with the perusal of Scott's 'Lady of the Lake.' I have the presumption to differ from many established critics in preferring it to his former writings; but it is, in my opinion, adorned with all the striking beauties, as well as free from the leading faults, which distinguished those performances. It interests the heart, and appeals to the feelings, much more forcibly, and its descriptive passages are less obscured by those legendary allusions which fatigue the reader of 'Marmion' and the 'Lay.' It is much to be regretted that a Bard so endowed with all the characteristics of true genius, with enthusiasm, fancy, and tenderness; should so far pervert those exalted gifts, as to employ them only in the decoration of some fantastic legend, some obsolete tale of 'Border chivalry,' which only answers the purpose of an hour's amusement, and leaves no impression tending to excite a virtuous wish, or a noble emulation. When I speak of his *perverted* powers, I do not wish to confound him with the Anacreons of the day, who employ all the fascinations of elegance and talent, to array Vice in the most enchanting colours, but surely all gifts, when not devoted to their true end, are perverted, and therefore he is *negatively guilty.* I have also read Campbell's 'Gertrude of Wyoming,' and was much pleased with its beautiful simplicity, though I should have admired it more had it been by any other Author, for we are led to expect so much from the Poet who could write the 'Pleasures of Hope,' that the reality must ever fall below our sanguine ideas. I am beginning to think it is a great misfortune to have a too vivid imagination, as when compared with its brilliant illusions, life with all the sad truths of experience, appears a scene of the most monotonous insipidity. I have learned, in *theory* at least, that it is necessary to prune the wings of fancy, if we would prevent her excursions making what is only tame and uninteresting, appear *insupportable.* How I shall practise this lesson, I cannot decide, as it is one very repugnant to the feelings of your

much indebted and

affectionate young friend,

FELICIA BROWNE."

The reply was prompt. On 21st December, 1810, Mr. Nicholson wrote to "My dear Felicia," and made full apologies for his neglect.

> "You know not what a terrible thing it is to be overwhelmed in debt—you who are in the habit of conferring favours! When I look back and find not a trace of one word written to you this whole year, I can scarcely believe myself to have been so ungrateful and am quite ashamed to plead the apologies which have at times satisfied my idle inattention. But the gentleness of your rebuke has roused me to an assertion of the truth in the main point of our quarrel. Indeed, indeed I have never forgotten you, nor since the 13th of August has a day passed without interesting recollections of what I then saw and heard. The smartness of your raillery convinces me that you cannot be seriously offended and that though you have nothing to be forgiven, yet you have learned to forgive others. The next thing I can do towards deserving your pardon is to fulfil, as well as I can, the promise I believe I made to send you some account of the Exhibition of Paintings, &c., upon the opening in August last of the Liverpool Academy."

This he proceeds to do at considerable length. This letter was "sent unfinished by Mr. George Bainbridge, 21st December, 1810, with an Eagle's quill, and Lord Byron's Satire on 'English Bards and Scotch Reviewers,' both for F. D. B., and also a letter to Mrs. Browne, and another to Harriett Mary B." A letter to Mrs. Browne also refers to the visit.

> "Permit me then to offer my best thanks for your civilities and for introducing me to the acquaintance of your daughter Felicia.
>
> I have now distinct ideas of your domestic proceedings and your surrounding scenery, and whenever I walk on the hill at Everton, which I do almost daily, I have little but a mortifying distance to intercept my sight of your sweet *wood Nymphs* which I think is a name of your suggesting. The cordiality of Felicia's reception and Harriett's very kind recollection of me have left very vivid images on my mind and interest my best feelings. I was lately much grieved on hearing that Robert Boardman my Nephew had passed through St. Asaph to a ship on shore near Rhidlan without my knowing it, and I was almost angry when I found on his return that he had recollected your living at Bronwhilfa and had not sent to know if you could acquaint me that you were all well. . . . I fear Messrs. C. & D. are not to be roused in the cause of your publications. I do not often see Messrs.

Roscoes but I omit no occasion of introducing the subject to them. They expressed great admiration of the poem on the Statue of the Dying Gladiator, but Liverpool has been so convulsed of late by mercantile derangements as very generally to allow no interest in other subjects."

Then follows a copy of an "ill-natured criticism" of Felicia's poems, which had appeared in the "Annual Review" of 1808. The reviewer acknowledged that "the flow of verse was admirable," that the writer had "an excellent ear," but he thought that "for the present her partial friends would do more wisely in exhorting her to read than in tempting her to write." Mr. Nicholson was grieved to think that this criticism had appeared in a review of which the editor was Arthur Aikin, the nephew of Mrs. Barbauld. But it made no difference to his appreciation of Felicia's poems. "For my own part," he says, "I receive fresh delight on every perusal of your daughter's compositions. The melody of the verse captivates on the first perusal, and it is only on often reading them that one finds fresh beauties in the natural and feeling flow of thought, and the correctness of epithet and language, and their perspicuity is singularly characteristic. If we are partial do we not admire the same sort of beauties in some of the poems of Campbell, Rogers, and Pope?"

The unfinished letter to Felicia was completed on 1st January, 1811.

"MY DEAR FELICIA,—

Mr. Bainbridge would tell you he found me employed in writing to you when he called to announce his immediate departure at least from this neighbourhood, on as stormy an evening as I ever remember. That circumstance induced me to trouble him then with conveying to you even the progress I had made. So I bundled together, a letter to your mother, and parts of two to Harriett and you along with a catalogue of the Liverpool Exhibition of Paintings the whole surrounding and I hope safely guarding that Eagle's quill which I promised you and which you have led me to hope shall communicate the effects of its inspiration. You should know, it fell from the wing of a *free American Bird*; and you will perceive that it was the choicest feather which it had to send you: and for anything I know to the contrary it dropped on the 25th September, 1793. I leave it to you to trace that association of my ideas which induces me to tell you I have this day read in the American President's Message to Congress on the 5th December his recommendation that there be instituted at its seat of government a *National Temple of Science*. Whilst the old world is quarrelling about shades of difference the new one seems studying to allay 'jealousy and prejudice, to beautify the features of national character and to extend social harmony.'"

The remainder of Mr. Nicholson's letter relates to recent publications of Byron, Campbell, and others. Felicia was "much oppressed with a bad cold," and did not immediately reply to Mr. Nicholson. Her mother, in a letter to Mr. Nicholson on 26th January, 1811, wrote of the effects of the criticism which he had copied for her, and which she had evidently communicated to the daughter.

"An ill natured person might say it [the criticism] proceeded from envy. It certainly has had the effect of checking Felicia's enthusiasm for poetry, which I rather regret, as I know her genius to be equal to anything she might undertake. Mr. Heber, the author of 'Palestine,' has read her poem of 'War and Peace' the last week and bestowed much unqualified praise upon it, even comparing it with the 'Pleasures of Hope' of Campbell."

Writing to Harriett, 30th January, 1811, Mr. Nicholson says:—

"I have lately been honour'd by an addition to my poetical acquaintances for which I am indebted to your sister. Her volume had been ordered into our Lyceum circulating Library and merely from similarity in size there was attached to it in order to save expence a poem by the young Lord Byron and of a very different character without his name to it. To gratify the zeal of my new friend for your Sister's honour and to form a more appropriate connection I have made interest to have the 'England and Spain' put in the place of this Lord's '*Epistle on Gas-lights*'; which, however, is a witty production, but calculated for a different class of readers."

The "poetical acquaintance" was Edward Ward, and Mr. Nicholson enclosed with his letter to Harriett, a "tribute to the genius of Felicia," anonymous, but written by Ward. Felicia was evidently interested. Her letter in reply is missing, but we get an idea of its contents from the draft of Mr. Nicholson's reply.

"Liverpool, 23 February, 1811.

MY DEAR FELICIA,—

I do not know why it should exclusively be termed feminine curiosity to desire to know to whom we feel obligation, however in the case to which I allude I think yours very natural. You are too generous to make terms, or you might have conditioned that the author of the Lines addressed to you should be intitled to a copy of your charming 'Call of emulation to genius' on permitting his name to be made known to you. You solicit this communication from me, and it is painful to keep you in suspense; but I have not that liberty yet; and I will tell you probably why. As you say that the 'Call' is part of an unfinished poem (though I cannot perceive it to be so) it occurs to me to ask you previously whether that is not a reason why you should withhold the copy of it at present. I have other reasons for not having obeyed your commands. The author of the Lines has resolved and re-resolved to drop his acquaintance with the muse; now I am not a little fearful that this 'Call' would overpower his resolution; and above all as he has enter'd into the Army I should be sorry to aggravate your anxieties. If these are frivolous objections, let me know, when your orders shall no longer be delayed to be executed, and your curiosity may probably be gratified. I understand that this young gentleman was first intended for trade, then for the Church, and now he is in the Army. He appears qualified to make a figure in any profession he adopts—he has shown his literary taste! That taste, and your 'Call'! how could they be resisted?

Your aunt has tantalised me by a sight of your three translations from the Italian. She will tell you herself how highly she applauds them and we all must admire them in their English elegance. Mr. Roscoe also having translated the sonnet by Lorenzo I have annexed a copy, which I don't believe you have seen. I suspect the English language is as musical as the Italian. Mr. Roscoe I see has arranged the rhymes in the same order with Lorenzo's. I doubt, and I think you do also, whether our language will bear such scattered tones. Nay, my ear condemns that formal imitation. The sound of his eleventh line was dead before the fourteenth was struck. I rejoice with you on the return of Spring, yesterday was a delightful one here; but the times are dismal in the extreme and I lament they have reached your neighbourhood. Harriett has made my curiosity very anxious. Thank her for her well-filled slip of paper. Present my kind regards to each of the ladies and reply immediately if in only three lines to your friend and obliged humble servant."

Felicia's reply to this letter, though missing from my collection of letters, is fortunately not lost. It found its way, no doubt after its recipient's death, into the papers of my great-uncle, Dr. Shepherd, of Gateacre, and is now the property of Manchester College, Oxford.

"Bronwhilfa, 2nd March, 1811.

My Dear Sir,—

The certainty of a speedy private opportunity, has induced me to delay my compliance with your request of writing immediately. You will perhaps call me a little, or rather *not* a little, *pertinacious*, when I reiterate my desire that the lines I last transcribed for you, should be presented to the Author of the gratifying address to me. You have yourself very kindly furnished me with an excellent excuse for my inquisitiveness; by saying that the desire of knowing to whom we are under obligations, is very natural. Now, do you know, my dear Sir, that I suspect you have delayed fulfilling my *injunctions*, and satisfying my curiosity, to show yourself as great an Adept in the *Art of teazing*, as we must all acknowledge you to be in that of *pleasing*! but let me just give you a friendly hint, that the *latter* is so much more difficult to attain, and affords a triumph so much nobler, *when* attained, that those who have arrived at a certain degree of excellence in this accomplishment, ought to look down upon the former with contempt. This is not your case, I *must* say; otherwise what occasion to inform me the *poetic Incognito* was a *Soldier*; a circumstance, above all others, calculated to increase my inquisitive spirit, as you know my decided predilection for everything *military*. But now, to be a little serious, why should you be *fearful* that my lines might overpower his resolution to desert the Muses? I by no means approve of his ingratititude, and as a Soldier must unavoidably have many leisure moments, when not occupied by the duties of his profession, I cannot imagine how they could be better employed than when devoted to the cultivation of a literary taste. This taste (setting aside the idea that it improves the heart and meliorates the passions, whilst it refines the understanding;) may *at least*, preserve its votary from the temptations which Dissipation offers to the vacant mind of Idleness. You say to me '*that* taste, and *this* 'Call,' how could they be resisted?' Now, my dear, provoking Mentor, let me know but *one* good reason, why they *should* be resisted, and I will silently acquiesce in the decrees of your superior discretion. But if this is *not* the case, and you are *obliged* to confess that I am the victor, I shall expect your next letter to be *satisfactory*, and to inform me that my mandates have been as punctually obeyed, as those of the Grand Signior, or the Great Mogul! I thank you for transcribing me the sonnet from Lorenzo;

it is elegant and correct, but I am of your opinion, and should prefer it if Mr. Roscoe had deviated from the original in the arrangement of his Rhymes. I am now reading his Lorenzo for the first time, and of course I am highly gratified. With the poetry I am delighted, and we may frequently pause in suspense, whether the palm of merit is most due to the Bard or his Translator. I cannot entirely coincide with you in the idea, that the English language is as musical as the Italian—the former *may* be polished into harmony, the latter can never deviate from it. But to compensate for its superiority in this respect, I think we have greatly the advantage in energy, which is surely a more noble characteristic than sweetness.

The late storms would have occasioned us much uneasiness on George's account, if we had not had the satisfaction of a letter from him dated Torbay, where the transports had been driven by the violence of the weather. We are anxiously waiting to learn the arrival of our gallant soldiers in Portugal. But the Spanish Campaign cured me of my enthusiastic expectations, and I am not at all sanguine as to the result of this. I hope you will favour me with a long letter by Mr. Bainbridge whose return will then be highly welcome to

your much obliged

affectionate young friend,

FELICIA DOROTHEA BROWNE."

To this letter Mr. Nicholson replied :—

"Liverpool, 13th April, 1811.

MY DEAR FELICIA,—

Your orders I have more cheerfully executed than ever Eastern Slave obeyed the Command of a Tyrant—for the service was voluntary. Your arguments are irresistable. But the fact is that you, my new acquaintance, and myself, thought much alike on the subject—the difference between us only arising from the terms of the proposition. He maintained that he should have not a minute's leisure for the next seven years from the immediate studies of his new profession—thus warmly has he entered it ! However, the result, I hope, will be the active cultivation of all those good qualities which you so charmingly pourtray. For I could not secrete the possible influence of such powerful pleadings ! An immediate consequence has been that the gentleman has requested me to present you with copies of two odes written in June last, on *His Majesty's Birthday*, and on *Friendship*, with *his name annexed*. This gentleman, Mr. Edwd. Ward, now in the 4th of Foot, is son to Mr. & Mrs. Robt. Ward of St. Ann St. here. Mrs. Ward's name was Miss Eliza Chadwick whom possibly your Mother and Aunt are acquainted with. She enjoys but delicate health, and I lament, in spite of your heroism, any circumstance that must add either to her or your solicitude. To teaze you with expectation would have been inconsistent with this sentiment, and I hope you acquit me of such design.

Mr. Roscoe was greatly pleased with your translations and I should be glad to hear that he had written to you on this subject. I believe he did not think himself at liberty to 'deviate from the original in the arrangement of his Rhymes.'

I should have written by Mr. Bainbridge the last time he was here had I known his stay would be so short and now I have but little time and can barely thank you for the two sonnets he brought me. That by Angelo I suppose you allow is highly poetical and that of Carlo Maria Maggi is finely moral; but I do not see the propriety of the epithet 'vain' as applied to life, it does not suit our opinion that this life is a school of education. Fearing to miss the opportunity I must beg you to accept the thanks and good wishes of yours,

M. N."

Two letters from Felicia are missing, but two of Mrs. Browne's help to fill up the period and to illustrate the financial aspect of juvenile poetry.

"My Dear Sir,—

When Felicia had the pleasure of giving you a few hasty lines by Mr. Hobson, she promised you the copy of a poem she was then beginning and I have now an opportunity of sending it. ('Domestic Affections'). She has been much troubled with an ugly cough and a pain in her side lately, which has given her friends a little anxiety; but a blister, and taking the Iceland Moss have been of great service, and our good and dear friend Miss Foulkes came for her last week, to breathe the pure air of Eriviatt, from which, under Providence, I am sure she will derive every advantage. I promised her, before she left me, that I would copy this poem for you. When you have read it, if you approve, it would be doing her a favor to show it to Mr. Roscoe, and if he thinks it deserving public notice, it would be an act of great kindness to Felicia and me, if he would interest himself to dispose of the copy-right. I should think 'War and Peace' with some of her best smaller pieces might be worth the attention of Cadell and Davies or some other eminent bookseller, to be printed without her name. I am very fearful of asking such a favor of Mr. Roscoe, but I am quite a novice in such a business, and though I am convinced her genius must, in time, shine forth and overcome every illiberal attempt to keep it down, yet my circumstances are such, at *this present time*, that they make Felicia very desirous to counteract their depressing weight, by employing the talents she has been endowed with, for the good of her family. She is surrounded by admiring friends, to none of whom I can open my mind as to pecuniary matters, and as I know Mr. Roscoe's philanthropy to be great, I think he may be induced, through your representation, to assist Genius in its laudable wishes. I cannot think Cadell and Davies have behaved with the least liberality, or made the *least* exertion in the sale of her two first publications. The time is as favorable now for 'England and Spain' as ever it was, and I should believe if they had only sent a copy to each of their correspondents, another edition of each work might have been gone through, instead of which a large property is lying like lumber in their hands. Do you think they might be roused to any exertion, or induced to become interested for Felicia? That they have the power I know very well, and perhaps Mr. Roscoe might have great weight with them, if he could be persuaded to be her friend with them. I know you will forgive my opening my mind to you, which my circumstances have induced me to. It is five months since I have had a line from Mr. Browne at Quebec, when he promised me a comfortable remittance, but I fear the calamitous times in England have spread their unpropitious influence to that quarter of the world, and under this impression, Felicia is anxious to evince that her genius has not been bestowed in vain. She could write in the stile of Scott, who seems to engross the public applause, but she does not like any subjects, but such as have a moral tendency and may stand the test of *time*. What strange people the reviewers are! I had a letter from a person lately who said she knew Dr. McKenzie, who reviewed one of Felicia's works, and says that when he reviewed it, he had not read it, but since he had perused it, and thought it delightful. I have sent you a letter from Tom and two late ones from Geo. to read, and when you have done with them, will you have the goodness to let my sister see them and return them to me, when you have a good private opportunity?

I am always giving you trouble, but your friendly zeal gives me unlimited confidence and I know by experience, that you delight in doing good; which is certainly the only thing worth living for.

At your leisure it will be a great satisfaction to hear from you, and with the united respects of all this family,

I remain, my dear Sir,

Your obliged friend,

F. D. BROWNE.

Bronwhilfa, 23rd May, 1811."

In a letter dated 10th July, 1811, Mrs. Browne, after thanking Mr. Nicholson for his "innumerable acts of disinterested friendship," mentions that she has at length received a letter, but no remittance, from Quebec. She then discusses the sale of the copyrights :—

"If the arrangement you mention, of disposing of the copyright of Felicia's productions, could be effected, it would be most acceptable to me, and whatever sum you think fair I shall be *perfectly satisfied with*;

only I should like a few copies of each work for myself, to be allowed me in the agreement. £200, I would not object to, *for the whole*, though the number of lines is so great; as the purchaser (who I should much wish to be Cadell and Davies) would take pains to establish the authoress's name and that once done, her pen is so rapid and so versatile, that I should then hope she might have the proud distinction of devoting her talents to the honor and glory of the Giver of them, by making them subservient to counteract the evil destiny of her family. It is no more difficult to her to write a poem, than to me to write a letter, and I do believe she could with ease, write twelve in a year of the length of 'War and Peace.' I need not say, that the sooner this arrangement takes place the greater will be the kindness, and if Mr. Roscoe could be induced to interest himself, it must have a good effect. I believe if he knew the anxious feelings of my mind, at this moment whilst I am writing to you, he would derive satisfaction from a successful interference in this cause. The poem called the 'Powers of Expression,' I know Felicia would not like to have published, as she thinks very poorly of it, but all the others you have pointed out are very proper for the selection and I have sent you copies I had by me of some others which might be chosen and particularly I could wish the 'Ode to cheerfulness,' 'The Memory of joys that are past,' and the 'Address to Music,' from some circumstances attached to the times when they were written. 'War and Peace,' Felicia thinks much too redundant and when she comes home, I will send you a corrected copy of it and I have now sent you another copy of 'The Dying Gladiator,' in which you will find two more lines, which she added when she copied it fairly out. *One* of the many sources of my present anxieties is, that my youngest son, sixteen years old and a very fine, spirited boy, was to have gone to his father in Quebec, with the first Spring ships, but I had not the means of his equipment, which almost appears a happy dispensation of Providence, who orders all things for the best. The army seems now to be the only path open to him and his oldest brother can get him a commission in a highly respectable regiment, if I can accomplish his outfit and therefore I would press the sale of the copy-right, as this regiment is now abroad and he is losing his time at home. Felicia does not return home until Monday next, when she will have been eight weeks receiving the affectionate attentions of all her inestimable friends at Eriviatt, which have restored her to health and spirits. The Friday in next week, she and Harriett go to Conway, to stay the remainder of the summer, but they shall both write to you before they go. Miss Foulkes will be my companion whilst they are away and if you, my dear, kind sir, would come and stay a few weeks with her and me, we should be so happy, and we would nurse you and let you follow your own pursuits as if you were at home. Do gratify us and give this plan a serious consideration.

We were *very much* pleased with Miss Hobson, her manner and appearance were such as to inspire me with great interest, and to make me wish she and my girls could be *friends.* Will you give my remembrance to all their party. Mr. Jones, who brought me your letter, seems a very intelligent man, and I liked his physiognomy *much*; I was sorry Felicia was not at home, as he expressed a great wish to see her. Harriett will be delighted with the sketch you have sent her and will thank you for it herself when she comes home. She is at Glan y mor, the little cottage close to the sea, near Gwrych, staying a few days with a friend of mine, Mrs. Middleton, who was much pleased with Miss Hobson, as was Mr. Jackson, the Vicar.

I had a very long and interesting letter from my dear George dated the 28th May, containing a very clear and unadorned detail of the sanguinary battle of Albuera and the subsequent operations of the army. . . And now, my dear Sir, I would say a thousand things expressive of *obligation*, *esteem*, *gratitude*, and *all* the feelings which at this moment are predominant in my mind, whilst I write under the deep impression I have of your unwearied assiduity and kindness to me and mine; but words cannot do me justice, and deeds are not in my power to show, so your own heart must tell you what a debt I owe, and whatever it suggests as due to you, you *may be assured* I am fully sensible of. I fear this letter will be hard to decypher but I am in great haste, for I have other letters to write, and if possible, I would also copy for you by this conveyance, 'The Dying Gladiator' and 'Wreath of Loyalty.' With the assurance of my esteem and gratitude, I remain,

my dear Sir,

Your deeply obliged friend,

and faithful servant,

F. D. BROWNE."

The next letter of Felicia's is one that wandered from its companions, but coming into the market I was able to purchase it.

"Bronwhilfa, 17th July, 1811.

I am much disappointed, my dear Sir, to learn that there is no prospect of our seeing you this summer, as I had indulged the expectation so long, that it almost became a certainty in my mind; and I am compelled to give up the idea, with more regret than I can possibly express. I am but just returned home, after a long visit in the Vale of Clwyd, where the kind attentions of my friends, and the change of air, have greatly contributed to the restoration of my health. I was for some time much indisposed, so as to be incapable of any exertion, but I am now quite recovered and intend to resume all my pursuits with more application than ever. Harriett and myself are going to

Conway next Friday and I shall take advantage of the picturesque scenery by which we shall be surrounded, to improve myself in drawing; as I am convinced that the practice of taking views from nature, is the principal way of acquiring that spirit and correctness, which alone constitute superior excellence. I have been reading lately the memoirs of Sir Joshua Reynolds, with his discourses to the Royal Academy, and I am so enthusiastic an admirer of the beauties of painting, that I derived both pleasure and instruction from the perusal. Will you assume a very good, grave *mentorial* face, and give me a long lecture, when I tell you I have also been guilty of reading a *Romance?* It is the 'Scottish Chiefs' by Miss Porter, and though I am by no means an advocate for *Historical* novels as they bewilder our ideas, by confounding truth with fiction, yet this animated authoress has painted her Hero, the Patriot William Wallace, in such glowing colours, that you cannot avoid catching a spark of her own enthusiasm, as you follow him through the incidents of the narrative. I am teaching myself Spanish, and find it much easier than I expected, but I envy all Latin Scholars, for the great facility with which *they* must acquire every new language, in consequence of an advantage from which so many are debarred. I regretted much that I had not had the pleasure of seeing the Hobsons as they passed through St. Asaph, it would have been very interesting to me to have had a long conversation about you; I am so *incensed* at your not visiting Wales this year that I am really half inclined to appear in person at your residence for the purpose of venting my displeasure, after which, I shall run away with you to Bronwhilfa, where the kindest welcome always awaits you. But I recollect that our approaching visit to Conway must render this fine scheme impracticable for the present, though you may depend on its being put into execution at some future time. I have not any new poetry to transcribe for you at present, as the only Pegasus I have mounted for some time past, has been a *Welsh Poney*, whose quiet even pace has been of much greater service to me, than all the vagaries of the former unmanageable steed. I do not doubt but the romantic scenes of Conway will breathe Inspiration, and from thence, my dear Sir, you shall receive the next poetic effusions of your ever grateful,

and affectionate young friend,

FELICIA BROWNE."

Meanwhile Mr. Nicholson was preparing a little surprise for Felicia. The fugitive poems which he had received from time to time were all carefully preserved and copied out, and in 1811 Mr. Nicholson arranged that they should be published for Felicia's benefit and without any risk to her. Mrs. Browne was acquainted with the scheme and was grateful. She also sent some further poems, saying, "I always give you discretionary power to make what use you please of these productions." In the same letter she writes, "Felicia has been studying the Spanish language with great diligence, and has made herself mistress of it, so that she can translate it and read it equally well with the French and Italian, and she is particularly pleased with it."

When Mr. Nicholson heard, probably from her Liverpool relations, that Felicia and Captain Hemans were engaged to be married, he sent his congratulations, and apparently made some enquiries about the fortunate man. He does not appear to have preserved a draft of his letter. Mrs. Browne replied on February 7th, 1812:—

"I must now, my dear Sir, expatiate with you upon a subject very near my heart and which all your words and actions prove you to have a most sincere interest in. I need not say that this relates to the future hopes and fears for my beloved Felicia, whose youth and peculiar frame of mind, make her naturally an object of my most anxious maternal solicitations on the present momentous occasion of her life. You will perhaps be surprised to hear that, young as she is, her present attachment has been the cause of much anxiety to herself and the object of it, for four years past; and perhaps I may say it has, in a great degree, alienated her mind from all delight in what the *world* generally calls *pleasure* and from every wish but that of domestic happiness. Though she is a child in years, yet her mind is so mature, that I think her quite competent to decide for herself, on a subject wherein she alone, is most deeply concerned; and as splendor and riches were never objects of any consideration with her (nor with me for her) I trust she has as much prospect of happiness with the man of her choice, and I hope, a competence, as can reasonably be expected in this state of probation. He is a man whose morals and manners are unexceptionable and in whom I feel an affectionate interest, very little (if at all) less, than in my own sons.

This will, I know, have great weight with you in the judgment you will form on this occasion, and I trust the progress of Felicia's genius towards perfection will not be impeded by the additional motive she will have to cultivate it and that the 'Domestic Affections,' beautiful as some of its ideas are, is but a humble pledge of what we are to receive from her future pen. She has been wishing to write to you herself, for some time past, but thought she could not do it without mentioning this subject and it was too delicate for her to touch upon. Now that you have spoken upon it, you will hear from her soon. I saw in the paper some time ago, that two thousand pounds would be given for the best translation of Lucien Bonaparte's poem of Charlemagne. Could you enquire where information respecting this could be had? It is a work for which Felicia's perfect knowledge of the French tongue and poetical genius make her quite competent."

Felicia's letter followed that of her mother, not "soon" but a month later:—

"Bronwhilfa, 12th March, 1812.

I must rely upon your indulgence, my dear Sir, to receive this letter with a *gracious* aspect, as I feel conscious, when I look at the date of your last, that my long neglect of it has forfeited all pretensions to such *clemency*. I trust, however, you will not consider my excuse as a superficial one, when I tell you, that I felt I should be deficient in what I owe to a friendship so zealous and disinterested as yours has been, if I wrote to you without mentioning a subject of the first importance to myself, and yet too delicate for me to introduce first. Now that this scruple is removed, I hope our correspondence will be more frequent, and be assured no change of prospects or situation will ever lessen the pleasure and improvement I shall always derive from your letters. You seem to think, my dear Sir, in your last letter, that my having 'concentrated my affections' will interfere with the pursuit of my favorite studies; on the contrary, as the object of those affections, (to whom they have been long devoted, with all the enthusiasm of a first attachment and an ardent mind;) will have delight in encouraging my progress, and will know how to appreciate excellence if I should ever attain it, I shall have in his approbation, an additional stimulus to exertion. Were you fully acquainted with him (which I wish you were,) you would feel satisfied, that the happiness of your young friend could not rest on a more secure basis than his worth and attachment; on which I rely with the most deserved confidence, for all that is to cheer and illumine my future life.

I have a particular desire to attempt a new style of writing, and think I should succeed in translation. Could you, or would Mr. Roscoe, recommend any poem in French, Italian, or Spanish, which you think would be desirable? I have so few books in any of those languages, that though I have acquired the two latter without any assistance, I am not sufficiently acquainted with their literature to know if they possess any work of merit which has not yet had an English dress. I hope I shall have the gratification of a letter from you shortly, and that it will contain a more favorable account of your health, and a free absolution for all my sins as a correspondent. We have had three very interesting letters from George, in the last of which he mentions you very particularly and desires his kindest regards. When you see my Grandmother and Aunts, pray give our united love to them, and believe me ever, my dear Sir, with the sincerest esteem,

Your obliged and affectionate

FELICIA BROWNE."

As no answer to this letter was sent, Felicia's younger sister wrote this note :—

"Bronwhylfa, 5th April, 1812.

MY DEAR SIR,—

Having but a short notice of the present opportunity, I have only time to say that my sister has sent two sketches of her own drawing, which accompanied by her kind regards, she begs you to accept. She hopes the bearer of this will bring her a letter from you in answer to that which she wrote to you a short time ago, and pray do not think me unreasonable in saying, that if you have leisure and inclination, I should also be happy to receive a few lines, as it is now some time since I have had that pleasure. I have only to add our united best wishes and to assure you that I am, my dear Sir,

your affectionate and obliged,

H. M. B.

We have also sent one of my sketches, and a pencil drawing of Felicia's."

Harriett's letter is endorsed "Ans. 8. April" and probably at the same date Mr. Nicholson sent to Bronwhilfa a dozen copies of the volume of Felicia's poems "The Domestic Affections," for which he had made himself responsible, and which had just come from the press. The gift brought an acknowledging letter from the author, and a much longer one from her mother.

"Bronwhilfa, 25th April, 1812.

MY DEAR SIR,—

Accept my best acknowledgments for the twelve copies of the poems, which were received yesterday. I am much pleased with the appearance and execution of the book, which are both extremely neat, and I think better chosen than those of the former publications. I feel much indebted to your partiality for the approbation you so liberally express, but as I have no *sanguine* expectations from readers or critics, at any rate their censure will not disappoint me, and I have so little of the passion for fame which renders authors so acutely sensible to the public opinion, that I am secured from much anxiety respecting the reviewers. I have always some fresh occasion to renew my thanks for your zealous exertions in my favor and I beg you will believe me sincerely impressed by them, and that you will also present my acknowledgments to Mr. W. Roscoe for the active interest he has shown in this undertaking. I regret much, my dear sir, that your health is so different from what all your friends would wish it, and wish you would try the experiment of a visit here in the summer. The change of scene and air might perhaps contribute to your recovery, and we should all exert ourselves to amuse you. When I tell you, that I am just recovering from an illness, which the Doctor calls an ephemeral fever, and which has left me very weak, and unfit for much exertion, you will I am sure, excuse so short a letter, and believe me, my dear Sir, with sincere respect and gratitude, your

much obliged and affectionate

FELICIA BROWNE.

When you see my Grandmother and my Aunts pray remember me affectionately to them all."

"MY DEAR SIR,—

Felicia's head not allowing her to fill up her letter, I must be her substitute. She made us all very uneasy the beginning of this week, for she was three days seriously ill, but thank God nothing now remains of her complaint but debility, which good nursing will speedily remove. Your noble *present* of twelve copies of the poems, was, indeed a high gratification to her, and enables her to compliment those friends immediately around her, from whom she has for years been receiving constant kindnesses. The book is a most eligible size and is printed with great accuracy; for I discover no mistakes, except those mentioned in the errata. I wish it may leave some profit and should hope that with your and Mr. W. Roscoe's kind exertions, this may be the case. The selling price I think a very fair one. How many copies have been printed? I wish we could see a second edition soon. I wish also that 20 copies might be sent to me here *as soon as possible*, either from London or Liverpool. I can dispose of them if they arrive soon and will you take the trouble to order them for me? As I do not communicate with Messrs. Cadell and Davies, I shall be much obliged if you will, when you write, or through Mr. W. Roscoe, desire them to send a copy to Miss Maynard, No. 6, Portland Place, Clifton, near Bristol, *carriage paid*, with Miss Browne's regards, and also another to Miss Blane, at Campbell Oliphant's Esqre., Cockspur Street, Charing Cross, with Miss Browne's remembrance. These are two very zealous friends, who can and will promote the sale. The former has introduced many of Felicia's manuscripts amongst the highest circles and will be very likely to have this work presented to the Queen. I do not know whether I should write to Mr. W. Roscoe to thank him for his exertions on this occasion. Perhaps it would be only intruding upon him, as he has not written to me, or Felicia and I wish to do what would be most proper, and I am sure my feelings would lead me to say a great deal to him. But I will not determine till we hear from you again. And now, my dear Sir, let me express all our regrets that your health is not so good as our best wishes towards you would have it. Do think seriously of trying this *air*, when the warm weather arrives. Every thing that grateful friendship could do, should be exerted by me and your two young friends, to contribute to your health and comfort and there is a certain young man of our circle, who would be happy to unite his zeal, to that of our family party, in showing kindness to Felicia's *invaluable and highly valued* friend. Do give us some hope that this little plan might be practicable and you will believe that it would delight us all. . . .

From what you say of Lucien's 'Charlemagne,' it must be a heavy work indeed and Felicia would not like it. But I wish something worth translating from the Spanish might occur. She has made herself mistress of that language and likes it much. . . We are impatiently expecting to hear from Quebec, after an interval of several months. Accept the assurance of best esteem, and believe me, my dear Sir,

Your deeply obliged and faithful

F. D. BROWNE."

Felicia recovered very slowly from her illness, but in May, 1812, she and Mr. Hemans were interesting themselves on the result of a joint speculation in lottery tickets. The last letter I have of this correspondence is dated 5th July, 1812, and is from Mrs. Browne.*

"MY DEAR SIR,—

Felicia begs you to accept a copy of the lines she has lately written to Lord Wellington and she hopes to hear from you by the bearer. The long expected letters from Mr. Browne are at last arrived and I suppose that a certain event will take place in about a month, or five weeks. On this occasion I am sure you will give your best wishes for your young friend, and I hope the same regard you have hitherto shown to her, will be continued *for ever*. Your friendship has always been a source of pride and gratification to her. Of the young man of her choice I can only say, that he has my *perfect* esteem and regard

* My brother, Mr. Albert Nicholson, has two letters written in 1816 by Harriett Mary Browne, and addressed to Mr. Matthew Nicholson. Apparently Mr. Nicholson had reopened the correspondence by writing to Mrs. Hemans, commending her hymn 'Lord, from my Closet, when alone,' and suggesting that it should be set to music. Harriett had taken the hint, and, in replying for her sister, sent Mr. Nicholson a musical setting for the hymn. His quick and critical eye or ear had detected the omission of several C sharps, and he wrote to Harriett, who replied acknowledging the justness of his observations, the marks having been accidentally omitted from the copy. She mentions that Felicia "is much flattered" by his approbation of her poem.

BRONWHILFA IN 1812.

From a drawing by Captain Hemans, in the possession of Manchester College, Oxford.

Face p. 39.

and that I know no one whose disposition and peculiar turn of mind are so framed to make her happy.

It was much my wish to have named you, my dear Sir, as the trustee for her, in her little settlements, but I feared your time of life and delicate health, might make you object to it, otherwise such an arrangement would have given me great satisfaction.

I think her genius develops itself every day and I hope we may see it gradually attaining perfection. I have most gratifying accounts from both my sons in Spain. Geo. is quite recovered and has again joined the Army. Your little friend Harriett is taller than Felicia, and is everything I could wish, devoting herself assiduously to the cultivation of her mind and making herself universally beloved. Should there be an American war Mr. Browne will send Claude to Europe again that he may enter upon the profession of his brothers. I hope in a little time, to have it in my power to remit you the seven pounds for the twenty copies of 'Domestic Affections' which you took the trouble of sending me. My sister would tell you why I could not do it before. Do you think Mr. W. Roscoe received my letter? I never had the pleasure of an answer from him. We all unite in kind regards to you and in our best wishes for your health and appearance here, this summer. Believe me, my dear Sir,

Your much obliged friend,

F. D. Browne.

Will you have the goodness to give the packet to my sister.

I have sent you a little drawing of Bronwhilfa done by Captn. Hemans, from nature."

Mr. Nicholson was a sensible man, and though he had apparently fallen in love with Felicia, he knew he was too old to be her husband. But it must have been a great shock to him to be told that he was too old even to be a trustee of her marriage settlement!

After all, Felicia would probably have been quite as happy if Mr. Nicholson had become her husband, despite his twenty years too many.

Felicia married her gallant Captain, and after a few years parted from him for ever. She was only 41 when she died. Matthew Nicholson died in January, 1819, aged 73.

PLATES.

Manchester Memoirs, Vol. liv. (1910), *No.* **10**.

X. A Hypothesis as to the cause of the Autumnal Epidemic of the Common and the Lesser Shrew, with some Notes on their Habits.

By Lionel E. Adams, B.A.

Received January 28th, 1910. Read February 8th, 1910.

The "autumnal epidemic" of the shrews has been a standing puzzle to naturalists for a long time. It does not seem to be generally known that, though the autumn is the time when these little creatures are found dead in the greatest numbers, their corpses may be found at any season of the year. During the winter months they die from hunger, cold, or attacks of enemies; in spring sexual conflicts lead to many deaths; in summer drought is often, I believe, the cause of much mortality, and also at this season many inexperienced young die from various causes. At the end of July, 1906, I found many dead on the roads, and I supposed that a prolonged drought accounted for the mortality. At this time the Shrews, Bank Voles, and Long-tailed Field Mice all seemed to have deserted a certain locality, near Reigate, where they were usually plentiful. During this period there was very little dew at night, and I think the little animals left the place in search of water. Mr. J. G. Millais with reference to this point says:* "Scarcity of food may account for it, but not drought, for in places where Lesser Shrews are abundant I have found many dead, while pools of water lay around in every direction." This instance, however, merely tends to show that these particular individuals died from some other cause, not that

* "Mammals of Great Britain and Ireland," vol. i., p. 147.

drought has no effect on shrews generally, and Mr. Millais writing to me on the subject says: "I have always thought that drought (creating absence of food necessary to shrews) was often the cause of the mortality." Such droughts, however, are only occasional and cannot be the cause of the persistent annual mortality.

I have made innumerable post-mortems of corpses found, and have often detected a wound, but in many cases I could find nothing to account for death, all the organs being apparently healthy.

It has been suggested that the corpses are those of animals killed and left uneaten, but if this were the case the killing would not take place in autumn more than at any other season, and wounds would usually be in evidence. So far as I know the wild animals which kill them also eat them, and perhaps owls account for the greatest numbers In a thousand pellets of the Brown Owl I found remains of 344 Common Shrews, 27 Lesser Shrews, and 21 Water Shrews, besides, of course, a multitude of mice, voles, &c.* Kestrels eat shrews readily. Our tame Magpie will eat shrews greedily if freshly killed, though it will not touch them if dead more than a few hours, and it has occurred to me that other scavengers find shrews—which become terribly putrid in a comparatively short time—too gamey for their tastes, and hence the numbers of dead ones found. I have often seen Weasels carrying off dead shrews across the country roads, and Mr. C. Oldham informs me that he has found a dead Lesser Shrew in a Weasel's nest.

Hedgehogs and Moles would probably eat them if they could catch them, and when they find them freshly dead; and I have heard of them being found in the

* Details may be found in "A Plea for Owls and Kestrels": *Journal of the Northampton Nat. Hist. Soc.*, June, 1898.

stomachs of Adders. Dogs will swallow them, but vomit them again, and cats are well known to kill but never to eat them. The number found dead, however, cannot all be put down to dogs and cats!

The male shrews fight fiercely, especially in the breeding season, when nearly all that are trapped bear wounds, notably on the tail. The females also show signs of conflict, their tails and feet being often quite denuded of hair and covered with bites. The fighting, moreover, is by no means entirely due to sexual quarrels, for the immature of both sexes bear the marks of teeth upon their tails, often within a very short time after leaving the nest. Immature individuals are found dead throughout the summer and autumn, owing to their lack of experience in obtaining nourishment and in escaping from enemies. This mortality of the young helps to swell the numbers found dead during the "autumn epidemic."*

I have found that during the winter shrews are to be trapped exclusively in the hedges, but after the beginning of May they mostly leave the hedges and frequent the long grass where they make their breeding nests. I may mention that Mr. Millais† was the first to draw attention to the ancient error, perpetuated through all the text-books, that the shrews spend the winter months "in profound torpor." Though they may be trapped freely during the hardest frost they have a great objection to wet. Neither are they solely nocturnal in their habits; they may be observed during the day time in dry weather at all seasons of the year.

* A similar loss of life may be noticed in the case of young Moles, many of which are run over by carts or meet with other disasters on the country roads and lanes.

† "Mammals of Great Britain and Ireland," vol. i., p. 164.

Of course, shrews may be found in coppices all the year round, though I think they often leave this cover to breed in the open fields, as I find that during the breeding season far fewer are caught in the coppices and hedges than in the rough patches of coarse grass in the open.

It is not known how many litters a single female produces during the breeding season, but it is certain that more than one are reared, as I have trapped pregnant females which had evidently suckled previously. In the case of the Common Shrew, I have examined four females with 8 embryos, two with 7, and one with 4; of the Lesser Shrew, one with 8, one with 6, and one with 5. As the breeding season lasts from the beginning of May till late in November, it would seem improbable that the same individuals continue breeding during the whole of this time; and in fact there is every reason to conclude that the breeding is kept up during the season by a succession of breeders coming into use at different times, since on July 5th and on November 21st of the present year (1909) I captured females, which, though recently impregnated, had not previously littered. The former showed only slight traces of conflict and the latter none at all, which immunity I have never observed with adults earlier in the season, and which I account for by supposing that adult competitors had died out—in which supposition I am supported by the evidence in the Table, column 3. (See pp. 12, 13.)

As winter draws on the survivors of the "epidemic" seek the shelter of the hedges and live in burrows. I do not think they often make burrows for themselves, but make use of those of mice and voles. By the way, it does not seem to be known exactly where they sleep in winter. One would imagine that they make nests somewhere in the burrows, but I have never been able to find any.

The Lesser Shrew may be trapped in the hedge banks throughout the winter, and so far as my experience goes, later into the spring than the Common Shrew. I think the former species keeps more generally to cover than the latter, though the presence of its skulls in owls' pellets shows that it must come into the open pretty freely. This species, though undoubtedly sporadic in England, is not quite so rare as is supposed. I have found it most plentifully in the neighbourhood of old woods and coppices, but as farmers and gamekeepers do not know it as differing from the Common Shrew, it is difficult to obtain definite information. Moreover, the Lesser Shrew is often overlooked by people who are aware of its separate identity, because they mistake it for the young of the larger species, especially when the tail has lost most of its characteristic hairiness during the breeding season. No mistake, however, need be made if measurements are taken of the head-and-body and of the hind foot.

The following Table may be of use. The measurements are in millimetres.

Species.	Head-and-Body.			Hind Foot		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Common Shrew	60	83	71·3	12	14	13
Lesser Shrew ...	49	62	56	10	11·5	11

As I have only found one Common Shrew so small as 60 mm., and only one Lesser Shrew to measure so much as 62 mm., the head-and-body measurement may be considered sufficient, but as people hardly ever make their own measuring of this part agree with that of another, the hind foot measurements, which never overlap, may be relied on to settle the question of identity. The comparatively longer and more hairy tail is by no means an infallible diagnostic character of the Lesser Shrew, as the length varies considerably in both species, and the tail of the young Common Shrew is as hairy as that of the Lesser; besides which, as I have mentioned, the tails of both species are often denuded of hair in the breeding season.

The Common Shrew is even when young a much more bulky animal than the adult Lesser; and the two being placed side by side need never be confounded.

It seems to have escaped notice that the coat of the young Common Shrew on quitting the nest is of the same brown tint as that which the other carries through life, but in a month or two this changes to almost black, first on the middle of the back, leaving a surrounding line of the original brown between the black and the light belly colour, and finally the black extends to the head and the whole of the upper surface. Thus young and old may be separated at a glance. I have had, however, one exception of an adult which retained the juvenile colour.*

The Lesser Shrew is supposed to be subject to the "autumnal epidemic," and I have no doubt this is the case.

For many years I have been in the habit of trapping small mammals, and recording details of measurement and anatomy. Glancing over these lists two years ago I noticed some points with regard to the Common Shrew which seemed to point to a solution of the problem of the

* Since writing the above I have seen the following remark by Mr. D. English in *Cassel's Nature Bk.*, p. 320:—"The Pigmy and the immature Common Shrew are often identical in colour."

autumnal mortality, and since then I have devoted considerable time to accumulating evidence for or against the theory which presented itself.

The facts which I noticed were these.

1. During and after December all specimens of both the Common and the Lesser Shrew were immature; and that from this time till early spring it was impossible to determine the sex of either species without dissection.

2. That during the same period all the females of both species were without exception sexually immature—the first exception not occurring till the middle of April. (As is the case with the Mole, immature female shrews closely resemble the males in outward formation.)

3. That the genital organs of both sexes commence to enlarge in February, and attain a remarkably large size in May and June. In the case of the male the development is relatively greater than even that of the Mole.

4. That the tails and feet of winter specimens were always in good condition, being thickly covered with hair, whereas the tails and feet of both species are often denuded of hair during the breeding season—almost invariably so in the case of the Common Shrew—apparently by the continual biting during the fights between the males and, perhaps, the capture of the females by the males. Possibly a summer moult may account for some of the loss of hair.

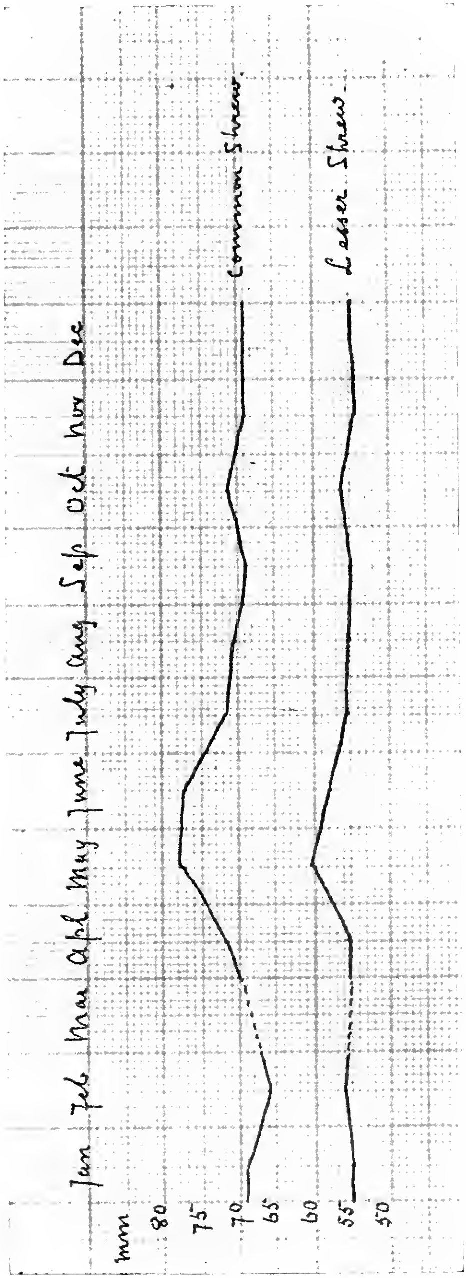
Now, what particularly struck me as curious was that during and after December females that had already bred should *never* be trapped, and that not a single adult male should be recorded; though I was prepared to find the male organs atrophied, as is the case of the Mole after the breeding season. I was at first disposed to regard the hairiness of the tails as due to the acquisition of a winter pelage, but considering the other evidence I am of the decided opinion that the original hirsuteness had never been lost.

These points being noticed the question naturally arose as to what had become of the adults. Clearly, if my series was sufficiently representative, and if my examinations of their internal anatomy were not faulty, the adults must have all died; and they must have died off as soon as they had done their part in the breeding season; or to state the matter in another and more startling form,—*the autumnal "epidemic" is due to nothing more than old age; old age in the case of the Common and the Lesser Shrew being reached in, roughly, thirteen or fourteen months.*

Considering the novelty of this proposition it occurred to me that, in spite of all my care, some at least of the seeming winter juveniles might really have been adults, that the hairy tails *were* clothed with a winter pelage, that the vaginas of the females *had* closed again after breeding, and that the genitalia of both sexes *had* atrophied practically to extinction.

Therefore, as a test that would either refute or confirm the points in doubt, I have drawn up from my records the following Chart showing the average size of the two species throughout the cycle of a year, month by month. In these I have taken the head-and-body measurements only as being most useful, neglecting the tail measurements which I found to vary independently of age, sex or season, and it will be seen that, judging by comparative size also, the winter specimens are immature.

In order to secure uniformity in the framing of the Chart I have compiled it entirely from my own measurements, as no two persons, unless accustomed to work together and check each other's measurements can be depended upon to give exactly the same results in



Jan Feb Mar Apl May June July Aug Sep Oct Nov Dec
mm
80
75
70
65
60
55
50
Common Shrew.
Lesser Shrew.

measuring the head-and-body,—one stretching the specimens more or less than another in the process.

I do not understand the low average of the Common Shrew as shown by the Chart for February, nor the rise in the average of both species in October, but probably if my series were large enough to be representative and taken from specimens from all parts of the country, this irregularity would be smoothed away; it may be that in the district where I have trapped I happen to have taken older individuals in January than in February, the older and stronger securing the food before the younger, and so getting trapped first.

But in considering the Chart with reference to the autumn mortality the most important point is the decrease in size as the breeding season progresses. Of course it is not to be supposed that the individuals actually diminish in length towards the end of the year, and it is plain that this decrease can only be accounted for by the fact that the young ones predominate more and more while the parent generation becomes less and less, until by its extinction the average is brought down to the level of the adolescents.

Further consideration of the Table (Column 3, Common Shrew), shows that the proportion of adults does dwindle as the breeding season progresses; the actual numbers of adults, 13, 10, 6, 0, 2, 1 are easily replaced by their representative percentages, viz., 61, 45, 31, 0, 11, $\frac{1}{4}$. In the case of the Lesser Shrew, the material is hardly sufficient to be worth considering. Though, so far as it goes, it bears out the statement.

It must be admitted, indeed, that the whole number of examples collated is insufficient for a positive generalisation, but, on the other hand, it will be noticed that the chart lines of the two species run almost parallel, rising and falling together at the most (for the purpose of this paper) important time of the year, *i.e.*, the breeding season; and the fact that I have found no exception to contradict the general conclusion is itself a most important point in its favour.

By the kindness of Mr. Douglas English I am able to reproduce a couple of his beautiful photographs of the Common and the Lesser Shrew.

COMMON SHREW.

	1	2	3	4	5	6	7	8	9	10	11	12
	Numbers measured.	Average length of Head-and-body	Number of adults.	Average length of adults	Number of juveniles.	Average length of juveniles	Number of ♂	Average length of ♂	Number of ♀	Average length of ♀	Largest specimen	Smallest specimen
January	23	69·8	—	—	—	—	10	69·8	13	69·8	75	65
February	21	66	—	—	—	—	11	67·6	10	64·4	75	60
March...	—	—	—	—	—	—	—	—	—	—	—	—
April	7	72·6	—	—	—	—	5	72·5	2	73	76	68
May	1	78	—	—	—	—	—	—	1	78	78	78
June	18	77·2	13	80·7	5	68·5	8	79·4	9	76·6	83	65
July	22	72	10	76·7	12	68	9	73·2	11	72·2	83	63
August	19	70·8	6	73·8	13	69·5	10	72·2	9	69·3	83	65
September	21	69	—	—	21	69	12	69·5	9	68·2	72	64
October	18	71·3	2	80·5	16	70·1	5	70	13	72	81	68
November	26	69	1	68	25	68·2	16	69·6	10	68·1	72	65
December	28	69	—	—	28	69	18	69	10	69	73	64
Total	204	71·3	32	77·3	120	—	104	71·3	97	71	83	60

LESSER SHREW.

	1	2	3	4	5	6	7	8	9	10	11	12
	Numbers measured.	Average length of Head-and-body	Number of adults.	Average length of adults.	Number of juveniles.	Average length of juveniles	Number of ♂	Average length of ♂	Number of ♀	Average length of ♀	Largest specimen	Smallest specimen
January	6	55	—	—	—	—	2	55	3	56·6	60	50
February	4	56	—	—	—	—	1	49	3	58·3	62	49
March...	—	—	—	—	—	—	—	—	—	—	—	—
April	4	55·2	—	—	—	—	2	52·5	3	58	59	50
May	4	60·5	4	60·5	—	—	2	60·5	2	60·5	61	60
June	1	58	1	58	—	—	—	—	1	58	58	58
July	7	55·7	2	59·5	5	54·2	2	59·5	—	—	60	51
August	2	55·5	1	56	1	55	1	55	1	56	56	55
September	1	55	1	55	—	—	1	55	—	—	55	55
October	3	56·3	—	—	3	56·3	1	58	1	55	58	55
November	5	54·8	—	—	5	54·8	5	54·8	—	—	58	52
December	3	55	—	—	3	55·5	2	55·5	1	54	56	54
Total	40	56	9	57·8	17	—	19	55·9	15	57	62	49

Fig. 1.

The Pygmy or Lesser Shrew (*Sorex minutus*).

Fig. 2.

The Common Shrew (*Sorex araneus*).

Photos by Douglas English.

XI. "Upper Liassic Reptilia. Part II. The Sauropterygia of the Whitby Museum."

By D. M. S. Watson, B.Sc.

Received and read March 8th, 1910.

The most important of the Sauropterygian remains in the Whitby Museum is the specimen which is the type of Blake's species *Plesiosaurus propinquus.*

This specimen bears the number 581 and is a nearly complete skeleton: it is unfortunately secured to the wall of a narrow room at a considerable height, and despite the facilities most kindly granted to me by Mr. T. Newbitt, I had some difficulty in examining it and my measurements are only approximate.

Measurements of Skeleton.

Skull	...	57	cms.
23 cervical vertebrae	...	100	,,
5 pectoral ,,	...	26	,,
28 dorsal ,,	...	138	,,
2 sacral ,,	...	9	,,
31 caudal ,,	...	110	,,
		440	,,

The Skull.

The skull is large, more than one-eighth of the entire length: it is considerably damaged, and no sutures are visible. On the left side the Squamosal, Quadrate, and Jugal to just behind the post-orbital bar are missing, and on the other side even this is broken away.

May 6th, 1910.

The anterior end is broken, but must have been rounded. There is a slight constriction of the muzzle, some 10 cms. behind the anterior end, behind which the sides of the skull slope outwards as relatively straight

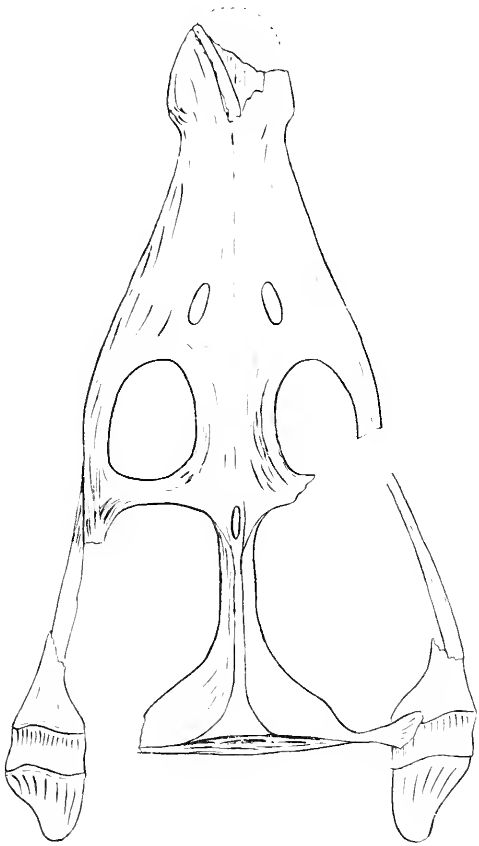


Fig. 1. Skull of "*Plesiosaurus*" *propinquus*. Dorsal aspect. × ⅛.

lines to the articulars of the mandible. The skull as a whole is depressed, though this may be partially due to crushing.

The surface is remarkably smooth, only a few rugosities being visible between the orbits and on the muzzle ; it is possible that this smoothness may be due to the development the specimen has undergone.

There is a slight but definite ridge running down the median line from between the orbits to the anterior end.

The cranium is strongly compressed from side to side at the anterior end, but widens considerably posteriorly to the parietal crest.

The pineal foramen is very conspicuous just behind the post-orbital bar.

There is a well-marked septum separating the temporal vacuities from the orbits.

The articular region and symphysis of the lower jaw are well preserved ; no characters of interest are presented by articular and angular, but the post-articular process is short and stout.

The symphysis is expanded and spatulate, and bears about four teeth on each side.

The very large teeth of the anterior end of the mouth are all damaged. An upper tooth completely shewn by the breakage of the premaxillae is over 7 cms. long, and lacks a great deal of the crown ; the crown where broken off is nearly 2 cms. in diameter. The crown is circular in section, and is covered with well-marked ridges. There are no visible carinae.

Measurements of the Skull.

Length	...	...	...	57	cms.
Width at	7	cms. from	anterior end	9·5	cms.
"	20	"	"	17	"
"	35	"	"	26	"
"	57	"	"	15	"

from middle line to squamosal.

Width of lower jaw across the articulars 38·5 cms.

Anterior end of anterior nares 20 cms. behind anterior end of snout.

Bar between nares 4·5 cms. wide.

Posterior end of orbit 35 cms. behind snout.

Frontal width 7 cms.

Length of orbit 9 cms.

Width of articular facet of the articulars 8 cms.

Antero-posterior length of articular facet 4 cms.

Length of post-articular process 5 cms.

Vertebral Column.

Cervicals. The atlas and axis are completely concealed by matrix, but the rest of the cervicals are fairly well shewn ; they are, however, set in plaster so as to conceal the lower parts of the centra.

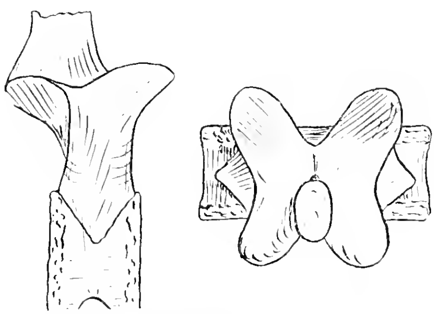


Fig. 2. "*Plesiosaurus*" *propinquus* 4th cervical, right lateral and dorsal aspects. $\times \frac{1}{2}$.

4th Cervical. This bone is rather well exposed, and is quite typical of the anterior part of the neck.

The centrum is 2·5 cms. long and 6 cms. wide, the height cannot be seen. Only one rib facet is visible, but a second is probably concealed by the plaster setting.

The ends of the centra bear a ring of roughened ornament.

The neural arch is very high, the pedicels being tall and rounded; the zygapophyses are large, directed more or less antero-posteriorly, and their articular facets are inclined to one another at a considerable angle.

The overall length of the vertebra over the zygapophyses is 4·5 cms., and the maximum breadth across the anterior zygapophyses is 5 cms.

The zygapophyses unite together forming a table similar to that of *Sthenarosaurus.* It is, however, less flat, much narrowed before the posterior zygapophyses, and shews a slight notch separating the anterior and posterior zygapophyses.

The spine is about 1·5 cms. long, and 1 cm. thick. It is broken off short in all the vertebrae in this region, but was probably never very high.

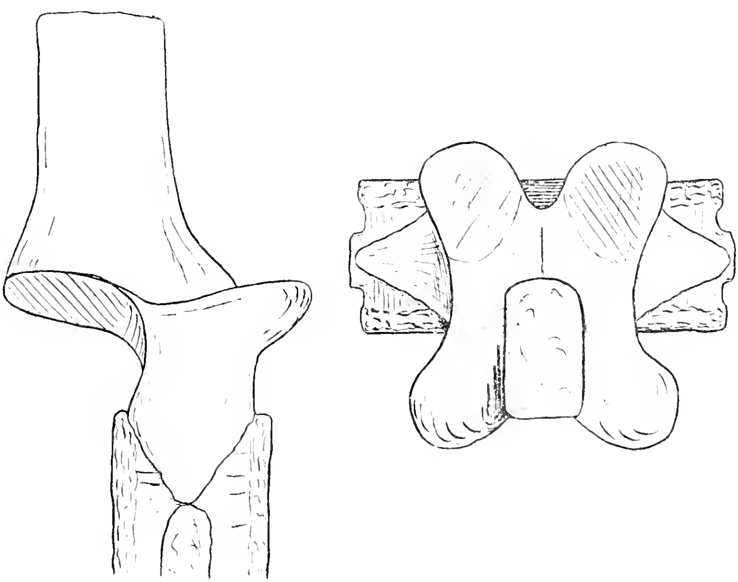


Fig. 3. "*Plesiosaurus*" *propinquus.* 23rd cervical, right lateral and dorsal aspects. $\times \frac{1}{2}$.

The posterior edge of the spine lies some ·5 cm. behind the posterior surface of the centrum, and the posterior zygapophyses project about 1·25 cm. behind the centrum.

23rd Cervical. The posterior cervicals differ from the anterior ones in the following ways:—

1. The arch is not nearly so high, relatively, to the general size of the bone.

2. The neural spine is placed a good deal further back; it is also proportionally rather larger in all ways.

3. The only visible rib facet is higher on the centrum, being touched by the neuro-central suture.

The dimensions of the 23rd cervical are:—

Maximum width of centrum	10	cms.
Maximum length of centrum	4·2	,,
From lowest point of neuro-central suture to top of anterior zygapophysis ...	6	,,
Overall length	7·8	,,
Breadth across zygapophyses	7·3	,,
Minimum breadth across zygapophyses...	5	,,
Minimum antero-posterior length of pedicels	3	,,
Height of spine (24th)	7	,,
Breadth of spine	2	,,
Overlap of zygapophyses	3·7	,,

The Pectoral vertebrae are not well exposed. They shew a gradual change from the cervicals to the dorsals.

The centra of the Dorsals are entirely concealed, but the neural spines and transverse processes are well shewn.

The 14th dorsal (the 42nd of the entire series) has a neural spine 7 cms. high above the anterior zygapophyses, 2·5 cms. long at the bottom, and 3·5 cms. at the top; it appears to be of nearly circular transverse section.

The zygapophyses, which are not well displayed, are weak, and do not project much. The transverse process is inclined slightly up. It is 4·5 cms. long and about 3 cms. in diameter.

The ribs are relatively slender, and are single headed.

The Sacrals are very badly shewn, but have a large facet for the rib, apparently partly carried on the arch.

One of the sacral ribs is preserved; it is a short stout bone of nearly rectangular section. It resembles extraordinarily closely that of *Sthenarosaurus Dawkinsi*.

The Caudals all lack their neural arches; they are badly shewn, and the series lacks several centra in the middle of the tail, the extremity of which, however, is present, the centra being reduced to mere nodules of bone.

The 12th caudal (70th vertebra) has a centrum measuring 3·5 cms. in length and 7 cms. in width.

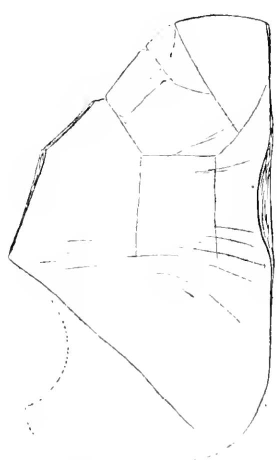


Fig. 4. '*Plesiosauru*" *propinquus* Lef coracoid. × $\frac{1}{6}$.

Pectoral girdle.

Of this girdle only the left coracoid is visible: it is exposed from the visceral surface. The fragments of which it is made are set in plaster and are probably wrongly arranged.

The glenoid end is well preserved and the part joining it to the median edge is genuine. The articular facet for the scapula is 5·5 cms. long, that for the glenoid cavity being 9 cms.

Fig. 5. "*Plesiosaurus*" *propinquus*. Left humerus, dorsal aspect. $\times \frac{1}{6}$.

The anterior edge is certainly artificial; it now forms a uniform convexity of which the inner part (that from the end of which the dotted line in the figure (*Fig.* 4) starts) is probably original; the other fragments composing it may belong to the posterior end of the bone. The median edge is well preserved, it is practically straight, and in the region between the glenoid cavities shews the usual hump, the bone here being more than 4 cms. thick.

The posterior border is completely broken away.

The 'scapula' will be described as an ilium.

The humerus is a very stout bone 35 cms. long, the anterior border is slightly convex, the posterior is rather strongly concave.

The width across the head is 8 cms., across the centre of the shaft 10 cms., and across the distal end 16 cms.

The distal end forms a uniform curve and does not show any distinct facets.

As the specimen is now mounted three bones of the fore-arms of both sides are shown. No two of these bones correspond, and none has the kidney shape of the Ulna or Fibula.

I give drawings of all these bones, but it is impossible to say which really belong to the specimen, and whether they are Radii or Tibiae.

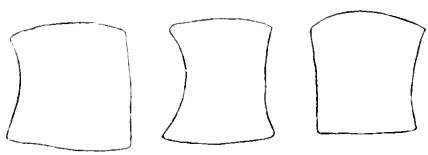


Fig. 6. "*Plesiosaurus*" *propinquus.* The three bones purporting to belong to the fore-arm. $\times \frac{1}{6}$.

Pelvic Girdle.

Of this girdle only the Ilium is preserved at all completely.

The ilium is inserted in the pectoral girdle as a scapula. It lacks some of the upper end, but so far as preserved it is 17 cms. long.

The shaft, apparently nearly circular in section, is slightly over 3 cms. in diameter, and the lower end is 7 cms. across; although the articulating face is completely concealed by plaster, there are traces of the usual two facets.

The Pubis and Ischium of the left (?) side are partly preserved. They lie, however, at right angles to the bedding, so that only their articular ends are really visible.

The visible part of the pubis shows the usual two facets; the posterior for the ischium 6·5 cms. wide and 4·5 cms. long, and the anterior 10 cms. long for the acetabulum.

Not actually united with this fragment but stretching away in front of it is a bone seen in section 15 cms. long and 1 cm. wide. This is probably the anterior plate of the pubis.

The Ischium shews its outer border, which is 15 cms. long. The bone is so injured as to be quite indescribable.

Fig. 7. "*Plesiosaurus*" *propinquus*. Ilium. $\times \frac{1}{6}$.

The two femora are preserved. They are 35·5 cms. long, 17 cms. wide distally, 9·5 cms. across at 15 cms. from the distal end, and 9·5 cms. across the head.

Both borders are concave, the posterior somewhat more so than the anterior. The distal end is rounded, and the head is a knob bearing a large trochanter some 5 cms. wide and projecting 3 cms. from the general level of the shaft.

The posterior surface of the bone is much roughened from the middle of the shaft to the proximal end.

Unless one of the bones purporting to belong to the fore-arm is a tibia, no other bone of the hind limb is preserved.

Systematic position of the specimen.

As Owen and Blake recognized there is no doubt of the specific distinction of the specimen from all other described species. The specimen although apparently a

Fig. 8. "*Plesiosaurus*" *propinquus*. Left femur, dorsal aspect. × ¼.

complete skeleton shews so few of its important characters that it is very difficult to compare it with others. Practically speaking only the general proportions, the skull and the arches of the cervical vertebrae, are available for comparison.

In point of relative dimensions the species comes near to "*Thaumatosaurus*" *megacephalus* Stutchbury, of the Lower Lias, and *Rhomaleosaurus Cramptoni* of the Upper Lias.

The skull also resembles those of these two species pretty closely.

Marked differences are, however, to be found in the cervical vertebrae.

Those of *P. megacephalus* differ from ours in the following characters :—

The centra are less shortened longitudinally, the arches are much larger in proportion to the centra ; the long axes of the zygapophyses are directed laterally, whereas in *P. propinquus* they point forward and backward.

These rather marked differences may indicate generic distinction of the two species.

The cervicals of *Rhomaleosaurus Cramptoni* differ in having much smaller zygapophyses, and in the position of the neural spine directly over the centre of the centrum.

On the whole the cervical neural arches of *P. propinquus* resemble shortened vertebrae of *Sthenarosaurus Dawkinsi* more than those of any other plesiosaur with which I am acquainted.

The whole problem of the large-headed Sauropterygia is a difficult one, and I do not propose to discuss it until I have examined the other species, both from the Lias and the Lower Oolites ; meanwhile the species is probably best referred to as "*Plesiosaurus*" *propinquus*, Blake.

The other Sauropterygian remains in the Whitby Museum are as follow :—

No. 854. A set of vertebrae bearing the following label :—

14 Caudal Vertebrae
of
Plesiosaurus homalospondylus. Owen.
Upper Lias,
Saltwick.

There are actually 16 vertebrae included under this number, of these one is a caudal of *Microcleidus homalospondylus* (Owen), the other 15 are cervicals of *Sthenarosaurus Dawkinsi*, Watson. It is possible that these vertebrae are the type specimen of *Plesiosaurus coelospondylus*, Owen, which consisted of 16 cervicals, two of which connected by matrix were cut through medially, these cannot be found. As Owen's description is so slight that it is impossible to check this conjecture by it, his species cannot stand.

No. 854. Three lumbar vertebrae united together by matrix. These belong to a type which in a former communication I suggested might be identical with *Plesiosaurus Guilelmi Imperatoris*, Dames.

Possibly Seeley's *P. macropterus* is identical with them.

No. 855. Two late cervicals resembling those of *Microcleidus homalospondylus*, but somewhat longer and more depressed.

No. 856. Four middle cervicals of *Sthenarosaurus Dawkinsi*, Watson.

No. 858. Two dorsal centra of *Microcleidus*.

No. 859. The distal half of a small humerus.

Unnumbered.

Three very large short dorsals, with very short and stout transverse processes.

A much weathered head of a very large femur.

These probably belong to *Rhomaleosaurus Cramptoni*.

The proximal end of a small and rather slender femur.

Manchester Memoirs, Vol. liv. (1910), *No.* **12.**

XII. On a new Octoradiate Coral, *Pyrophyllia inflata* (new genus and species).

By Sydney J. Hickson, D.Sc., F.R.S.,
Professor of Zoology in the University of Manchester.

Read 19th April, and Received 21st April, 1910.

A few small corals were observed by Mr. Standen of the Manchester Museum in a bottom deposit obtained by Mr. Townsend at a depth of 156 fathoms in the Gulf of Oman (Persian Gulf).

They were handed to me for examination and have proved to be of extraordinary interest. At present I have examined about forty specimens, but I have little doubt that more will be found when the deposit has been thoroughly overhauled. Many of the specimens are broken and others waterworn, but there is a sufficient number of nearly perfect specimens to determine the important characters.

As the genus to which the corals belong has not, so far as I can discover, been described, I propose to name them *Pyrophyllia inflata* (N. g. et s.).

The corals are solitary and unattached, slightly bent and hornshaped, with an inflated base. The size varies to some extent, but a medium-sized full grown specimen is about 4 to 5 mm. in length and 1 mm. in diameter at the margin of the calyx.

The most important character exhibited by this coral is, that there are eight stout protosepta and eight slender metasepta, and a laminate columella. It is important to note, that at present I have found no specimen showing either more or less than sixteen septa, and in every case the eight protosepta are well defined in size and position from the eight metasepta.

The septa and the columella have a regular undulating course, they are not straight rigid calcareous laminae as they usually are in other corals. It is for this reason—the calyx having a fanciful resemblance to a cauldron from which regular undulating flames arise—that I have suggested the name *Pyrophyllia* for the genus. Unfortunately, although this is a recent coral, we have no specimens preserved in spirit to enable us to study the structure of the soft parts; but the evidence afforded by the shell suggests very forcibly that the bulk of the living tissues were confined to the upper part of the corallum to a depth of about 1 to 2 mm. from the margin of the calyx. As the inflated base is so frequently unbroken it is possible that some strands of living tissue extended throughout the whole length, but of this there is no definite evidence. On examining the coral from above with a dissecting microscope and adjusting the focus on a plane just below the margin, the eight protosepta and the columella can be seen, and on focussing down a little further the eight metasepta come into view. (*Fig.* 1). At this level all the protosepta are exactly equivalent and the metasepta are also equivalent; there is no one septum nor single pair of septa that are more or less pronounced than others of the same series. In other words if it were not for the columella, which is definitely laminate or flattened, the coral would be perfectly radially symmetrical. On adjusting the focus to a still lower level, one or more of the protosepta may be seen to be fused to the columella, and sections of the lower part of the corallum show that fusions of an irregular character between protosepta and protosepta, and between protosepta and columella, occur throughout the corallum from the plane of first fusion as far down as the upper part of the inflated base. In using the expression "irregular," it is only intended to signify that at present the order of the fusions, if there is an order, has not been determined. The general appearance of the contents of the lower part of the corallum is that which is sometimes called vesicular tissue, or "endotheca," so characteristic of the fossil corals of the family Cyathophyllidae.

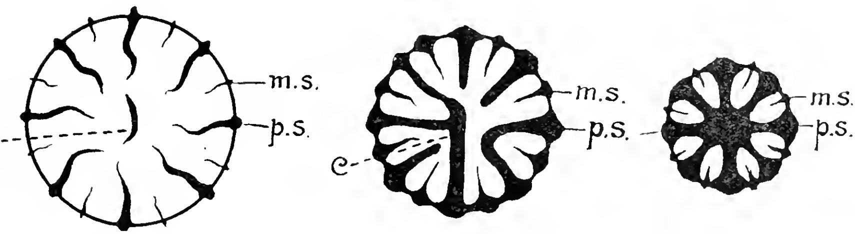


FIG. 1. FIG. 2. FIG. 3.

Figs. 1-3.—Diagrammatic sketches of the septal arrangement of *Pyrophyllia inflata*. *c* columella, *m.s.* metasepta, *p.s.* protosepta. *Fig.* 1.—Arrangement of the septa just below the margin of the calyx; *Fig.* 2, at the base of the calyx; *Fig.* 3, in the lower parts of the coral.

The septa, although sinuous in their course, are smooth and without perforations, granulations, or synapticulae.

In the lower part of the calyx the columella unites with the protosepta. In some sections taken near the base all the eight protosepta are fused with the columella (*Fig.* 3), but between that region and the upper or calical end sections show a very irregular fusion of columella with protosepta (*Fig.* 2). There is no reason for believing that, as in *Guynia*, the columella fuses with one locally defined larger septum before it fuses with the others. In the lower parts of the corallum the arrangement is not exactly like that shown in *Fig.* 3 throughout, but gaps occur between protosepta and columella, bringing the interseptal cavities into communication with one another. The eight metasepta do not apparently fuse either with the protosepta or with the columella. They can be traced from the margin of the calyx to the upper part of the inflated base. The arrangement of the septa in this region has not yet been determined, but both septa and thecal wall are here very much attenuated. The base is not perforated, nor does it show any evidence of attachment.

Fig. 4.—Side view of the coral *Pyrophyllia inflata*, showing the costae, the annular ridges, and the inflated base × 8 diameters. From a photograph by Mr. Jackson of the Manchester Museum.

Of the external surface of the coral very little need be said at present. There is no evidence of an epitheca—in the sense this term was used by Duncan—as distinct from the theca. There are sixteen distinct costal ridges extending the whole length of the coral and there are 15-20 (according to the age of the coral) transverse annular ridges marking successive growth periods. Wherever the annular ridges meet the costae, the latter project as short blunt spines. In a perfect specimen therefore there would be sixteen rows of spines.

Although many of the water-worn specimens have rows of holes between the costae there can be no doubt that these are due to post mortem wear and that *Pyrophyllia* is an imperforate coral.

The zoological position of this interesting coral must be considered fully when its structure has been more carefully studied. All that can be said at present is that there are only two recent corals that seem to approach it at all in the system of Zoantharia. These are *Guynia annulata*, Duncan, from the Adventure Bank, in 92 fathoms of water, and *Haplophyllia paradoxa*, Pourtales, from off the coast of Florida, in 324 fathoms of water.

Guynia annulata approaches most closely to *Pyrophyllia* in its annulate surface and its small size, but although in some specimens of *Guynia* there are eight large septa and eight small ones, in others there is evidence of a hexameral septal arrangement, and the columella is columnar. I have found one specimen of *Pyrophyllia* which, like many specimens of *Guynia*, is adherent by its side to a foreign body.

Haplophyllia on the other hand is broadly adherent by its base and shows no signs of annulation or successive growth. It has eight large septa (protosepta) connecting with the columella, alternating with eight smaller septa (metasepta), as in *Pyrophyllia*, but another cycle of septa is represented by rudiments in some of the chambers.

Duncan* placed the two genera in the family Cyathaxoniidae of the otherwise extinct order Rugosa. He said that "the great distinction between *Guynia* and *Cyathaxonia* is the absence of the septal fossula in the first-

* *Phil. Trans*, 1872.

named genus ; but its species has a large septum which is a very marked Rugose peculiarity, and the replacement of such septa by depressions or fossulae is common." But *Pyrophyllia* has neither a fossula nor a large septum and is therefore less closely related to *Cyathaxonia* than *Guynia* is. There is another point of difference between them which may be of less importance than appears to be when it is set down in words. *Guynia* is said by Duncan to have no endotheca, according to my account *Pyrophyllia* has an endotheca below the true calyx. The absence of endotheca separates *Guynia* from the Cyathophyllidae and the presence of it would according to the definitions separate *Pyrophyllia* from the Cyathaxoniidae. According to Duncan the endotheca is composed of "thin plate-like structures which......unite septa, close the loculi and enable the coral to grow in height and strength and limit the growth downwards of mesenteries and soft parts." If we accept this as the definition of endotheca there can be no doubt of its presence in *Pyrophyllia*, but some doubt may be expressed whether, judging from the figures and description, there is not something corresponding with the endotheca in *Guynia* also.

I am inclined however to agree with Gardiner* that this character may not be one of any great importance, and I regard *Guynia* and *Pyrophyllia* as members of the same family and probably closely related to one another. The very regular radiate arrangement of the septa in *Pyrophyllia* and their very definite and invariable number, separate it very distinctly from both *Guynia* and *Haplophyllia* as a distinct genus, but by the same characters it is also distinguished from their supposed palaeozoic allies.

* Turbinoliid corals of S. Africa, 1904. *Marine Investigations in S. Africa*, Vol. III.

It cannot be denied that *Pyrophyllia* has some characters reminiscent of the extinct *Rugosa*, but it does not seem possible at present to give it a resting place in any of the families of these fossil corals.

I consider that *Guynia* and *Pyrophyllia* should be placed in a distinct family, the Guyniidae, and that this family should be placed next to the family Turbinoliidae. The genus *Haplophyllia* appears to me to be quite distinct, and it may possibly prove to be but a stage in the growth of a form like *Duncania*, with which genus Gardiner considers it to be identical.

Manchester Memoirs, Vol. liv. (1910), *No.* 13.

XIII. The Electrical Resistance of the Human Body.

By Prof. W. W. Haldane Gee, B.Sc., M.Sc. Tech.,

and

F. Brotherton.

Read January 25th, 1910. Received for publication April 9th, 1910.

In an investigation, which is in progress, relating to Electrical Endosmose, tests have been made with organised structures, and those relating to the human body have been thought to be suitable for a separate paper, now brought under the notice of the Society. The increasing use of Electricity in Therapeutics and the revival of Electrical Medication or Catopheresis makes a knowledge of the electrical resistance of the body of importance. To the general user of electrical energy the subject is also of interest in connection with dangers associated with the usual supply voltages.

In so complex a structure as the human body the problem of determining its electrical resistance presents unusual difficulties. First, there is the question of how to secure a proper contact between the skin and the electrodes. Evidently measurements made by the application of dry metallic disks, etc., to the dry skin must be of very questionable value, for the resistance will depend on the firmness of the contact of the electrodes and the state of the skin as regards texture, moisture, and temperature. In the larger number of our experiments it was therefore thought advisable to make the measurements with the skin immersed in salt solution. Again the human body with its tissues immersed in fluids may be regarded as an electrolyte of a very complex type. According to the investigations of Dr. G. N. Stewart the current passes almost wholly through the salt solutions in the tissues. The effect of passing a current through the body will then be like the charging of an accumulator or rather a battery of cells arranged in parallel and series. This view of the body has been advocated by Weiss[1] and others, and more recently Nernst[2] has shown that many electro-physiological phenomena may be explained by considering the alterations in concentration of the electrolytes which occur at the surfaces of the membranes of the body. A like explanation applies to the source of E.M.F. in the electrical organ of the torpedo which Bernstein and Tschermak[3] regard as a concentration battery acting by osmotic forces. In the case of the *Melapterurus*, Gotch and Burch[4] find this E.M.F. as high as 200 volts.

Taking this view of the body the result of passing a direct current through it will be to cause a series of polarisation back-pressures giving an apparent resistance much greater than the true one. The true value can be more nearly approached by using alternating currents. Both methods have been used in our measurements, for in many medical applications the value of the fictitious or apparent resistance is that which must be considered. This is the case where medicinal substances are passed into the body by endosmose, and whenever direct currents are applied.

Method of Measurement. Two circular stone-ware vessels V_1 V_2, 10 inches deep and 10 inches in width, were

[1] *Journal de Physique*, 1897.

[2] W. Nernst. *Sitz. Ber. Preuss. Akad. Wiss. Berlin*, 1, p. 3, 1908.

[3] *Sitz. Ber. Preuss. Akad. Wiss. Berlin*, 8, p. 301, 1904.

[4] *Pro. Roy. Soc.*, 65, p. 434, Jan. 1900.

nearly filled with $\frac{1}{10}$ normal common salt solution. Within each was placed a large porous pot, 8 inches deep and $2\frac{1}{2}$ inches wide, containing $\frac{1}{10}$ normal zinc sulphate

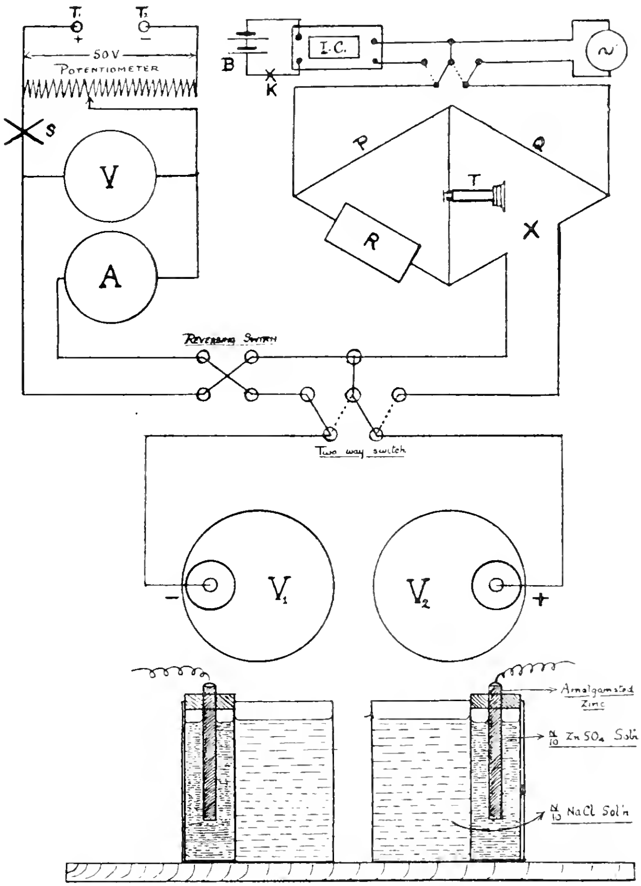


Fig. 1.

solution. An amalgamated zinc rod placed in each pot served as an electrode. The person under test, having protected any abrasions or cuts in the skin by vaseline, places a hand in the salt solution in each vessel, immersing the hands as a rule up to the wrist lines. The vessels when short-circuited by a band of zinc had a resistance of 2·5 ohms.

Measurement with Direct Currents. The electrical connections are shown in the diagram (*Fig.* 1). A potentiometer resistance of about 500 ohms and capable of carrying

TABLE I.

	D.C. Measurement.			A.C. Measurement.
	Pressure (Volts).	Current (Amperes).	Resistance (Ohms).	Resistance (Ohms).
Cotton rope moistened with water	20·58	0·00172	12000	12400
4 strands from rope wet with salt solution...	4·36	·00250	1745	1674
	8·42	·00485	1735	
	12·36	·00726	1705	
	16·47	·00949	1735	
	20·58	·01198	1715	
	24·92	·0145	1725	
	29·00	·0168	1730	1645
Wet rope with ends in porous cells.........	20·58	·0029	7100	7360
Wet rope enclosed in paper	20·58	·0029	7100	7360

$\frac{1}{3}$ of an ampere was used to supply pressure up to 50 volts. The type made by Snell and Tinsley with a sliding contact, was found very suitable for the purpose, enabling the change of voltage to be made very gradually and without sudden variations. This is essential to prevent discomfort to the subject under test. The voltage was measured by a standardised voltmeter V, and the current by a standardised milliammeter A, the latter so placed in the circuit that it did not include the voltmeter current. A reversing switch was employed in order that the current could be sent from the right to the left hand or the reverse, as required.

TABLE IA.

Experiments with Wet Cotton Ropes.

No. of Expt.	Time (Minutes).	Pressure (Volts).	Current (Amperes).	D. C. Resistance (Ohms).	Time (Minutes).	A. C. Resistance (Ohms).
1	0	20·06	0·0390	5150	0	5340
2					1	5070
3					2	5090
4					3	5050
5	0	,,	·0407	4940	0	4950
6	1	,,	·0410	4890	1	4950
7	2	,,	·0410	4890	2	4953
8	3	,,	·0412	4880	3	4950

Measurement with Alternating Currents. For this purpose a Kohlrausch Bridge with telephone, made by Hartmann and Braun, was found suitable. The alternating current was supplied either by a small induction coil I.C., or by a small alternator marked ~.

A throw-over switch enabled either of these methods to be used at will.

Preliminary Measurements. In order to compare the two methods it was thought to be advisable to make measurements with materials such as cotton which could be moistened with water or salt solution. In Table I. comparative tests are recorded.

The instruments were then recalibrated and the bridge method made more sensitive.

Table IA. shows the results which were then obtained.

TABLE II.

No. of Experiment.	Initials of Subject.	Pressure in Volts.	Current Amperes.	Apparent D.C. Resistance Ohms.	A C. Resistance in Ohms. $\varpi = 300$.	D.C. Res. / A.C. Res.	Calculated Back E.M.F. e Volts.
1	A.K.	10·38	0·00510	2040	766	2·7	6·5
2	,,	20·58	0·01310	1570	693	2·3	12·5
3	A.L.	20·70	0 01480	1400	837	1 6	8·3
4	,,	20·58	0·01380	1490	870	1·7	8 6
5	T.H.	20·58	0·01320	1560	950	1·7	8·1
6	— M.	20·58	0·01720	1198	828	1·5	6·4
7	W.O.	20·06	0·01200	1670	993	1·7	8 1
8	J.O.	20·06	0·01400	1430	714	2·0	10·0

These figures show that the results by the two methods are in substantial agreement. This was also the case when measurements were made with porous materials and parchment membranes.

MEASUREMENTS OF BODY RESISTANCE.

We have applied the two methods in finding the resistance from hand to hand and representative results are shown in Table II.

In obtaining the above results the hands were kept immersed in the salt solutions until the direct current readings were approximately constant. The subjects were all young men. Most of the tests were carried out

TABLE III.

Expt. No.	Age.	Maximum Volts.	Maximum Milliamperes.	Average D. C. Resistance in Ohms.
1	21	35	27	1300
2	21	35	25	1400
3	39	41	29	1410
4	16	42	36·8	1140
5	19	39	33	1180
6	25	43	35·4	1210
7	22	40	26·0	1540
8	19	34	25·6	1330
9	40	32	25·6	1250
10	20	20	17	1180
11	19	33	19·8	1670

at 20 volts, this being the pressure at which discomfort was usually produced. Average values of the resistance to direct current with subjects of different ages are shown in Table III.

The limits of the resistance recorded in the above table are 1140 and 1670 ohms, the highest voltage used being 43. This caused a very uncomfortable burning sensation. It is important not to suddenly vary the voltage, and especially not to break the circuit until the voltage has been gradually reduced, for otherwise violent shocks will be administered.

Tests were next made for the purpose of ascertaining the change of resistance during the time the current was passed. Here it was necessary to have the salt solutions more nearly of the temperature of the body and to take other precautions. Examples of the measurements are given in Tables IV. and IVA.

TABLE IV.

Time Test with Direct Current.

Subject.	Time (Minutes).	Volts.	Amperes.	Ohms.
F. B. (Age 22)	0	10·35	0·0063	1647
	15	,,	·00392	2641
	26	,,	·00345	3000
	34	,,	·00370	2800
	45	,,	·00390	2655

The results in two tests on the same person are plotted in *Fig.* 2 which show that the apparent resistance increases up to a certain point and then gradually decreases and tends to become constant. These observations are important in establishing the production of polarisation which takes time to reach a maximum. Assuming that the true resistance of the body, R, is that measured by the $A.C.$ method and that the apparent increase of resistance is due to polarisation we have :—

$$C = \frac{E - e}{R} = \frac{E}{R} - \frac{e}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where E is the applied and e the back E.M.F., C the current. If E and R be regarded as constant during the experiment, then the relation between C and e will be expressed by the relation :—

$$C = K_1 - K_2 e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where K_1 and K_2 are constants.

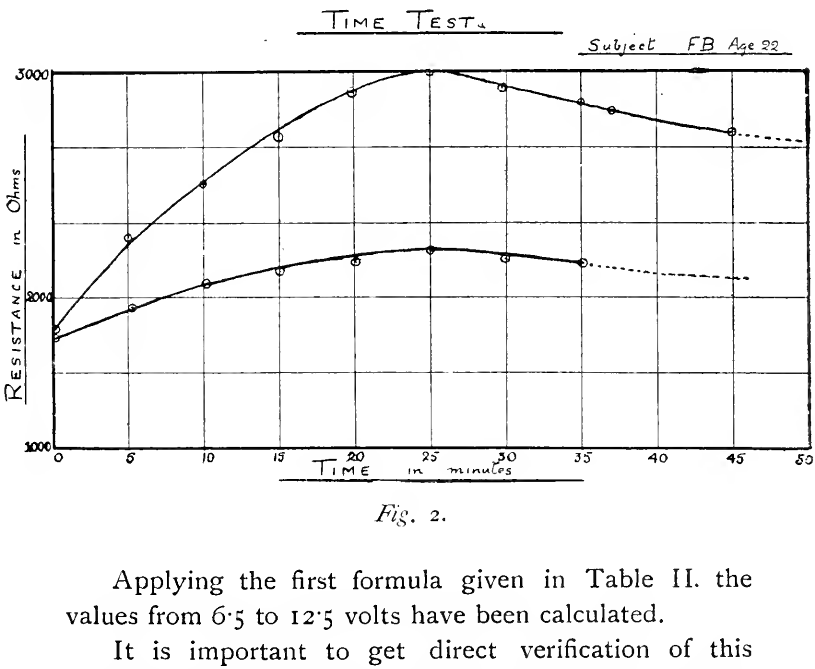


Fig. 2.

Applying the first formula given in Table II. the values from 6·5 to 12·5 volts have been calculated.

It is important to get direct verification of this polarisation by cutting the supply voltage out of circuit and immediately connecting the electrodes to a galvanometer.

This was done by charging the body for one minute and then immediately discharging into a galvanometer. After a small interval of time (necessary to read the galvanometer) a second charge for one minute was given and a second discharge observed. This process was continually repeated. Table V. gives the observations

TABLE IV.A.

*Subject—J. B. Age—26. Voltage—*12.

Time (Minutes).	Temperature of Bath (°C.).	Amperes.	Ohms.
0	24	0·0073	1645
1	24	·0067	1790
2	24	·00630	1900
3	24	·00610	1970
4	24	·00595	2020
5	24	00590	2040
6	23	·00580	2070
7	23	·00575	2090
8	22·5	·00572	2100
9	22·2	·00570	2108
10	22	·00567	2118
11	22	·00565	2122
12	22	·00564	2127
13	22	·00560	2141
14	22	·00565	2125
15	21	·00566	2122
16	21	·00575	2087

and *Fig.* 3 the result of plotting the galvanometer deflections against current. The straight line obtained shows that the formula 2 is verified.

It is important to confirm the result of this approximate method by diminishing the time of opening the circuit. This was done by arranging a compensation method with a galvanometer, G, for a zero instrument (see *Fig.* 4).

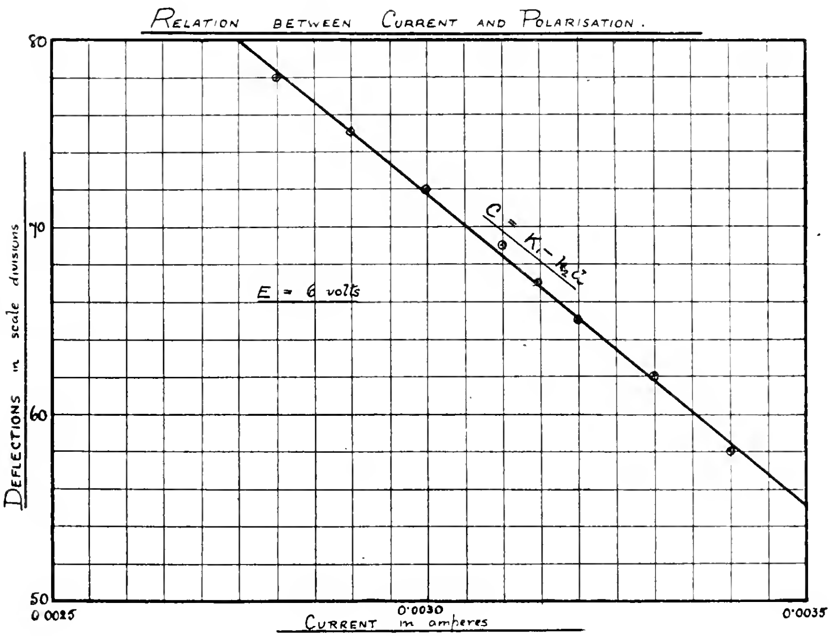


Fig. 3.

By means of a rotating commutator, C, of a secohmmeter driven by a small electric motor M, the interval of opening the circuit was reduced to less than $\frac{1}{100}$th of a second. It was, however, soon discovered that the rapid intermission of the current caused extreme discomfort to the subject, a state of rigidity being soon established. The maximum current attained has been about 0·0002 amperes. The continuance of this small current for about five minutes was found to be quite sufficient to give rise to a polarisation of about 0·85 volt. It would therefore seem probable that a polarisation of 5 to 6 volts may be attained with higher current

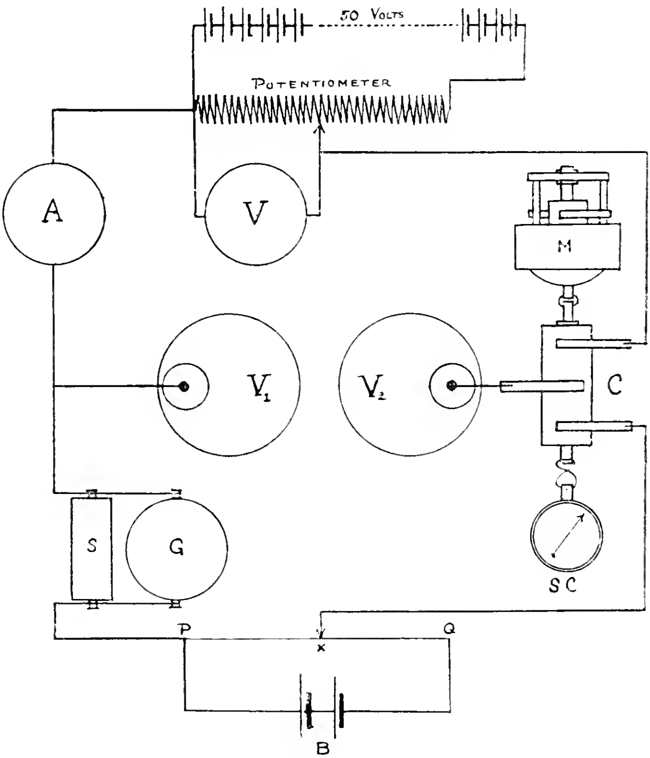


Fig. 4.

densities. In Table Va. results by the compensation method are given.

Our observations confirm those of Chanoz[5] who obtained a maximum polarisation of about 0·75 volts for

[5] *Compte Rendus* 147 p. 848, Nov. 9, 1908.

an application of 32 micro-amperes for 30 minutes, but an interval of time elapsed before the polarisation was measured.

TABLE V.

Polarisation.

Subject.	Time. m. s.	Pressure. Volts.	Current. Amperes.	Res. (D. C.). Ohms.	Res. (A. C.). Ohms.	Deflection after 1 second.	Observed e after 1 second. Volts.	Calc. $e = E - CR$. Volts.
F. B., age 22	4 21	6·00	0·0036	1660	850	31 divs.	0·100	2·94
	4 22	,,	·0035	1710	,,	52 ,,	0·167	
	4 23	,,	·0034	1770	,,	58 ,,	0·185	
	4 24	,,	·0033	1820	,,	62 ,,	0·198	
	4 25	,,	·00325	1850	,,	64 ,,	0·204	
	4 26	,,	·0032	1875	,,	65 ,,	0·208	
	4 27	,,	·00315	1910	,,	67 ,,	0·214	
	4 28	,,	·0031	1940	,,	69 ,,	0·221	
	4 29	,,	·00305	1970	,,	70 ,,	0·224	
	4 30	,,	·0030	2000	,,	72 ,,	0·230	3·45
	4 31	,,	·0030	2000	,,	73 ,,	0·234	
	4 32	,,	·00295	2030	,,	75 ,,	0·240	
	4 33	,,	·0029	2070	,,	75 ,,	0·240	
	4 34	,,	·00285	2110	,,	75 ,,	0·240	
	4 35	,,	·00285	2110	,,	76 ,,	0·243	
	4 36	,,	·0029	2070	,,	77 ,,	0·246	
	4 37	,,	·00285	2110	,,	79 ,,	0·253	3·58

TABLE Va.

Expt.	Subject.	Pressure. in Volts.	Current. in Amperes.	Time from Start. Minutes.	Interval in Seconds.	Polarisation measured in Volts.
1	W. O. Age 19	8·4	0·0010	—	$\frac{1}{50}$th	0·478
		9·6	·0010	—	$\frac{1}{67}$	0·656
		11·0	·0010	—	$\frac{1}{83}$	0·705
		15·5	·0010	—	$\frac{1}{100}$	0·757
		17·0	·0009	—	$\frac{1}{117}$	0·663
2	—M.	11 6	0·0010	1	$\frac{1}{100}$th	0·717
		,,	,,	2	,,	0·770
		,,	,,	4	,,	0·793
		,,	,,	6	,,	0·777
		,,	,,	8	,,	0·732
		,,	,,	10	,,	0·702
		,,	,,	12	,,	0·651
		,,	,,	14	,,	0·613
		,,	,,	16	,,	0·575
		,,	,,	18	,,	0·591
		,,	,,	20	,,	0·567
3	J. B. Age 26	10	0·00080	—	$\frac{1}{117}$th	0·522
		,,	·00105	—	$\frac{1}{83}$	0·562
		,,	·00130	—	$\frac{1}{67}$	0·598
		,,	·00130	—	$\frac{1}{27}$	0·561
		,,	·00130	—	$\frac{1}{17}$	0·563
		,,	·000505	—	$\frac{1}{142}$	0·544
		,,	·00037	—	$\frac{1}{175}$	o 602
		,,	·00160	—	$\frac{1}{133}$	0·586

To determine whether higher values for this back E.M.F. were likely to be reached, the following experiment was attempted.

A steady direct current of 21 milliamperes was first passed through the patient for about two minutes, the necessary pressure amounting to 30 volts. This current was then quickly reduced to a safe value, and the commutator-motor started. When rapid determinations

Table VI.

Expt. No.	D.C. Resistance. (Average—Right and Left.)	Frequency ∼	A.C. Resistance.	D.C. Resistance. / A.C. Resistance.
	Ohms.	Periods per sec.	Ohms.	
1	1705	15	1210	1·41
		300	1152	1·48
2	1210	15	1072	1·13
		300	1070	1·13
3	1435	15	990	1·45
		300	840	1·71
4	1490	15	797	1·87
		300	837	1·78
5	1355	15	719	1·88
		300	733	1·84

of the polarisation were now carried out, considerably higher values were attained.

Three consecutive experiments gave the numbers 0·833, 1·010 and 1·045 volts respectively.

Study of Effect of Change of Frequency. Whether the frequency was low or relatively high, approximately the same value of resistance was obtained with alternating currents.

In the following table the lower frequency was furnished by a small motor-driven alternator, capable of supplying 6 amperes at 15 volts and giving a sine curve. The higher frequency current was derived from the secondary windings of a small induction coil with the usual asymmetric wave.

The chief resistance of the body is at the skin. This

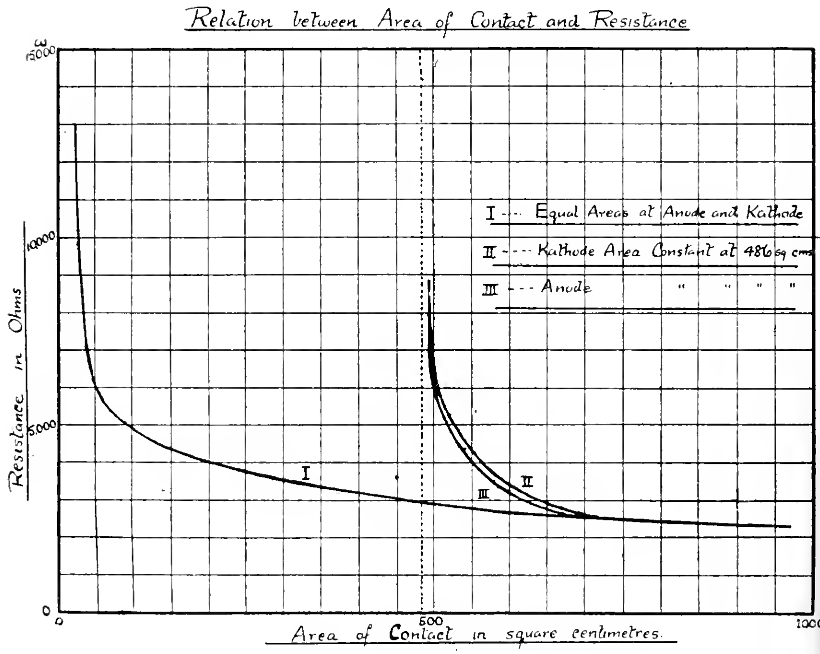


Fig. 5.

is verified by the observations of Stone, Leduc[6] and others.

Leduc[7] has given a law connecting the relations between electrode surface and electrical resistance which involves the length of the periphery of the electrodes, and not their area. It would seem more important to connect the resistance directly with the area of contact. Measurements of

[6] S. Leduc, *Comptes Rendus*, **137**, p. 814, Nov. 16, 1903.

[7] *Archives d'Électricité Medicale*, **13**, p. 457, June 25, 1905.

this kind we have only so far made with direct currents as tabulated below :—

TABLE VII.

Relation between Area and Resistance.
Hand to Hand.
Subject—H. P. Volts—20·6.

Exp.	Cathode Area. Sq. cms.	Anode Area. Sq. cms.	C. Amps.	Resistance. Ohms.
1	486 (up to wrists)	486 (up to wrists)	0·0092	2240
2	180 (up to ends of fingers)	180 (up to ends of fingers)	0·00615	3350
3	20 (first finger)	20 (first finger)	0·0030	6870
4	9 (1″ of finger)	9 (1″ of finger)	0·0016	12900
5	486 (up to wrist)	9 (1″ of finger)	0·0028	7360
6	9 (1″ of finger)	486 (up to wrist)	0·00295	6980
7	486 (up to wrist)	180 (ends of fingers)	0·0075	2750
8	180 (ends of fingers)	486 (up to wrist)	0·0080	2580
9	3 (tips of 3 fingers)	3 (tips of 3 fingers)	0·0029	7110

These results when plotted give the curves shown in *Fig.* 5.

Resistance with Metallic Contacts. In the cases when ordinary metallic contact is made, as usually occurs in practice, the values of the resistances will obviously be very much higher. A number of measurements have been carried out by the two methods, with a view to obtaining results under conditions most likely to obtain in workshops. The nature of the numbers to be expected is indicated by the following results :

Exp. 1. Dry contact on brass rods. Diameter = ¾″. These rods were held in the hands.

A.C. Measurement. ~	Ohms.	D.C. Measurement. Direction of Flow.	Ohms.	Ratio $\frac{D.C.}{A.C.}$
15 ...	5080	Left to Right...	15000	
300 ...	4450	Right to Left...	10900-13600	2·7
Mean ...	4765	Mean ...	12950	

Exp. 2. The hands were washed with soap and water, and then dried on a towel. Contact made as before.

~	Ohms.	Direction of Flow.	Ohms.	Ratio $\frac{D.C.}{A.C.}$
15 ...	3970	Left to Right...	12800	
300 ...	3460	Right to Left...	11500-12800	3·3
Mean ...	3715	Mean ...	12150	

Exp. 3. Hands wet with tap-water.

~	Ohms.	Direction of Flow.	Ohms.	Ratio $\frac{D.C.}{A.C.}$
15 ...	2050	Left to Right...	6310	
300 ...	1940	Right to Left...	5940	3·1
Mean ...	1995	Mean ...	6125	

Exp. 4. Hands wet with Salt Solution.

~	Ohms.	Direction of Flow.	Ohms.	Ratio $\frac{D.C.}{A.C.}$
15 ...	1480	Left to Right...	6310	
300 ...	1310	Right to Left...	5940	4·4
Mean ...	1395	Mean ...	6125	

Exp. 5. Hands immersed in Salt Solution to wrists.

~	D.C.	Ratio $\frac{D.C.}{A.C.}$
Mean 1100 ohms.	Mean = 1775 ohms.	1·6

Exp. 6. Dry finger tips on metal. D.C.
Resistance by galvanometer = 150,000 ohms.

Physiological Effects. The various types of electronic effects known to physiologists were manifest during these experiments. The muscular contractions were made very evident by the movement of the reflection images at the surface of the solution. With the hands immersed in salt solution 1-2 volts gave a sensation on closing the circuit with a key, the effect with 30 volts causing great discomfort and vigorous contraction of the muscles. Involuntary muscular contractions took place on making the circuit, with a minimum of 8 volts at the cathode and of 11 volts at the anode. By placing the muscles in a strained condition these numbers were reduced to 4 and 6 volts respectively.

It was thought that the effect being greater at the cathode this would furnish an easy method of distinguishing the polarity of circuit terminals. With dry finger tips on brass terminals the following effects were observed.

TABLE VII.A.

Voltage.	
230	... Smart shock to ends of fingers. More marked at the cathode.
150	... Same effect.
110	... Less shock. Distinctly greater at the cathode.
50	... No effect with dry fingers. With wet fingers the cathode contraction is very distinct.

A number of observations concerning these interesting sensation effects are appended in Table VIII. In the following experiments the skin contact remained unbroken, the current being started and stopped by means of an ordinary knife-switch.

TABLE VIII.

Applied Pressure. Volts.	Current. Amperes.	Sensations.			
		Cathode.		Anode.	
		Opening.	Closing.	Opening.	Closing.
1	0·0007	—	—	—	—
2	·0010	—	C	—	—
3	·0020	—	C	—	C
4	·0025	—	C	—	C
5	·0035	c	C	—	C
6	·0045	c	C	—	C
7	·0050	c	C	—	C
8	·0060	C	C	C	C
9	·0070	C	C	C	C
10	·0080	C	C	C	C

In the preceding Table, "C" is used to represent a considerable muscular contraction, and "c", a smaller contraction. The hands were as usual immersed in Salt Solutions.

Human Telegraphy. The distinction between the cathode and the anode effects suggested the application for the purpose of telegraphy. The arrangement shown in the accompanying *Plate* was found to be suitable.

A battery of from five to ten dry cells in series, was connected through an ordinary "tapper" commutator and formed the transmitting portion of the system. The messages, which were sent in the Morse code were received by the operator who placed the left-hand in a vessel containing dilute salt solution in which was immersed a zinc rod to serve as an electrode. In the right-hand was held a pencil wrapped round with tin-foil or contained in a metal pencil-case. The pencil was connected to one end of the line whilst the other end was placed in connection with the zinc rod. A "dot" was represented by a shock in the right-hand and a "dash" by one in the left-hand. After a little practice Messrs. W. B. Smith (of the P.O Engineering Dept.) and A. Hodgson and T. Alston (of the Manchester Postal Telegraphs) were able to send and receive messages at the rate of from 7 to 15 words per minute: the lower speed being when the receiving operator actually made his own record in writing, and the higher speed when he dictated the message as received. When the message is dictated it is better to receive with the right hand also immersed in salt solution. The method may prove to be one of value in practice in case of emergencies where receiving instruments are not available.

Dangers of Supply Circuits. The resistance between the hands wet with salt solution being with alternating currents only about 800 ohms, the result of including the body in an alternating supply of about 100 volts will be excessively dangerous and probably will cause death. An accident of this kind is recorded by A. Kolpen.[8]

[8] *Elektrotech Ztschr.*, **21**, p. 133, Feb. 15th, 1900. The glow lamps of some potash works near Prague were connected with one phase and the neutral wire of a three-phase system giving 110 volts. A man standing on an iron soda tank with his boots soaked with soda, accidentally touched one of the bare wires of a lamp. Two of his fingers stuck to the wire and before he could be released he was unconscious and all attempts to resuscitate him failed.

With the application of alternating current, only about 1·7 milliampere is required to produce muscular fixation.

Zipp[9] mentions the case of a man who was rendered speechless for three weeks by coming into contact with a 120 volt circuit.

To so-called medical electricians the case that occurred at Clöthen may serve as a warning :—

> The owner of a bathing establishment who knew little of the dangers attending the use of electricity, had the idea of installing an electrical bath.
>
> He arranged a pair of electrodes at the two ends of a slipper-bath, and had them connected with a source of alternating current at 120 volts.
>
> Trying the effect upon his own person, at the moment of entering he received a violent shock which proved fatal.

The fatalities at the Fulham baths due to 200 volts alternating current are yet fresh in our memory.

The Board of Trade has recently revised the regulations relating to portable electric lamps and switch lamp-holders so as to minimise the danger to users of electricity in factories.[10]

Our thanks are due to a number of students at the Manchester School of Technology who have given assistance in carrying out the experiments and especially to Mr. A. K. Bentley.

[9] *Electrical Review*, p. 295, 1907.
[10] *Electrician*, March 4th, p. 852, 1910.


LINE.

Manchester Memoirs, Vol. liv. (1910), *No.* **14**.

XIV. The Physical Aspect of Time.

By H. BATEMAN, M A.

Received May 31d, 1910.

1. During recent years mathematicians and philosophers have been much occupied in analysing the fundamental conceptions on which the different sciences are based, with the result that many things which were formerly regarded as quite simple and axiomatic can no longer be regarded as such. The tendency has, of course, been to make definitions as precise as possible, and to make descriptions of phenomena approximate to reality as we know it, and not to a preconceived idea of what the description ought to be.

Many difficulties arise, however, in a careful examination of the fundamental concepts of any science, and this is soon found to be the case when we commence to examine the ideas of space and time which are fundamental in all physical and metaphysical enquiries.

In the case of time, for instance, it is found that we have to examine the connection between time as it is known to us by the mind's experience, *i.e.*, psychological time, and time as it is measured by the course of physical phenomena, *i.e.*, physical time.

With regard to psychological time, it has been contested that it is purely qualitative, in other words that we are quite unable to decide intuitively whether two intervals of time are equal or not.* This means that

* See for instance Poincaré, "La Valeur de la Science," ch. II.

there is no fixed method by which two sequences of events may be compared in the mind. The comparisons which actually occur give a qualitative description of events, inasmuch as the sequence of processes is generally unaltered in direct perception and in memory, but the lack of a standard set of units invariably connected with the method of comparison, prevents the description from being a true quantitative one.

This being the case, we are met with a fundamental difficulty when we try to analyse the idea of simultaneity as presented to us by the mind.

If we could represent an event by a point on a line, the idea of simultaneity would be quite simple, for two events could be regarded as simultaneous when their representative points were coincident. In reality such a representation is not valid, there is no sensation of such a simple nature that it can be represented by a point on a line. If we adopt a representation by means of an interval on a line, we obtain what is probably a truer representation of an event as regards its duration ; but if we suppose that two events are simultaneous when their representative intervals have a common part, it is clear that two events which are simultaneous with the same event would not necessarily be simultaneous with one another.

It will be realised after a little thought that we can only obtain a satisfactory definition of simultaneity by introducing the idea of the measurement of time ; we are thus obliged to consider the physical aspect of time in order to understand the idea of simultaneity.

An observer provided with an instrument for measuring time, such as a clock or a pendulum, can attach a definite number to each event that occurs. In some cases he may find it difficult to decide as to which of two consecutive numbers should be attached to an event; but we shall suppose that he has a consistent method of avoiding the difficulty, as, for example, by always choosing the larger number of the two.

A satisfactory definition of simultaneity for two events which happen in the immediate vicinity of the observer can be given as soon as events are numbered, for we can say that two events are simultaneous when their corresponding numbers are equal. The actual enumeration may depend upon the personal equation of the observer, but discrepancies may be eliminated as soon as a method of comparing the observations of different observers has been adopted.

We now require a method of comparison by means of which we can decide whether the observations of time made by two different observers are equivalent or not. The criterion of equivalence must be such that if the observations of A are equivalent to those of B, and also to those of C, then the observations of B and C are equivalent to one another.

It is clear that if two observers are situated at different points of space a comparison of observations can only be made by means of something which travels from one to the other, and for the sake of simplicity it is convenient to choose something which can be supposed to travel in a straight line with constant velocity. It should be remarked, however, that these terms have no meaning until time and distance have been defined.

It is by no means obvious that a universal method of comparing observations can be found which will lead to consistent results, for this presupposes the existence of a universal time, an entity which has sometimes been regarded as the psychological time of an infinite mind governing the whole of the universe. The latter point of view is really not sound, because the universal time we are endeavouring to define is essentially quantitative in character. The best way of establishing the existence of a consistent method of comparison is to give an example of one, and so we shall consider Galileo's method of light signals,* which was used in a first but unsuccessful attempt to measure the velocity of light.

The way in which this method is applied is as follows. An observer situated at a point A observes at time t an event which has taken place at another point B. If τ is the time which light takes to travel from B to A, the universal time to be associated with the event at B according to A's measurements is $t-\tau$. As soon as A has observed the event he makes a signal, and it is clear that by a series of signals the two measures of an interval of time may be compared.

By means of this rule the clocks belonging to a number of observers $A_1, A_2, \ldots$ can be regulated in a consistent manner, provided light always takes the same time to travel from an observer A_r to an observer A_s.

Let us suppose that a large number of observers A_r find that their observations of one another's experiences give a consistent universal time as far as they are concerned; they can then regard themselves as being at constant distances from one another, the distance between two observers A_r, A_s being defined as $C\tau_{rs}$ where τ_{rs} is the time light takes to travel from A_r to A_s, and C is a constant called the velocity of light.

These observers may then form a standard system for the measurement of time and distances at other points of space. The measurements of four standard observers should suffice to determine the position and time of any

* This method is used for the purpose of studying the properties of time by A. Einstein, *Ann. der Physik*, vol. 17 (1905).

occurrence, if space is of three dimensions. If there are more than four observers in the standard system the relations between all the different observations of an event will depend upon the nature of space, and will take a comparatively simple form if the space is Euclidean.

If the position and time associated with an object B is always determined from measurements by a number of standard observers $A_1, \ldots A_r$, so that a consistent universal time exists for each point of space, the following conclusion may be deduced by elementary geometry for Euclidean space:

If two observers B and C are at rest or in motion relative to the standard system, and their velocities are less than that of light, there is only one instant* at which B is able to observe an instantaneous event experienced by C, but if one of the observers is moving with a velocity greater than that of light this is not necessarily the case; in fact it may happen that B sees two or more pictures of the same event.†

* An analytical proof of this result is given by Prof. A. W. Conway. *Proc. London Math. Soc.*, Ser. 2, vol. 1. (1903).

† If the times associated with B and A in two views of them are t_1 and t_2 respectively, B will be able to witness at time t_1 an event experienced by B at time t_2 if a sphere of radius ct_1 having the point B as centre is touched internally by a sphere of radius ct_2 having the point A as centre.

Now if B is moving with a velocity less than that of light, the spheres associated with consecutive positions of B surround one another in succession as in Fig. 1.

It is clear then that there is only one sphere of the series which is touched

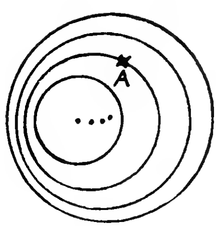


Fig. 1.

In order that Galileo's method of comparing times at different points of space may be suitable for a sober world, it seems necessary to suppose that a body cannot move with a velocity greater than that of light, and it may be of interest to remark that this view is supported by modern electrical theories.

Now let us suppose that a second system of observers, $B_1, B_2, \dots B_n$, find that their observations are in agreement, and so can regard themselves as a standard system. It may happen that according to their measurements the first system of observers $A_1, A_2, \dots A_n$ are in motion, and then it is easy to see that the specifications of position and time as made by the A's and the B's will not agree.

internally by a given sphere associated with A, or if we make $t_2 = 0$ it is clear that there is only one sphere of the series which passes through a given point in space, provided the radii of the spheres associated with B are all positive; the equivalent supposition in the other case is that $t_1 > t_2$

If B is moving with a velocity greater than that of light, two of the spheres associated with it may intersect, and so two of them may be touched internally by the same sphere belonging to A, and then B is able to see more than one picture of the same event. See Figs. 2 and 3.

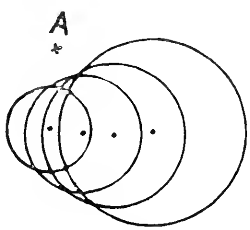


Fig. 2.

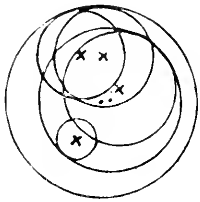


Fig. 3.

Again, if A is moving with a velocity less than that of light the spheres associated with A lie within one another or surround one another in succession, and it is clear that there is only one sphere of the series which touches internally a given sphere associated with B. Hence B cannot see two different states of A at the same time. If A is moving with a velocity greater than that of light two of its spheres may intersect, and then it is quite possible for B to see two or more different positions of A at a given time.

If B and A are moving with velocities less than that of light, and we

For instance, if two observers A_r, A_s pass an observer B at different times, their distance apart as measured by B is zero, while measured from A's point of view it is not.

The relation between the two sets of measurements may be obtained by taking into account the fact that the analytical conditions that an observer P should be able at time t_1 to observe an event which happened at another point Q at time t_2, ought to be of the same form in the two systems of coordinates.

If (x_1, y_1, z_1), (x_2, y_2, z_2) are the coordinates of P and Q, we have, in the first place, the necesssary conditions

$$(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 = c^2(t_1 - t_2)^2 \quad t_1 > t_2.$$

These conditions, combined with the kinematical character of the motion of the B's relative to the A's, are

establish a correspondence between the spheres connected with the different positions of B and A by associating together two spheres which touch internally, then since the two series of spheres are such that any sphere of a series surrounds all the smaller ones of the series, it is clear that as the radius of a B sphere increases the radius of the corresponding A sphere also increases. Fig. 4. This shows that B observes the events happening to A in the

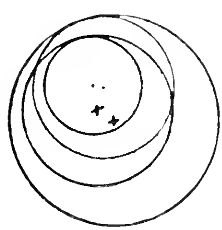


Fig. 4.

correct order. This is not necessarily the case if one or both of the observers are moving with a velocity greater than that of light; in fact under certain conditions it would be possible for one observer to witness the other's experiences in the reverse order. For instance in figure 3 if the four crosses denote successive positions of B, it appears that the first and last positions are seen by A at one instant and the two intermediate positions at another instant. The two earlier positions of B are thus seen in the reverse order, and the two later positions in the correct order.

practically sufficient to determine the relation between the two systems of measurement in certain cases, as, for instance, when the *B*'s are moving with a uniform velocity relative to the *A*'s.*

It is found that in the case of uniform relative motion the units of length and time in the two systems are different, and that two events occurring at different points of space may appear to be simultaneous according to measurements made by the *A*'s, and not appear to be simultaneous according to measurements made by the *B*'s. Also, the shape of a body is theoretically different according to the two series of measurements, but the difference is so very slight as to be unnoticeable.

The fact that the electromagnetic equations have the same form in the two systems of coordinates, indicates, that as far as our observations of electromagnetic phenomena are concerned, a uniform motion of a system of observers would remain undetected. This, of course, is in accordance with the view that position and motion are purely relative, and that the term absolute motion is meaningless.

* The transformation for the case of uniform velocity was given by Voigt, Larmor and Lorentz, it is

$$x' = \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}}, \quad y' = y, \quad z' = z, \quad t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

This transformation makes

$$(x'_1 - x'_2)^2 + (y'_1 - y'_2)^2 + (z'_1 - z'_2)^2 - c^2(t'_1 - t'_2)^2 = 0,$$

a consequence of

$$(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 - c^2(t_1 - t_2)^2 = 0.$$

It can be shown that any transformation of coordinates which leaves the last equation unaltered is such that the electrodynamical equations are unaltered in form. See papers by E. Cunningham and the author in the *Proceedings of the London Mathematical Society* (1910).

A. Einstein* has developed this theory of relativity starting with the fundamental idea of the constancy of the velocity of light, and has thus been able to present us with a new kinematics which is apparently more consistent with the modern theories of electrodynamics than the approximate kinematics to which we are accustomed. Some of the most interesting results of the theory are that the resultant of two velocities, both of which are less than that of light, is always a velocity less than that of light; the resultant of two velocities one of which is equal to that of light is a velocity equal to that of light; the resultant of two velocities equal to that of light but of opposite directions is indeterminate, and may have any value less than or equal to that of light.

This theory of relativity is not based simply on theoretical considerations; it has received considerable support from some very delicate experiments. It was first put forward in an approximate form by Lorentz† and Larmor‡, following a suggestion made by FitzGerald§, to explain the negative results of the Michelson-Morley experiment. It was then found that it provided an ample explanation of a number of other negative results concerning the effect of the motion of the Earth on double refraction‖, the rotation of the plane of polarisation¶, the resistance of a piece of metal**, and other physical phenomena. Also, the theoretical formula

***Ann. der. Physik*, vol. 17 (1905). *Jahrb. der Radioaktivität* (1907).

† "Versuch einer Theorie der elektrischen und optischen Erscheinungen in bewegten Körpern." Leiden. (1895.)

‡ Aether and Matter. (1900.) Ch. x., xi., xiii.

§ Public lectures in Trinity College, Dublin.

‖ D. C. Brace. *Phil. Mag.*, (6), vol. 7, p. 317, 1904.

¶ Rayleigh. *Phil. Mag.*, (6), vol. 4, p. 215. Brace. *Phil. Mag.*, (6), vol. 10, p. 383, 1905. *Ibid.*, p. 391.

** Trouton and Rankine. *Phil. Trans.* A. (1908), p. 420.

deduced for the transverse mass of a moving electron* is in fairly good agreement with the results of Kaufmann's experiments, and has been verified very closely in a recent experiment made by Bucherer.

At present the theory is being widely used as a working hypothesis, and is of great theoretical importance, as it enables us to pass from the known analytical specification of a phenomenon for a medium at rest to the corresponding case of a medium in motion. It has been used in this way by the late Hermann Minkowski to obtain a scheme of electromagnetic relations for ponderable bodies in uniform motion, and has been shown by Planck and von Mosengeil to provide a very useful method of studying the properties of radiation in a cavity in a moving body.

With regard to the ideas of time that have arisen in connection with the theory, it may be mentioned that two new terms have been introduced. The term local time is used by Lorentz to denote time as it is measured by a set of observers who are moving uniformly in a straight line relative to a standard set of observers. The relation between the local time and the standard time is a reciprocal one, the local time for one set of observers being the standard time for the other set, and vice-versa.

A second term, used by Minkowski, is *Eigenzeit* or the "proper time." It is defined for each particle and may be regarded as the *age* of a particle. As a particle moves from one point to another, the increase of age depends upon the increase of the standard time, and also upon the velocity of the particle. If the particle is moving

* This formula is $m = \dfrac{m_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}$ where m_0 is the mass which the electron would have if it were at rest.

uniformly, the increase in age is equal to the increase in local time. The advantage of using the *age* of a particle in forming the equations of motion is that there is a gain in simplicity. The analytical methods based upon the use of the age of a particle may be compared with Lagrange's method of dealing with problems in hydrodynamics, while the methods based on the use of a standard time may be compared with the Eulerian method.

When a particle is moving in an arbitrary manner it is by no means certain that its age can be derived from a knowledge of an initial position and the position at a given time. It is to be expected, in fact, that the age of the particle will depend upon the path from one point to the other, and also upon the rates at which it describes different parts of the path.

There is, at present, considerable uncertainty with regard to the exact laws of the kinematics and dynamics of a body whose motion is not uniform. Systems of non-Newtonian mechanics and kinematics of a rigid electron have been based upon the theory of relativity for the case of uniform motion, but they can hardly be regarded as satisfactory, and difficulties arise as soon as a uniform motion of rotation about an axis is considered.*

If mechanics is to be based on the science of electromagnetism, we must make a complete study of the transformations connected with the fundamental equations of electromagnetism.

Now the general problem of determining the transformations which leave the electrodynamical equations unaltered in form, may be partially solved by simply paying attention to the conditions which must be satisfied

*This difficulty was pointed out by Ehrenfest, *Physikal. Zeitschr.*, vol. 10, p. 918 (1909).

in order that an observer P who is at a point (x_1, y_1, z_1) at time t_1 may be in a position to record the effect of a disturbance which issued from a point (x_2, y_2, z_2) at time t_2.

It should be remarked that the conditions given above with regard to the possibility of P seeing Q at the given times are necessary, but not sufficient. This accounts for the fact that the transformations for which the condition

$$(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 = c^2(t_1 - t_2)^2$$

is invariant are limited to a certain group.

It is clear that P is able to see Q if there is a flow of energy from P to Q. If (s_x, s_y, s_z) denotes the direction in which energy is flowing from Q at time t_2, and we regard the differences $x_1 - x_2$, etc., as small, so that

$$x_1 - x_2 = dx, \quad y_1 - y_2 = dy, \quad z_1 - z_2 = dz, \quad t_1 - t_2 = dt$$

we may consider transformations such that the equations

$$\frac{dx}{s_x} = \frac{dy}{s_y} = \frac{dz}{s_z}$$

$$dx^2 + dy^2 + dz^2 - c^2dt^2 = 0$$

are invariant. Since the flow of energy depends upon the state of the electromagnetic field, the formulæ of transformation will depend upon the character of the electromagnetic field, but it can be shown that if the above equations are invariant, the fundamental equations which describe the sequence of electromagnetic disturbances are also invariant.* The description of any series of phenomena is thus qualitatively the same in the two series of coordinates.

It is interesting to compare the result just obtained with some ideas with regard to the way in which experience is interpreted by the mind.

If we suppose that some physical process taking place

* These are not the only transformations which may be used to transform a particular electromagnetic field into another, there appear to be many different types of transformation which are suitable for this purpose.

in the brain is the physical adjunct of a sensation in the mind, such as visual perception, we may regard the mind's interpretation of the sensation as a transformation of the actual physical process as it would be described by external observers if observed directly by them.

If now the exact nature of this transformation depends upon the physical process taking place as in the case of the transformations just considered, but at the same time leaves invariant the fundamental laws on which a description of the process depends, the description of the process by means of the transformation will be a correct qualitative description but will not be a true quantitative one, since the transformation varies for each independent event and so there are no fixed units of measurement. It is possible that when the mind is concentrated on a subject the type of transformation is practically constant, and so our interpretations of sensations become clearer as they become more of a quantitative nature, but it is dangerous to speculate and so I shall leave the subject at this point.

XV. A third List of the adventitious Vegetation of the Sandhills of St. Anne's-on-the-Sea, North Lancashire, vice-county 60.

By Charles Bailey, M.Sc., F.L.S.
(of Haymesgarth, Cleeve Hill, Gloucestershire.)

Received April 21st, 1910. Read May 3rd, 1910.

In previous communications to the Society* I have reported the appearance of a considerable number of alien plants which have occurred upon the sandhills of the Lancashire coast at St. Anne's-on-the-Sea. Almost the whole of these plants originate with poultry runs, which are temporarily accommodated on the sandhills, until such times as advancing building operations drive the poultry further afield. Their removal from the released land permits the growth of much of the foreign seed upon which they are fed, and in the next following seasons a curious admixture of native and alien vegetation presents itself, when the hens are no longer on the ground to consume it almost as soon as it germinates.

The area now to be reported upon was carefully examined some two or three seasons ago, and the additions now recorded more than double the numbers in the previous lists, and bring up the total to more than a hundred species. The majority of the plants included in the present list were found in the area bounded by Beach Road, St. Andrew's Road North, St. Leonard's Road, and the North Drive, and this area is to be understood

* *Manchester Memoirs*, vol. 47, No. 2, 1902; and vol. 51, No. 11, 1907.

where no reference is made to a locality. Thirty-one of these fifty-four additions were communicated to Mr. J. A. Wheldon, F.L.S., and Mr. Albert Wilson, F.L.S., F.R.Met.S., just in time to be included on the last page of their admirable 'Flora of West Lancashire,' (Eastbourne, 1907, p. 511).

For help in determining the names of many of the species about to be enumerated, I am indebted to the authorities at Kew, and to Mr. J. G. Baker, F.R.S., F.L.S. The enumeration is in the order of the 'London Catalogue,' ed. x. (1908).

Adonis æstivalis, Linn. This species has a south European distribution, and was represented by a few examples in 1909.

Delphinium orientale, Gay. A strong growing species of Roumelia, Servia, Hungary, and southern Russia, which occurred in small quantity only, its conspicuousness rarely allowing it to reach maturity. It was usually accompanied by *D. Ajacis*, Linn.

Sisymbrium Columnæ, Jacq., var. *stenocarpum*, Rouy et Foucaud. A widely spread European species which occurred, in some quantity, on three different portions of the area, and seemed a very likely plant to become permanent were it not for building operations.

Sisymbrium austriacum, Jacq., was much less in evidence; only a few plants survived the toll of the flower-gatherer.

Conringia orientalis, Andrz., was another frequent plant in both 1908 and 1909. It is rather noteworthy how many cruciferous aliens make their appearance in these lists.

Sinapis juncea, Linn. This is an unlooked for species, although it has occasionally been reported in European floras. It occurred in profusion over many portions of the St. Anne's sandhills, and I had it under observation for several summers, without being able to associate it with any plant then known to me. It grew on a cinder path on the south side of my old residence (Atherstone House); other portions of the sandhills produced a more fleshy plant, which I was a long time in connecting with the plant of the cinder walk. Upon searching my herbarium for its counterpart, it seemed best to agree with examples of *S. juncea*, from Swinemünde, in Pomerania, collected there in August, 1889, July and August, 1890, and August, 1892—the latter under the synonym of *Brassica Willdenovii*, Boiss.; it has been reported at Port Juvénal, in France, by Spach, and is one of the oil plants of China and Japan. Doubt, however, attached to this determination of the St. Anne's plant, on account of its lacking the "ramis fasciculatis" of the 'Prodromus' (vol. 1, p. 218). In the summer of 1908 there reached me a plant, which required a name, from Mr. James E. Macdonald, of Heaton Norris, and the specimen sent furnished the fasciculate branches given as one of the characters in the 'Prodromus'; under the name of *S. juncea*, Linn., I distributed numerous examples through the Botanical Exchange Clubs. At the date of de Candolle's work (1824) it is described as a Chinese plant growing in Egypt in fields of *Trifolium Alexandrinum*. It is right to add, however, that some British botanists regard the St. Anne's plant as being only *Sinapis nigra*, Linn., but in St. Anne's—where *S. nigra* is abundant—

there is little difficulty in separating the two species; moreover, the authorities at Kew looked through a series of more than twenty sheets of a full range of the plant, and passed them all as *S. juncea.* Mr. Baker has also seen an example or two, and considers the name correct. The plant was not nearly as copious in the summer of 1909, but I have little doubt of its having been established at St. Anne's throughout the seven years of my residence there, but passed over for *S. nigra.*

Eruca sativa, Lam.,—an Iberian, southern French, Italian, Croatian, and Greek species—was a frequent alien throughout 1908, but was greatly reduced in numbers the following summer.

Lepidium virginianum, Linn. This American cress was occasionally met with.

Neslia paniculata, Desv., a common European plant, was represented on the sandhills, and was quite typical.

Myagrum perfoliatum, Linn. Three or four of this widely distributed European species were collected.

Rapistrum Linneanum, Boiss. et Reut., a plant of the Iberian peninsula and of Greece, was one of the striking plants of the sandhills in 1907; it owed its preservation up to the fruiting stage to its growing in dense masses of *Sinapis nigra.* One plant furnished sufficient material for ninety herbarium specimens, and another sixty-five. This species makes the fifteenth belonging to the *Cruciferæ.*

Saponaria Vaccaria, Linn.—a frequent cornfield plant of Britain furnished a few examples on the poultry area.

Silene dichotoma, Ehrh., an eastern European species, often found on waste heaps in Great Britain, occurred in a solitary example.

Malva parviflora, Linn., another Iberian plant, found also in southern France, Dalmatia, and Greece, was plentiful in 1908, but infrequent in 1909.

Linum usitatissimum, Linn. The common flax was an occasional plant of stunted growth.

Lupinus luteus, Linn., a Spanish and Italian species, was found on the sandhills of the South Drive, and, although I have not seen it in cultivation in the neighbourhood, it may well be a garden escape, though found on ground recently abandoned by poultry and now covered with dwelling houses.

Trigonella polycerata, Linn., a French and Spanish plant, was found quite fresh in my collecting book ; I was unaware that I had collected it, as it was entangled with the stem of another plant, and though it was derived from the poultry area I could not re-find the species.

Melilotus indica, All., occurred in great abundance, especially in an area in Devonshire Road now covered with dwellings.

Coronilla varia, Linn., with a wide area of distribution on the Continent, was represented by a single plant.

Vicia pannonica, Cr., var. *purpurascens*, DC., an Austrian and further eastern plant, and two undetermined *Viciæ*, were amongst the aliens recorded, but only in small quantity.

Lathyrus ciliatus, Guss., is a vetchling determined for me by Mr. Baker, and widely disseminated in Europe westward from central Spain. I met with but a single example.

Œnothera sinuata, Linn., was determined for me at Kew. A plant which I sent to Kew three years ago as *Œ. sinuata* was then named *Œ. humifusa*, and I cannot separate it from *sinuata.*

Bupleurum rotundifolium, Linn., accounted British; and *B. protractum*, Link et Hoffm., a plant with south-eastern European distribution, were both frequent in 1908. In the following year both species occurred sparingly.

Orlaya grandiflora, Hoffm. Only two examples of this widely distributed species were noticed in 1908.

Caucalis daucoides, Linn., another widely spread European species, was represented by a single plant.

Helianthus annuus, Linn., is a third species of this large genus which has occurred on the sandhills in about half-a-dozen examples. There is a fourth species which, I think, belongs to this genus growing on the roads in St. George's Gardens, and which I brought away with me in the spring of 1909 to cultivate in my Gloucestershire garden, but it flowers late and did not disclose itself in that year. It has been named for me by botanical friends as a *Dahlia*, and as a *Scabiosa !*

Matricaria Chamomilla, Linn., although growing in cultivated fields in various parts of north Lancashire, must be included in a list of St. Anne's aliens, as it was a frequent plant in one portion of the poultry area.

Onopordon Acanthium, Linn., was a not infrequent species, but it was rarely allowed to reach maturity.

Mariana lactea, Hill. This conspicuous milk-thistle was represented by three or four examples and, though occasionally seen in the St. Anne's gardens, I had no reason to suspect its having been introduced other than through poultry grain.

Centaurea Cyanus, Linn., and *C. melitensis*, Linn.; the first named frequent; the last named, in few examples only, is a south European species.

Carthamus lanatus, Linn. (*Kentrophyllum lanatum*, DC.). The foliage only, but there is no doubt as to the species. It ranges from Portugal to Crete, and from Switzerland to the Adriatic, Greece, and Turkey.

Anagallis cærulea, Lamk. Only a plant or two occurred; but in an old fowl run at Birkdale, on the opposite shore of the estuary it was most abundant, in the summer of 1907, with many other aliens, as *Cerinthe minor*, *Salvia verticillata*, *Silene noctiflora*, *Delphinium Ajacis*, *Silene dichotoma*, *Trifolium resupinatum*, *Berteroa incana*, *Anchusa officinalis*, *Chenopodium ficifolium*, *Stachys italica*, &c.

Benthamia lycopsioides, Lindl. (*Amsinckia lycopsioides*, Lehm.) Beyond making out this plant to be a species of *Amsinckia*, I found it so dimorphic that I sent a range of seventeen sheets to Kew to assist in unravelling the species, some of which I named *A. lycopsioides*, and some *A. angustifolia*. Of these sheets eight were returned named *lycopsioides*; the other nine were unnamed including three which I had thought to be *angustifolia*. All the examples of *lycopsioides* had their anthers at, or below, half the length of the tube of the orange-coloured corolla, the typical example of the species having them much below half that length. The nine unnamed sheets represent some other species having a corolla with a shorter tube, and in which the anthers are above half the length of the tube. In 1907 these plants occurred in the greatest profusion and I was able to send away more than 200 sheets for herbaria. In the season following it was not possible to collect more than a dozen examples, through the building of a pair of houses and the levelling of the adjacent land for roads and gardens, Devonshire Road, and a new road exactly intersecting the locality. *A. lycopsioides* has occurred in Europe, but the only examples of this species in my herbarium are a stunted, unbranched, form not exceeding four inches in height, from the neighbourhood of Berlin; whereas the St. Anne's plants are luxuriant examples eighteen inches or more in height. From a note in the 'Prodromus' (vol. x., p. 118) it would appear that the native country of *A. lycopsioides* is unknown, though thought to be north western America. The species of *Amsinckia* must be spreading in this country, as I have a third species collected by Mr. Jas. E. Macdonald on waste heaps at Poynton, in Cheshire; in this example the stamens are in the throat of the corolla. *A. angustifolia*, Lehm., if correctly named, was sent me from Rouen in 1904.

Anchusa italica, Retz. A plant with a wide European distribution, occurred in the middle of October, 1907; few examples were seen, as by that date the traffic across the sandhills did not permit the plants to mature.

Myosotis virginica (Linn.), B.S.P. This was one of the very few American species which were noticed during the summers of 1907 and 1908. The corolla is usually white, but the St. Anne's examples were a faint blueish pink.

Datura Stramonium, Linn. A single example of a widely-spread European species.

Verbascum virgatum, Stokes. A plant in the British lists, but adventitious at St. Anne's. *V. thapsiforme*, Schrad. (named for me by Mr. Baker), occurred on the sandhills within the area, but not associated with other aliens.

Salvia verticillata, Linn., was another European species of wide distribution which was fairly frequent at St. Anne's in 1908; it was scarcer in 1907.

Salvia viridis, Linn. A few examples of this brightly coloured species were met with; it attracted too much attention to escape destruction.

Salvia Andrzejowski, Blocki. A Transylvanian species, the name of which I owe to Mr. Baker; very difficult to account for at St. Anne's. There were numerous examples, but few reached maturity.

Stachys italica, Mill. A species with distribution from southern Italy eastwards. Only a single example seen.

Dracocephalum parviflorum, Nutt. This plant gave some trouble to the Kew authorities to name, and it was returned without a name, but Mr. Baker unravelled it for me. It is an American species, and about half a dozen examples were seen; one, which I transplanted to my garden at St. Anne's, developed into a stunted, starved plant, quite unlike the naturally grown plants.

Cyclocoma atriplicifolium, Coulter, (*C. platyphyllum*, Moq.). Another American species, which I could not have made out without assistance from Kew. It is a plant which affects the banks of streams in Manitoba, Indiana, Nebraska, &c.

Chenopodium murale, Linn. A British species, but considered a casual at St. Anne's. Mr. J. A. Wheldon has found it at the Wyre Docks, Fleetwood.

Chenopodium hybridum, Linn. This species was plentiful in one locality only, in 1907, growing with *Rubus cæsius*. It had not occurred at this spot during the five previous years. It is a British species, not native at St. Anne's.

Axyris amarantoides, Linn. A gigantic specimen, from which I was in time to rescue two good examples only; one of these was presented to Kew, at the request of the herbarium department. I have the plant from Nertschinsk, and from between Omsk and Kurgau, in Siberia, where it is frequent. It is difficult to surmise how it reached St. Anne's.

Panicum miliaceum, Linn. A moderately sized colony of this grass has been established in one of the hollows of the sandhills, apparently for some years, but it did not flower until 1907; little of it was left in 1908, as road formation had begun.

Phalaris canariensis, Linn., and *P. minor*, Retz., were not infrequent during the summers of 1907 and 1908.

Bromus tectorum, Linn., occurred sparingly, but always in association with other aliens.

Secale cereale, Linn. In profusion, on one part of the sandhills, close to Devonshire Road. The grasses escape the depredations of flower-gatherers, and so reach maturity.

During the latter part of my residence at St. Anne's a good portion of this area was being broken up into paved roads, and the sites of the houses which follow the roads have greatly interfered with the locality; but as the poultry get pushed further north a similar alien flora may be expected to follow in their wake. I can only regret that my removal from the neighbourhood now prevents me from continuing these observations.

CORRIGENDA AND ADDENDA.

Page	2	line	22	for	*inæquilateralis*, Schlumberger	read	*affixa*, Terquem.
,,	32	,,	5	,,	*inæquilateralis*, Schlumberger	read	*affixa*, Terquem.
,,	7	,,	15	,,	*involvans*	read	*involvens.*
,,	13	,,	16	,,	*dilitata*	,,	*dilatata.*
,,	13	,,	18	,,	Sequenza	,,	Seguenza.
,,	15	,,	7	,,	,,	,,	,,
,,	16	,,	26	,,	,,	,,	,,
,,	18	,,	13	,,	,,	,,	,,
,,	19	,,	11	,,	,,	,,	,,
,,	18	,,	6	,,	*staphylleria*	,,	*staphyllearia.*
,,	19	,,	17	,,	*lucunata*	,,	*lacunata.*
,,	34	,,	14	,,	,,	,,	,,
,,	22	,,	17	,,	*sorroria*	,,	*sororia.*
,,	29	,,	2	,,	*mineaceum*	,,	*miniaceum.*
,,	29	,,	18	,,	*boneana*	,,	*boueana.*
,,	32	,,	8	,,	*baccillaris*	,,	*bacillaris.*
,,	17	,,	2	after	"one nearly globular"	*add*	("with very deep cells of which the walls are exceedingly delicate");

Manchester Memoirs, Vol. liv. (1910), *No.* **16**.

XVI. Report on the Recent Foraminifera from the Bay of Palermo, Sicily, 14-20 fms. (Off the Harbour.)

By HENRY SIDEBOTTOM.

Received and read May 3rd, 1910.

NOTE.

The following note was printed at the end of my Delos papers :—

> "I hope next year to deal with the Foraminifera from Palermo, describing and illustrating the species that occur there, and not at Delos. This contribution, taken in conjunction with my Delos papers, will give a complete record for Palermo."

A full description of the species not described in this work, will be found in my papers on the Delos Foraminifera.*

The material was dredged by my brother-in-law, C. H. Nevill, Esq., of Bramall Hall, Cheshire, in 1897, from the harbour of Palermo, 14-20 fms. He went carefully through the material, and mounted type-slides of the specimens, presenting them to me.

MILIOLIDÆ.

NUBECULARINÆ.

Nubecularia, Defrance.

Nubecularia tibia, Jones and Parker. (Pl. 1. fig. 1).

The tests are semi-transparent.

* Report on the Recent Foraminifera from the Coast of the Island of Delos. *Manchester Memoirs*, vol. 48 (1904) No. 5., vol. 49 (1905) No. 5., vol. 50 (1906) No. 5, vol. 51 (1907) No. 9, vol. 52 (1908) No. 13, vol. 53 (1909) No. 21.

Nubecularia lucifuga, Defrance.

Nubecularia bradyi, Millett. (= *N. inflata*, Brady).

MILIOLININÆ.

Biloculina, d'Orbigny.

Biloculina irregularis, d'Orbigny.

The tests are not typical, and may be the biloculine form of *Triloculina cuneata*, Karrer. This remark refers also to the Delos specimens.

Biloculina elongata, d'Orbigny.

Biloculina ringens, Lamarck, sp.

Good, but rather elongate, one nearly globular occurs.

Biloculina tubulosa, Costa.

A single specimen.

Spiroloculina, d'Orbigny.

Spiroloculina planulata, Lamarck, sp.

Spiroloculina excavata, d'Orbigny.

Spiroloculina dorsata Reuss (= *Sp. limbata*, d'Orb.).

Spiroloculina impressa, Terquem.

Spiroloculina nitida, d'Orbigny.

Spiroloculina grata, Terquem.

Very good examples of this species occur.

Spiroloculina inæquilateralis, Schlumberger. (Pl. 1, fig. 2).

Only three found, and they agree with Schlumberger's figure.

Sigmoïlina, Schlumberger.

Sigmoïlina tenuis, Czjzek, sp.

Only one found.

Sigmoïlina costata Schlumberger.

Miliolina, Williamson, 1858.

Miliolina oblonga, Montagu, sp.

Miliolina bosciana, d'Orbigny, sp.

Miliolina rotundata, d'Orbigny, sp.

Miliolina circularis, Borneman, sp.

Miliolina subrotunda, Montagu, sp.

See Delos work, *Manchester Memoirs*, vol. 48 (1904), No. 5, p. 8, for account of the two forms present in these gatherings.

Miliolina suborbicularis, d'Orbigny, sp.

Miliolina marioni, Schlumberger, sp.

See remarks in Delos paper, *Manchester Memoirs*, vol. 48 (1904), No. 5, p. 9.

Miliolina schreiberiana, d'Orbigny, sp.

This species appears to be very closely related to *M. trigonula*, Lamarck, sp.

Miliolina labiosa, d'Orbigny, sp.

As in the Delos examples no line of demarcation can be drawn between *Nubecularia bradyi* (= *N. inflata*, Brady) and *M. labiosa*, d'Orbigny, sp.; and Mr. Millett in his Malay work states that it ranges from *N. bradyi* to *M. valvularis.*

Miliolina reticulata, d'Orbigny, sp.

The examples are of the carinate and bi-carinate variety.

Miliolina seminulum, Linné, sp.

The flat variety, see Delos, (*Manchester Memoirs*, vol. 48 (1904), No. 5, p. 10, and pl. 3, figs. 13—15) is also present, but is evidently rare.

Miliolina auberiana, d'Orbigny, sp.

There are only two on the slide, and they are of the elongate variety.

Miliolina cuvieriana, d'Orbigny, sp.

The specimens are small. The *Q. seminuda* of Reuss, with the rounded periphery striate, is also present.

Miliolina boueana, d'Orbigny, sp.

These are all in the triloculine condition. (See Delos paper).

Miliolina lævigata, d'Orbigny, sp.

Miliolina undosa, Karrer, sp. (Pl. 1, fig. 3.)

The examples are finely striate.

Miliolina pygmæa, Reuss, sp.

They agree with the Delos forms of this species. One of the specimens is much stouter than the rest.

Miliolina contorta, d'Orbigny, sp.

The tests are slightly roughened.

Miliolina sclerotica, Karrer, sp.

The tests are rough and much broader in proportion to their length than *M. contorta*. They appear to be the same as those figured by Schlumberger under the name of

Q. rugosa, d'Orb., in his monograph of the *Miliolina* from the Gulf of Marseilles.

Miliolina stelligera, Schlumberger, sp.

See remarks in Delos paper.

Miliolina gracilis, d'Orbigny, sp.

Judging from the number on the slide, these must be of very frequent occurrence.

Miliolina agglutinans, d'Orbigny, sp.

The specimens are rather small and similar to the Delos examples.

Miliolina bicornis, Walker and Jacob, sp.

Very fine specimens are present of the form figured in the Delos work, although some of the specimens are much broader.

Miliolina disparilis, d'Orbigny, sp.

See remarks, Delos paper. The Palermo examples are very fine.

Miliolina costata, d'Orbigny, sp.

This is a neat, elongate variety, the test is rather finely costate.

Miliolina ferussacii, d'Orbigny, sp.

Only two specimens are on the slide, but there are five good examples of the form referred to under this heading in the appendix to my Delos work. I state there that they are probably a feeble variety of the elongate form of *M. ferussacii*.

Miliolina valvularis, Reuss, sp.

The extent to which the valve fills up the orifice varies very considerably. The biloculine form is also present, but is evidently very rare.

Miliolina linnæana, d'Orbigny, sp.

Only one on the slide.

Miliolina pulchella, d'Orbigny, sp.

HAUERININÆ.

Articulina, d'Orbigny.

Articulina funalis, Brady.

There is only a single specimen on the slide.

Articulina funalis, var. *inornata*, Brady.

Five good examples found.

Vertebralina, d'Orbigny.

Vertebralina striata, d'Orbigny.

Glancing through some of the material, this species seems fairly common.

Massilina, Schlumberger.

Massilina secans, d'Orbigny, sp.

Hauerina, d'Orbigny.

Hauerina compressa, d'Orbigny.

I must draw my readers' attention to the remarks on this form in my Delos paper (*Manchester Memoirs*, vol. 48 (1904) No. 5, p. 19, and pl. 5, figs. 7, 8). It is a curious fact that in the fourteen specimens on the Palermo slide not one has the aperture showing the cribrate arrangement, entire. Two specimens have partial indications of it; whereas, in the numerous examples from Delos, the majority have the cribrate aperture complete.

Planispirina, Seguenza.

Planispirina schlumbergeri, Sidebottom.

There are three examples of this species on the slide, but they have not fully reached the hauerine stage, and, therefore, the outline of the test is oblong, instead of nearly circular. For full particulars see the Delos paper (1904).

Planispirina striata, Sidebottom.

See Delos paper (1904). This species must not be confused with the hauerine form of *Mil. suborbicularis*, d'Orb., which also has three chambers in the last whorl.

In *P. striata* the central chambers are exposed, but in *M. suborbicularis*, at any rate in the Delos examples, this is not the case.

Cornuspira, Schultze.

Cornuspira foliacea, Philippi, sp.

Fine examples occur.

Cornuspira involvans, Reuss.

Only one of them shows the microspheric condition.

Peneroplidinæ.

Peneroplis, Montfort.

Peneroplis pertusus, Forskål, sp. var. a. *planatus*, Fichtel and Moll, sp.

Peneroplis pertusus, Forskål, sp. var. c. *arietinus*, Batsch, sp.

Peneroplis pertusus, Forskål, sp. var. d. *cylindraceus*, Lamarck, sp.

Peneroplis pertusus, Forskål, sp. var. g. *laevigatus*, Karrer.

Orbitolites, Lamarck.

Orbitolites duplex, Carpenter.

There are only two or three specimens on the slide, and although on their peripheral edges the chambers sometimes alternate and sometimes do not, still I think they may be referred to this variety, viz., *O. duplex*.

ARENACEA.

ASTRORHIZIDÆ

SACCAMMININÆ.

Psammosphæra, Schultze.

Psammosphæra fusca, F. E. Schultze. (Pl. 1, fig. 4).

Three were found. The test is composed of whitish sand grains, cemented together with dark brown material. They are very small and rough.

LITUOLIDÆ.

LITUOLINÆ.

Reophax, Montfort.

Reophax difflugiformis, Brady.

Reophax scottii, Chaster.

This flexible and curious species is well represented.

Reophax scorpiurus, Montfort.

Reophax bacillaris, Brady. (Pl. 1, fig. 5).

A single, rather distorted specimen. It answers well to Brady's description of the species, except as regards colour, which, instead of being the usual grey, is light yellow-brown.

Haplophragmium, Reuss.

Haplophragmium pseudospirale, Williamson, sp. (Pl. 1, fig. 6).

The five specimens are more compactly built than is usual with this species. They are brown in colour, and the spiral commencement of the test is much smaller than in the type.

Haplophragmium canariense, d'Orbigny, sp.

Frequent.

Haplophragmium nanum, Brady.

There is a single characteristic example on the slide.

Haplophragmium globigeriniforme, Parker and Jones, sp.

Haplophragmium agglutinans, d'Orbigny, sp.

A fragment.

TROCHAMMININÆ.

Ammodiscus, Reuss.

Ammodiscus incertus, d'Orbigny, sp.

It occurs in two colours, yellowish-brown and white, the latter is the smaller of the two varieties.

Ammodiscus gordialis, Jones and Parker, sp.

A solitary specimen.

Ammodiscus perversus, n. sp. (Pl. 1, fig. 7).

There is only one specimen in fair condition on the slide, and this is the one figured, the remaining two being fragments. They are evidently adherent forms. The test is composed at its commencement of a simple coiled tube, but later on the tube is much larger, and is coiled over the earlier portion with the last part of the tube bent back irregularly. The test is rough, of a light brown colour, and is built up of fine sand grains. The under surface is flat.

Looking through some of the coarse material, I have come across another specimen which is perfect; but too late to make a drawing of it, as the plates were already set up. It only differs from the one illustrated in not having the central portion of the test completely covered up, and the end of the tube is not bent back on the upper surface, but is doubled back at the side of the test.

Trochammina, Parker and Jones.

Trochammina inflata, Montagu, sp.

Trochammina squamata, Parker and Jones.

The tests are very small, and the number of chambers in the last whorl varies from three to five. In some of the specimens the chambers are more inflated than in the type.

Trochammina ochracea, Williamson, sp.

Carterina, Brady.

Rotalia, Carter (1877).

Carterina spiculotesta, Carter, sp.

There are seven small examples of this interesting species on the slide.

TEXTULARIDÆ.

TEXTULARINÆ.

Textularia, Defrance.

Textularia concava, Karrer, sp.

The specimens are typical.

Textularia agglutinans, d'Orbigny.

The form *T. candeiana*, d'Orbigny is also present.

Textularia gramen, d'Orbigny.

Textularia trochus, d'Orbigny.

Two good examples are on the slide.

Textularia rhomboidalis, Millett.

Excellent examples occur.

Spiroplecta, Ehrenberg.

Spiroplecta sagittula, Defrance, sp.

One very good specimen is present.

Spiroplecta rosula, Ehrenberg. (Pl. 1, fig. 8.)

This is a hyaline and perforate form of *S. biformis*. Brady reports it from the North East Coast of England. There are seven specimens on the slide. They are quite transparent and very small. The perforations do not show quite so distinctly as those in my illustration.

Gaudryina, d'Orbigny.

Gaudryina filiformis, Berthelin. (Pl. 1, fig. 9.)

The tests are very small and of a light rusty-red colour. They correspond to some of the specimens from the Irish coast, and Mr. Wright of Belfast considers they are rightly placed under this heading. Most of the tests are nearly sharp at the commencement, and this may be the microspheric form.

Verneuilina, d'Orbigny.

Verneuilina polystropha, Reuss, sp.

Very large specimens are found in this material, and they are of a rusty-red hue as a rule. Among the examples on the slide are two which are short and stumpy.

Verneuilina spinulosa, Reuss.

Evidently very frequent.

Clavulina, d'Orbigny.

Clavulina angularis, d'Orbigny. (Pl. 1, fig. 10).

Two very good examples are shown on the slide. Brady in the Challenger Report states that it occurs in the Mediterranean and the Red Sea.

BULIMININÆ.

Bulimina, d'Orbigny.

Bulimina elegans, d'Orbigny.

Bulimina elegans, d'Orbigny, var. *exilis*, Brady. (Pl. 1, fig. 11).

A solitary specimen.

Bulimina subteres, Brady.

Frequent.

Bulimina elegantissima, d'Orbigny, var.

See Delos paper (1905) pl. 2, figs. 7-12, and pl. 3, fig. 1.

Bulimina elongata, d'Orbigny.

Bulimina marginata.

Excellent examples are on the slide and they are frequent.

Bulimina aculeata, d'Orbigny.

Present in two forms, one of which is short with the earlier chambers very small, and the rest rather suddenly increasing in size ; and the other is elongate with chambers more or less inflated. Some of the latter might be brought under *B. elegans* if it were not for a few spines about the base, and others under *B. pupoides* but for the same reason.

Bulimina pyrula, d'Orbigny.

Bulimina convoluta, Williamson, var. *nitida*, Millett.

One of the specimens on the slide is very large.

Virgulina, d'Orbigny.

Virgulina schreibersiana, Czjzek.

There are typical specimens on the slide, and also the variant figured in the Delos paper (1905), pl. 3, fig. 4.

Virgulina squamosa, d'Orbigny.

See Delos (1905) pl. 3, fig. 5.

Virgulina subsquamosa, Egger.

Bolivina, d'Orbigny.

Bolivina punctata, d'Orbigny.

Bolivina nobilis, Hantken.

The specimens vary a great deal as to the number of striæ; in one case the striæ are so numerous that the chambers of the lower half of the test are completely concealed by them. Most of the tests are broader at the oral end than those figured by Brady in the Challenger Report.

Bolivina textilarioides, Reuss.

The tests are small and transparent.

Bolivina tortuosa, Brady.

Bolivina dilitata, Reuss.

The specimens are typical.

Bolivina beyrichi, Reuss, var. *alata*, Sequenza.

Four large typical specimens are on the slide.

Bolivina plicata, d'Orbigny.

These agree with the British form of this species.

Bolivina limbata, Brady ?

See Delos paper, p. 15 (1905) for particulars of the specimens (line 10 from top of page).

Mimosina, Millett.

Mimosina hystrix, Millett, var.

They agree with the Delos form of this interesting species.

Cassidulina, d'Orbigny.

Cassidulina crassa, d'Orbigny.

The examples are small.

Cassidulina lævigata, d'Orbigny.

The tests of this species are of the usual milky hue, and are much larger than the previous form.

Cassidulina bradyi, Norman.

Evidently very rare.

CHILOSTOMELLIDÆ.

Chilostomella, Reuss.

Chilostomella ovoidea, Reuss.

There is a single specimen on the slide.

LAGENIDÆ.

LAGENINÆ.

Lagena, Walker and Boys.

Lagena globosa, Montagu.

Globular and slightly elongate examples are frequent.

Lagena apiculata, Reuss.

A single specimen of the globose form.

Lagena botelliformis, Brady, var.

One example, see Delos (1906), pl. 1, fig. 1.

Lagena ampulla-distoma, Rymer Jones.

Both the forms illustrated in the Delos paper are frequent, the smaller has the tubercles on the lower half of the test better developed than they are shown in the Delos illustration.

Lagena lineata, Williamson, sp.

Lagena variata, Brady.

Lagena lævis, Montagu, sp.
Frequent.

Lagena lævis, Montagu, var. *distoma*, Silvestri. (Pl. 1, fig. 12).
Both the globular and ovate forms are on the slide.

Lagena lyellii, Sequenza, sp. (Pl. 1, figs. 13, 14, 15, 17, 18?).
These range from the nearly globular form to the ovate, and are frequent; they nearly all have the neck decorated and a phialine lip.

Lagena striata, d'Orbigny, sp. (Pl. 1, figs. 16, 19, 20, Pl. 2, fig. 1).
Besides the oval form, there are elongate (frequent), and two or three somewhat club-shaped forms. . . . .

I would here draw particular attention to the fine "clusters" of *Lagena* found at this locality. They are apparently composed of *L. lyellii*, *L. striata* and *L. semi-striata*. The lower portion of their tests springs from an irregular chamber and is not embedded in it, the bases of the *Lagena* being part of the irregular chamber. This chamber is marked more or less by broken-up costæ, and small blunt spines or tubercles, and often has several orifices besides the one that opens into the body of the *Lagena*, which sometimes has three necks. The orifices of the irregular chamber are, I think, simply nipples. It looks as if this irregular chamber were the parent one. In Fig. 1, Pl. 2, it will be noticed that one of the tests is smaller than the other two, and has a short neck with everted lip. Would it have expanded its test, and increased the length of its neck as the others have done? The lowest test in this figure has its chief neck snapped off. In Fig. 17, Pl. 1, two tests appear to be joined together. Is this a case of plastogamy? In one example the *Lagena* has evidently been broken off from the irregular chamber, and has left a circular mark with the small nipple orifice in the centre, the contour of the irregular chamber remaining undisturbed.

There are nine other examples on the slide, but most of them are smaller, and not in such good condition as those chosen for illustration.

Lagena semistrata, Williamson. (Pl. 2, fig. 2).

Very good examples are on the slide, and they are evidently of frequent occurrence. There is considerable variety in the shape of the tests.

Lagena sulcata, Walker and Jacob, sp.

Two examples.

Lagena sulcata (W. and J.), var. *interrupta*, Williamson.

Three or four only.

Lagena acuticosta, Reuss.

Very rare.

Lagena gracilis, Williamson.

One test is exactly like fig. 12, pl. 1 in Williamson's "Recent Foraminifera of Great Britain" (1858). In the other examples the number of costæ varies from four upwards.

Lagena clavata, d'Orbigny, sp.

Lagena gracillima Sequenza, sp.

Lagena distoma, Parker and Jones.

A single good specimen.

Lagena hexagona, Williamson, sp. (Pl. 2, fig. 3).

Present in two forms, one nearly globular, and the other very small. The hexagonal markings on the latter are large in comparison with the size of the test, and it also has a short neck with four very small wings running up it from the upper part of the body of the test.

Lagena reticulata, Macgillivray, sp. (Pl. 2, fig. 4).

A few good ones occur.

Lagena melo, d'Orbigny, sp.

Only one example on the slide.

Lagena striatopunctata, Parker and Jones. (Pl. 2, fig. 5).

There are thirty-seven specimens on the slide, of the form that has its sides parallel. All the necks are bent to one side, as was the case with the Delos specimens. The bottoms of the tests are rounded off. One example (see figure) has five costæ, and the body of the test is of a different form from the rest. The neck is apparently broken off.

Lagena desmophora, Rymer Jones. (Pl. 2, fig. 6).

A single, small specimen, of which the neck appears to be broken.

Lagena lævigata, Reuss, sp.

Lagena lævigata, Reuss, sp., var. *acuta*, Reuss, sp.

The form with the small ring at the base (which often projects very slightly at the sides into a delicate point) is also present.

Lagena lucida, Williamson, sp. (Pl. 2, fig. 7).

The three forms present are those represented by my drawings in the Delos paper (1906) pl. 1, figs. 9, 10, (also apiculate) and 11.

There is one example of trigonal form, see figure.

Lagena quadrata, Williamson, sp. (Pl. 2, fig. 8).

Besides the single specimen illustrated, there are solitary examples similar to those figured from Delos, pl. 1, fig. 22 (but without the frosted band), and pl. 2, fig. 2, also many like pl. 2, fig. 3.

Lagena staphylleria, Schwager, sp.

Apparently rare. There is a single test like fig. 20 on the Delos plate.

Lagena marginata, Walker and Boys.

The examples are small. There is a form present which seems to me to be half way between *L. marginata* and *L. marginata*, var. *semimarginata*, Reuss.

Lagena marginato-perforata, Sequenza.

Occurs in five forms. One like the Delos figure 5, pl. 2; another (the largest) approaching *L. quadrata* in contour; a single specimen, circular, with a slightly produced neck; two or three approaching *L. marginata*, var. *semimarginata*, Reuss, and two or three very small ones of *L. lævigata* form. All show the bare patch in the centre of the test.

Lagena marginata (W. & B.) var. *inæquilateralis*, Wright.

Very rare.

Lagena fasciata, Egger, sp.

See Delos paper (1906) pl. 1, figs. 15, 16. Only these two varieties are on the slide.

Lagena lagenoides, Williamson, sp. (Pl. 2, figs. 9, 10, 11).

There is one large specimen agreeing with Brady's Challenger figure, fig. 14, except that the test is twisted. There are likewise eleven very small tests of this variable species like the one illustrated, Fig. 9, Pl. 2, and three of the trigonal form in which the keel is split, Fig. 11. There is a single example which is four-sided and has a neck produced. A very handsome variety (Fig. 10, Pl. 2) also occurs, but very rarely, which I have placed under this heading on the advice of Mr. Millett, as the band between the body of the test and the keel is unornamented, otherwise it would be placed under *L. formosa*, Schwager.

Lagena lagenoides (Williamson) var. *tenuistriata*, Brady.

A few like those figured in the Delos paper. They are very small.

Lagena orbignyana, Sequenza. (Pl. 2, fig. 12, and fig. 13, var.).

Occurs in various forms besides the following. Fig. 12, Pl. 2 is trigonal. Fig. 13 is a pretty variation.

Lagena orbignyana, var. *clathrata*, Brady.

Lagena orbignyana, var. *variabilis*, Wright.

Lagena orbignyana, var. *lucunata*, Burrows and Holland. (Pl. 2, fig. 14).

Lagena orbignyana, var. *walleriana*. (Pl. 2, fig. 15).

Very rare.

Lagena fimbriata, Brady.

Frequent.

Lagena alveolata, Brady.

They are like the Delos example of this species. Very rare.

Lagena exculpta, Brady. (Pl. 2, fig. 16).

One example of the compressed form.

Lagena protea, Chaster. (Pl. 2, figs. 17, 18).

Fine and varied specimens are on the slide.

NODOSARINÆ.

Nodosaria.

Nodosaria calomorpha, Reuss.

Very frequent. Some have as many as seven chambers, and are of similar form to the Delos figure, pl. 1, fig. 2 (1907).

Nodosaria communis, d'Orbigny.

Nodosaria scalaris, Batsch, sp. (Pl. 2, figs. 19, 20, 21).

A few good examples. There are about nine similar to Fig. 19, Pl. 2, and they are much larger than the ordinary form present. It is possible they may be double Lagenas, as the individual chambers bear a strong likeness to some of the Lagenas on the slide, both as regards size and markings.

Nodosaria chrysalis, Sidebottom.

About twenty good examples are on the slide ; they are the same as those from Delos.

Lingulina, d'Orbigny.

Lingulina carinata, d'Orbigny.

Several of them are good examples of this species, and have the aperture normal. Forms similar to the Delos figures 18, 19, pl. 1 (1907), are on the slide.

Lingulina carinata (d'Orb.) var. *bi-carinata*, Sidebottom.

There is one test with four chambers on the slide ; the bi-carinate condition is well marked.

Lingulina pellucida, Sidebottom.

There are thirty-four typical specimens on the slide and one with three segments. Their likeness to a pocket brandy flask is remarkable. A full account of this species is given in the Delos paper.

Frondicularia, Defrance.

Frondicularia spathulata, Brady, sp. (Pl. 2, fig. 22.)

A solitary specimen.

Marginulina, d'Orbigny.

Marginulina costata, Batsch, sp. (Pl. 3, figs. 1, 2, 3.)

Frequent; see Delos paper for full account of this variety.

Intermediate forms between *Cristellaria,* and the genera *Vaginulina* and *Marginulina.* (Pl. 3, figs. 4—7.)

Fig. 5, Pl. 3, as Mr. Millett kindly pointed out, has the characters of *Amphicoryne.*

Cristellaria, Lamarck.

Cristellaria crepidula, Fichtel and Moll, sp.

Typical and non-typical examples are fairly frequent, and a few are of the ensiform variety.

Cristellaria rotulata, Lamarck, sp.

The specimens are very rare.

Cristellaria variabilis, Reuss.

Four good examples, with the last two chambers erect; they are without the keel. There is, however, a solitary one which is small, almost round in contour, and with a narrow keel.

Cristellaria acutauricularis, Fichtel and Moll. (Pl. 3, fig. 8.)

Amphicoryne, Schlumberger.

Amphicoryne, sp.?

They correspond to the Delos forms in every particular.

POLYMORPHININÆ.

Polymorphina, d'Orbigny.

Polymorphina lactea, Walker and Jacob, sp.

Polymorphina amygdaloides, Reuss.

The specimens on the slide are very good examples of this compressed form.

Polymorphina lactea (W. and J.), var. *oblonga*, Williamson.

One or two specimens occur, but they are not quite typical.

Polymorphina gibba, d'Orbigny.

Polymorphina communis, d'Orbigny.

Two examples only.

Polymorphina compressa, d'Orbigny.

Large examples ; fistulose forms also.

Polymorphina lactea, var. *concava*, Williamson.

A few small examples occur.

Polymorphina sororia, Reuss.

The tests are not quite typical. Some are round at the base, approaching *P. gutta*, and others slightly pointed ; all are small.

Polymorphina spinosa, d'Orbigny, sp.

See Delos paper (1907) for an account of these.

Polymorphina complexa, Sidebottom.

There are ten tests of this protean species on the slide. They none of them correspond with the Delos examples, but the aperture and colour are the same.

Full particulars are given on page 16 in the Delos paper (1907).

Polymorphina, sp.

There are a few large masses of *Polymorphina*, which are, no doubt, monstrosities.

Uvigerina, d'Orbigny.

Uvigerina angulosa, Williamson.

Fair examples.

Uvigerina, sp.

See Delos paper (1908), fig. 7, pl. 1. The Palermo specimens are better examples of what appears to be an intermediate form, approaching *U. porecta*, Brady.

Uvigerina pygmæa, d'Orbigny.

There are three good ones on the slide.

Uvigerina auberiana (d'Orb.), var. *glabra*, Millett.

Very fine examples are present, and in considerable numbers.

Sagrina, Parker and Jones.

Sagrina nodosa, Parker and Jones. (Pl. 3, figs. 9, 10).

Occurs in two forms as illustrated. In one case the test is almost smooth, and in the other the striæ are well marked ; in both the striæ are broken up into dots.

GLOBIGERINIDÆ.

Globigerina, d'Orbigny.

Globigerina bulloides, d'Orbigny.

Globigerina triloba, Reuss.

See remarks in the Delos paper.

Globigerina rubra, d'Orbigny.

Globigerina inæquilateralis, Brady.

Globigerina inflata, d'Orbigny.

These are in capital condition.

Orbulina, d'Orbigny.

Orbulina universa, d'Orbigny.

Besides the usual typical form, there is one specimen which is double, the *G. bilobata* of d'Orbigny.

ROTALIDÆ.

SPIRILLININÆ.

Spirillina, Ehrenberg.

Spirillina vivipara, Ehrenberg.

The largest examples on the slide are like the one figured in the Delos paper (1908), fig. 1, pl. 2. The others are represented by Fig. 13, Pl. 1. The Palermo examples of this form are composed of only two convolutions.

Spirillina obconica, Brady.

This is a rare form. There are three specimens of this small and delicate species. The swollen commencement of the tube, referred to by Brady in the Challenger Report, is well marked, especially in one of the tests, all three of which consist of about three and a half convolutions.

ROTALINÆ.

Patellina, Williamson.

Patellina corrugata, Williamson.

Frequent.

Cymbalopora, Hagenow.

Cymbalopora poeyi, d'Orbigny, var.

The tests are of the variety figured by Brady in the Challenger Report, pl. 102, fig. 14.

Discorbina, Parker and Jones.

Discorbina globularis, d'Orbigny, sp. and varieties.

The type is evidently rather rare, but the variations frequent. Forms like those figured in my Delos paper (1908) occur, viz., pl. 3, figs. 3, 5, and pl. 4, figs. 1, 2.

Discorbina rosacea, d'Orbigny, sp.

Large examples like the Delos specimens, pl. 4, figs. 3, 4, also fig. 5, which are rare, and one good test almost identical with the Challenger figure, pl. 87, fig. 1.

Discorbina orbicularis, Terquem, sp.

Discorbina araucana, d'Orbigny, sp.

Discorbina vilardeboana, d'Orbigny, sp.

Discorbina tabernacularis, Brady. (Pl. 3, fig. 12.)

I am much puzzled with these; they appear to be nearest to Brady's Challenger figure, pl. 89, fig. 7, but they show no limbation, and the sutures are slightly sunk. Some of the tests are tall, others much flattened, and with three exceptions they are all in the state known as plastogamy, that is joined together at their bases, and there are in some instances as many as four pairs clustered together. There are also cases of a tall cone-shaped test joined to a flattened one, as in the illustration, Fig. 12, Pl. 3. The striæ show on the inferior surface.

Discorbina tuberculata, Balkwill and Wright.

Very frequent.

Discorbina parisiensis, d'Orbigny, sp.

In the Palermo examples the final convolution never entirely covers the central portion of the test on the superior side. There is a set present which has much shorter and more inflated segments, these have the edge of the test more rounded.

Discorbina nuda, n. sp.

In the appendix to my Delos papers (1909) reference is made to this species under the heading *Discorbina*, sp. p. 18 and figured on pl. 5, fig 11. On the Palermo slide are numerous specimens and they are so unvarying in their characteristics that I feel justified in giving a specific name to them. They are transparent, and have from six to eight segments showing on the superior surface, of which four or five constitute the final convolution. The pores can only be seen under a high power. The test is convex on the superior surface, and on the inferior the umbilical cavity is large and deeply sunk. The edge of the test is slightly rounded, the segments arched, the sutures sunk, and the margin of the test is lobulated. The initial chamber is round and conspicuous.

Discorbina vesicularis, Lamarck, sp.

Beautiful specimens of this species are on the slide, with well-developed astral flaps.

Discorbina bertheloti, d'Orbigny, sp.

Discorbina saulcii, d'Orbigny, sp. (Pl. 3, fig. 11).

The specimens are in good condition and agree with examples Mr. Millett sent to me from the coast of Algiers, 80 fms. Very frequent. Numerous in the Bay of Eleusis.

Discorbina rugosa, d'Orbigny, sp.

Planorbulina, d'Orbigny.

Planorbulina mediterranensis, d'Orbigny.

Forms similar to the Delos specimens, figs. 1, 2, pl. 1, (1909).

Planorbulina acervalis, Brady.

There is only a single specimen on the slide

Truncatulina, d'Orbigny.

Truncatulina lobatula, Walker and Jacob, sp.

Truncatulina variabilis, d'Orbigny.

A small complanate specimen, and several large ones like those figured in the Delos paper, where a full account is given of them.

Truncatulina reticulata, Czjzek, sp.

One only on the slide.

Truncatulina tenuimargo, Brady.

I think it is right to bring the two examples on the slide under this heading, although one of them has a very strong likeness to *D. rarescens*.

Carpenteria, Grey.

Carpenteria, sp.

One example agreeing with the specimen figured in the Delos paper (1909) in pl. 2, fig. 5.

Pulvinulina, Parker and Jones.

Pulvinulina lateralis, Terquem, sp.

Very good examples occur.

Pulvinulina oblonga, Williamson, sp.

There are on the slide some of the largest specimens I have seen.

Pulvinulina oblonga (Williamson), var. *scabra*, Brady ?

See Delos paper (1909) for a full account of this variety. Frequent.

Pulvinulina concentrica, Parker and Jones.

The examples are not nearly so fine as those that occur in the Delos material.

Pulvinulina hauerii, d'Orbigny, sp.

See Delos paper (1909), p. 7.

Pulvinulina karsteni, Reuss, sp.

Pulvinulina vermiculata, d'Orbigny.

Pulvinulina micheliniana, d'Orbigny, sp.

All the tests are in beautiful condition, and are of frequent occurrence.

Pulvinulina exigua, Brady?

The Palermo specimens, which are small, agree with the Challenger figure, pl. 103, fig. 14, both as regards the number of segments and the contour of the test; but they do not show the lines of opaque-white shell-substance on the superior face, mentioned by Brady.

Rotalia, Lamarck.

Rotalia beccarii, Linné, sp.

See Delos paper for description of the varieties present; they include the highly decorated form.

Rotalia orbicularis, d'Orbigny.

A single specimen.

TINOPORINÆ.

Gypsina, Carter.

Gypsina globulus, Reuss, sp.

One only on the slide.

Polytrema, Risso.

Polytrema mineaceum, Linné, sp.

Present both in the adult and embryonic states.

NUMMULINIDÆ.

POLYSTOMELLINÆ.

Nonionina, d'Orbigny.

Nonionina depressula, Walker and Jacob.

Several varieties occur, including the clear compressed tests, and those that are opaque.

Nonionina stelligera, d'Orbigny.

Large examples are of frequent occurrence.

Nonionina scapha, Fichtel and Moll, sp. (Pl. 3, fig. 13).

The one figured is commencing the linear manner of growth.

Nonionina asterizans, Fichtel and Moll, sp. (Pl. 3, fig. 14).

These Palermo specimens are nothing more than *N. stelligera*, with the stellate portion arrested.

Nonionina boneana, d'Orbigny.

These vary greatly as to their contour, and none of them are stoutly built.

Nonionina turgida, Williamson, sp.

This pretty form is well represented in this material.

Nonionina umbilicatula, Montagu, sp. (Pl. 3, fig. 15).

Only five are on the slide.

Polystomella, Lamarck.

Polystomella striatopunctata, Fichtel and Moll, sp. (Pl. 3, fig. 16).

The form figured in the Delos paper (1909) fig. 1, pl. 5, is common. The one I have chosen for illustration is opaque, and the pores do not show except under a high power. It is the only one of the kind on the slide.

Polystomella crispa, Linné, sp.

Very frequent, the spinous condition of the small tests is well marked.

Polystomella verriculata, Brady.

Several well-marked but small examples are on the slide.

Polystomella macella, Fichtel and Moll, sp.

Large and beautiful examples occur.

Polystomella subnodosa, Münster, sp.

The examples of this foraminifer are good, and are of the usual milky-blue colour.

Foraminifera. (Pl. 3, fig. 17).

This fragment is the only example on the slide, and as the initial part is wanting, it cannot very well be placed under a generic heading. The test is built up of fine sand-grains, and is of a light-brown colour, the surface slightly roughened.

Foraminifera? (Pl. 3, fig. 18).

Several specimens are on the slide. This is a doubtful foraminifer. It appears to be built up of very fine sand-grains, the test is thin, and its superior face varies in convexity. The under surface is concave in the centre. The orifice is small, round, and at the bottom of the cavity, but it is not always apparent. The colour is a silvery-grey brown, but I have twelve specimens from La Liberstad, Salvador, West Coast of America, in which the colour varies from silvery-grey to light-brown.

My friend Dr. Chaster, of Southport, whose lamented death took place on May 5th, was greatly interested for many years in the study of the Foraminifera.

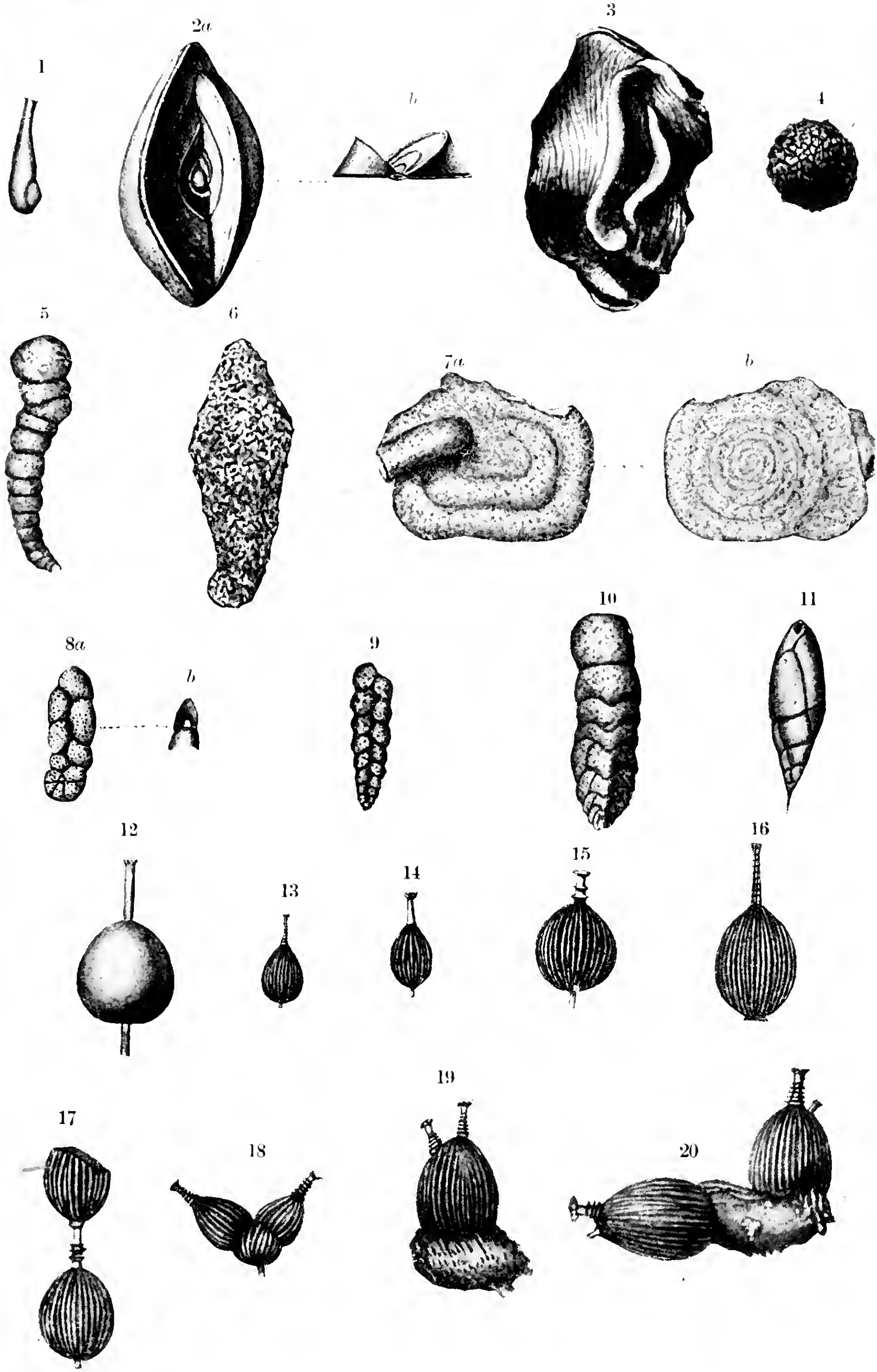
His chief work on this subject is a "Report upon the Foraminifera of the Southport Society of Natural History District," which is a valuable addition to the literature of the British Foraminifera.

Dr. Chaster was a very acute observer, a most genial man, and personally I owe much to him, as he was the means of my taking up the study of the Foraminifera. I cannot let this opportunity pass without stating how much his death is regretted, and especially by those who had the good fortune to know him intimately.

EXPLANATION OF PLATES.

PLATE I.

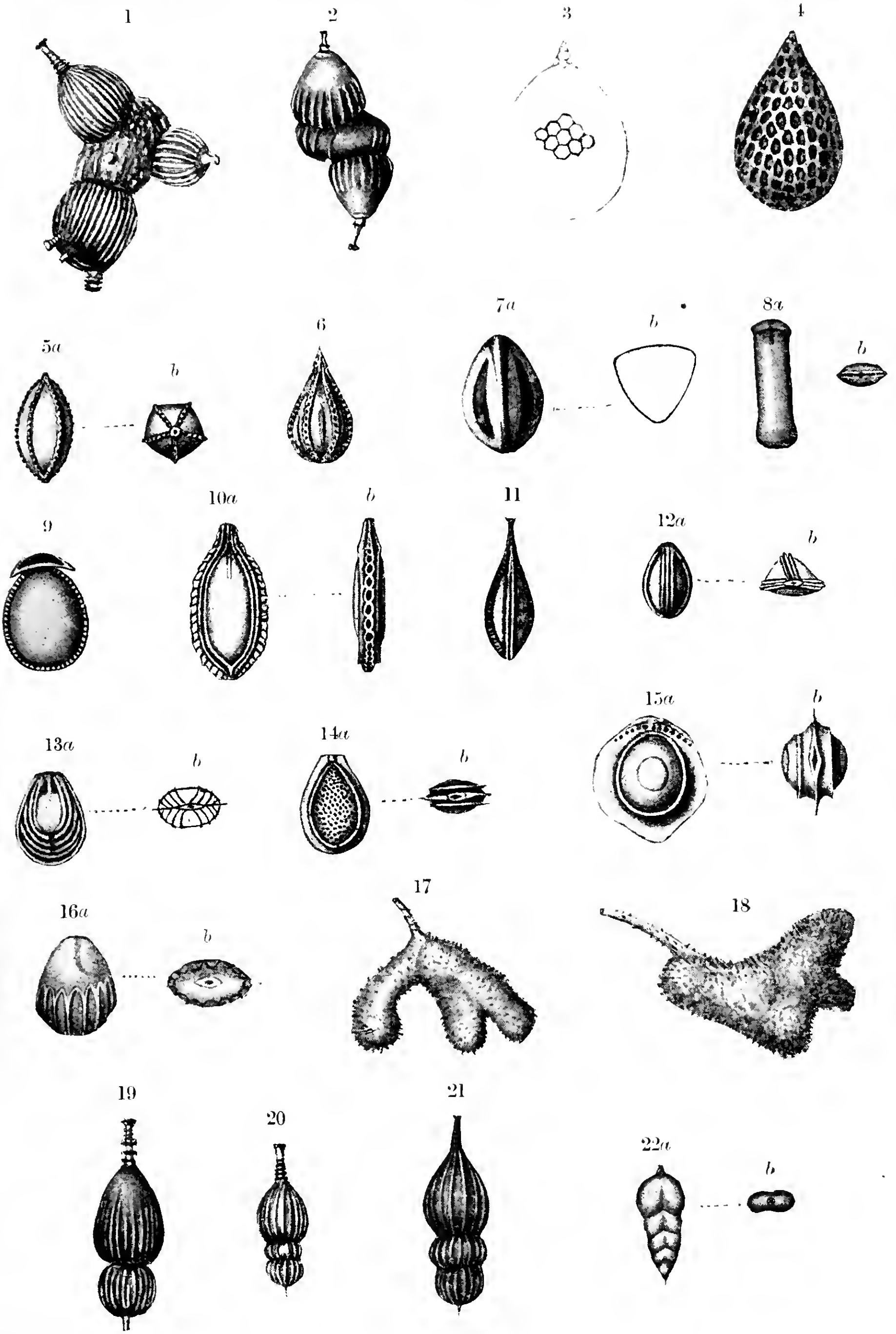
FIGS.			PAGE.
1.	*Nubecularia tibia*, Jones and Parker	× 75 ...	1
2.	*Spiroloculina inæquilateralis*, Schlumberger	× 50 ...	2
3.	*Miliolina undosa*, Karrer, sp.	× 50 ...	4
4.	*Psammosphæra fusca*, F. E. Schultze	× 50 ...	8
5.	*Reophax baccillaris*, Brady	× 25 ...	8
6.	*Haplophragmium pseudospirale*, Williamson	× 25 ...	8
7.	*Ammodiscus perversus*, n. sp.	× 50 ...	9
8.	*Spiroplecta rosula*, Ehrenberg	× 100 ...	11
9.	*Gaudryina filiformis*, Berthelin	× 75 ...	11
10.	*Clavulina angularis*, d'Orbigny	× 25 ...	11
11.	*Bulimina*, d'Orbigny, var. *exilis*, Brady	× 75 ...	12
12.	*Lagena lævis*, var. *distoma*, Silvestri	× 75 ...	15
13, 14, 15, 17, and 18.	*Lagena lyellii*, Seguenza	× 50 ...	15
16, 19, 20.	*Lagena striata*, d'Orbigny, sp.	× 50 ...	15, 16



H. Sidebottom del. ad nat.

Foraminifera from the Bay of Palermo.

PLATE II.



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Foraminifera from the Bay of Palermo.

PLATE III.

FIGS.			PAGE.
1, 2, 3.	*Marginulina costata*, Batsch, sp.	× 50 ...	21
4, 5, 6, 7.	Intermediate forms between *Cristellaria* and the Genera *Vaginulina* and *Marginulina*,		
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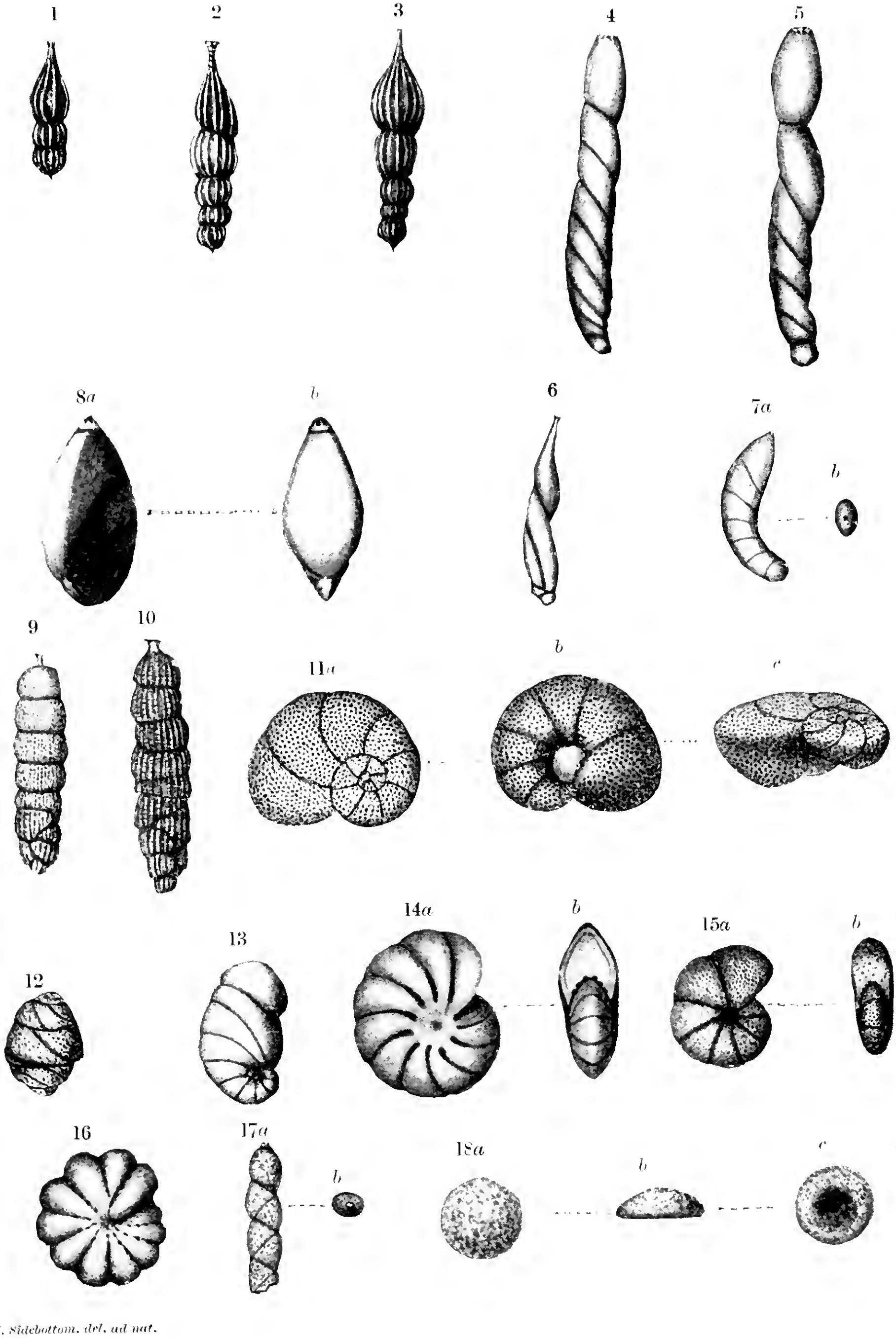
	figs. 6, 7	× 75 ...	21
8.	*Cristellaria acutauricularis*, Fichtel and Moll, sp.	× 50 ...	21
9, 10.	*Sagrina nodosa*, Parker and Jones	× 50 ...	23
11.	*Discorbina saulcii*, d'Orbigny	× 50 ...	26
12.	*Discorbina tabernacularis*, Brady	× 75 ...	25
13.	*Nonionina scapha*, Fichtel and Moll, sp.	× 50 ...	29
14.	*Nonionina asterizans*, Fichtel and Moll, sp.	× 50 ...	29
15.	*Nonionina umbilicatula*, Montagu, sp.	× 50 ...	29
16.	*Polystomella striatopunctata*, Fichtel and Moll, sp.	× 50 ...	29, 30
17.	*Foraminifera*. A fragment	× 50 ...	30
18.	*Foraminifera ?*	× 75 ...	30



H. Sidebottom, del. ad nat.

Foraminifera from the Bay of Palermo.

Manchester Memoirs, Vol. liv. (1910), *No.* **17**.

XVII. The Anatomy of *Calamostachys Binneyana*, Schimper.

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Read February 8th, 1910. Received for publication June 14th, 1910.

Notwithstanding the care with which this cone has been repeatedly investigated, by Binney, Carruthers, Williamson, Hick and Williamson and Scott (see under "Literature"), our knowledge of its vascular anatomy still remains very imperfect. Remains of the cone are abundant, and in general very well preserved, in the coal-balls of Lancashire and Yorkshire. The extreme delicacy of its vascular tissues is the cause of our imperfect knowledge regarding them.

It is now generally accepted that the cone was characterised by a slender axis bearing, on alternate nodes, whorls of 12—14 bracts or 6—8 sporangiophores; that the axis had a stele with a solid medulla, surrounded by 4 or 6 endarch vascular bundles, each with a "protoxylem-" or "carinal-" canal; and that each bundle gave off at alternate nodes traces which passed out more or less horizontally to the bracts or sporangiophores respectively. It is known that the bundles do not alternate at the nodes. The peculiar masses of "nodal wood," and the character of the tracheids have also been well described.

The observations on which this note is founded have been especially directed to the elucidation of such features of the vascular organisation of the cone as would seem to throw light on its phylogenetic relations. It has been found possible to add very little to what has already been described, yet my investigations lead me to make such amendments to the current interpretation of the anatomical structure as I think justify their publication. The current view appears to me to require correction in two important points. In the first place, I believe there is ample proof that the so-called "sporangiophore-" or "fertile-" nodes should not be regarded as nodes in the same sense as the true or "bract-" nodes at all. Secondly, I believe the old descriptions were strictly correct (see *e.g.* Hick, '92) which stated that the axis in the more common cases contained *three* vascular bundles, not three pairs, as now commonly interpreted. It is believed to be possible to show that the sporangiophore-trace virtually arises at the subjacent "bract-node." It is also shown that in one and the same cone the conditions of 3, 4, and 6 vascular bundles in the stele may coexist. In the course of the work it has been proved possible to extend the method of Prof. Sollas for obtaining serial sections to histological work, by slowly grinding down the petrified material and taking microphotographs, by reflected light, of the successively exposed surfaces (see *Photo.* 4 of *Plate*).

Turning first to the morphological character of the "sporangiophore-nodes," we have the following evidence: In small vegetative stems of Calamites, the nodes are characterised by a strong development of "nodal wood," and by the obliteration of the carinal canals of the bundles. The medulla commonly persists in the form of nodal diaphragms, composed of very short cells. In impressions, the node always appears as a distinct "joint." Precisely the same features mark the true or bract-nodes of the cone, with just this difference; that as the whole medulla is persistent, instead of nodal diaphragms we have a marked "shortening-up" of the otherwise elongated medullary cells (see *Photo.* 2 of *Plate*). On the contrary, none of these features are found at the level of the sporangiophores, where, as Dr. Scott (Williamson and Scott '94, p. 906) long ago pointed out, there is "scarcely any modification of structure as compared with the internodes"—we may say none which is not absolutely inevitable. There is no trace of "nodal wood," no obliteration of the carinal canals, and no modification of the medulla. In impressions of the closely-allied *Calamostachys Ludwigii*, Weiss (Weiss '76, p. 41) states that there is no trace of jointing at that level ("von quergliederung an dieser stelle keine Spur"). These facts appear to me to offer the gravest difficulty to the interpretation of the sporangiophores as modified leaves.

In confirmation of the above, and passing to the next point, it must be remarked that in the rare event of the sporangiophore-trace being seen to part company with the main vascular bundle, it merely separates from the *outside* of the latter and causes no gap, whereas the bract-trace clearly originates from the main protoxylem-mass at the node and passes *through* the main bundle.

The true relations of the sporangiophore-trace are extremely difficult to determine. This is largely due to the great delicacy of the vascular tissues in the neighbourhood of the insertions of the sporangiophores and their consequent very imperfect preservation in nearly all cases. The best example I have seen is a transverse section (Q. 291, Manchester Museum Coll.) in which portions of four traces are seen just separated from the stele, the remaining pair appearing as projections from the other stelar bundle. By careful focussing, each of the free traces can be made out to be slightly arched, ascending slightly from the stele and descending again towards the sporangiophore. Something of the same arching may be made out in a few longitudinal sections (Q. 295, Q. 308), while others show the trace curving simply

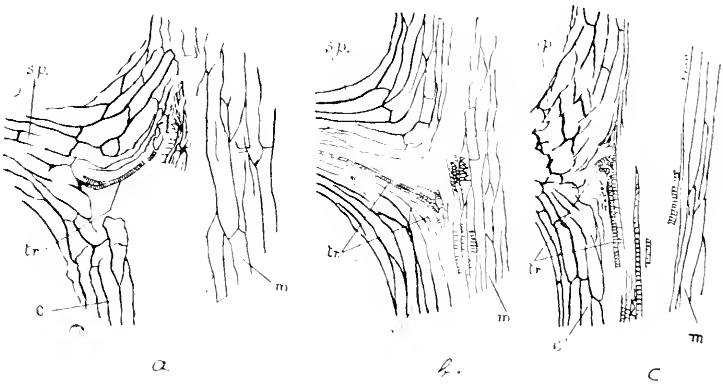

FIG. 1.

Sections (longitudinal) showing passage of sporangiophore-trace from axis into sporangiophore.

tr. = sporangiophore-trace.
sp. = base of sporangiophore.
c. = cortex.
m. = medulla.

All sections × 50.

1*a*. Trace here enters in *downward* direction. The manner in which it follows the conformation of the surrounding cortical cells renders it unlikely that this course is due to displacement.
"Cash" Coll., Manchr. Museum. Q. 308.

1*b*. Trace curving upward into sporangiophore.
Manchr. Museum Coll. R. 138A.

1*c*. Trace sharply bent at right-angles, but with slight initial recurving. Compare arrangement of tracheids at bend with that in 1*b*.
"Cash" Coll., Manchr. Museum. Q. 295.

downward from the base of the sporangiophore. It seems undesirable to lay any stress on this point, as slight displacement would readily cause considerable modification.

There is no good evidence that the sporangiophore-trace really arises from the stelar bundle at the point where it parts company with it. On the other hand we have the very strong evidence already detailed that this point is not morphologically a true node, and further, the absence of any indication that the main protoxylem-mass was here connected with the sporangiophore-trace. I have in no case been able to observe a true fusion of the trace with the stelar bundle, while, on the contrary, in one section belonging to Mr. Watson (A90) the trace can be followed quite uninterruptedly almost half-way down to the subjacent node. In some cases the traces may be distinguished in transverse sections below the sporangiophores as more or less projecting masses of tracheids on either side of the main bundles (see *Photo.* 3 of *Plate*), reminding one of the condition of things in *Palæostachya.* As in the latter cone also I have observed in one or two instances what I believe to represent small independent carinal canals belonging to the traces (see *Photo.* 5 of *Plate*). In the great majority of cases, however, any tracheids which may have separated these canals from that belonging to the main bundle have broken down, the result being a single tangentially elongated canal, often broadly V-shaped in transverse section. Indeed, the whole trace is commonly broken down, leaving a space on either side of the mass of tracheids representing the stelar bundle.

With a view to further investigating, among other things, the relation of these traces, I obtained from Mr. Lomax a block containing *Calamostachys* and prepared serial sections by the method already mentioned. One part of this series shows very clearly the relations of the traces in the manner just described, as represented in the annexed sketches (*Fig.* 2, *a*, *b*, *c*). The section is oblique, and tangential to the bundle. The trace on the left has degenerated and is represented by a space ; on the right, the trace itself still remains. One of the actual photographs out of the series of 22 which were taken is reproduced in *Photo.* 4 of the *Plate*, to illustrate the possibilities of this method of obtaining serial sections. The sections are about 0·2 mm. apart.

a b c

FIG. 2.

Three successive oblique tangential sections of a bundle with its carinal canal and the lateral canals presumed to represent the degenerated sporangiophore-traces. On the right of the bundle the trace appears to have more or less completely persisted. The lowest section is *a*, the highest *c*. The sections are about 0·2 mm. apart.

×75 dia.

px. c. = carinal canal.
sp. c. = canal representing sporangiophore-trace.
phl. = position of phloëm.

The various considerations stated above lead me to believe that the sporangiophore-trace really has its origin at the true or "bract-" node, merely rising in contact with the stelar bundle through the internode above until it bends outwards to the sporangiophore.

Closely connected with the relations of these traces is the question of the number of bundles in the stele. As already mentioned, it is now commonly accepted that there are usually four or six, the bundles in the latter case being in partially fused pairs. Two circumstances tend to favour this view that the triangular steles have six bundles, rather than three, as the earlier descriptions stated. Firstly, there are really six distinct bundles in some cases, though that is comparatively rare. Secondly, the bundle, together with its carinal canal, is usually tangentially elongated. This latter circumstance, as already suggested, appears to me to be due to the fact that each bundle is accompanied through a large part of its course by a pair of sporangiophore-traces, one on either side. The weight of evidence, however, appears to me strongly in favour of the single nature of each bundle in normal cases. Admittedly, most examples would be so interpreted, apart from preconceived ideas; but the crucial sections are clearly those which are cut *above* the level of the sporangiophores and *below* the succeeding node. Such sections are not common, because the nodal wood makes its appearance a very short distance above the departure of the sporangiophore-trace. In several examples, however, the bundle is here seen to be very definitely single. A very good example is seen in *Photo.* 1 of the *Plate* (Manchr. Museum Coll. R. 801 A), in which the tissues are completely preserved. This section also illustrates the extreme delicacy of the vascular tissues. Further evidence is afforded by many sections in which the bundles are partially broken down. The xylem mass is commonly detached from the medulla, and more or less adherent to the cortex; it is noteworthy that in such cases the xylem invariably breaks away in a *single* piece, and when this piece is attached to the cortex it lies *between* the bases of the sporangiophores. A few tracheids are commonly to be found separated from this principal xylem mass on one or both sides; these smaller strands lie opposite the sporangiophores and must be regarded as their traces. A further argument may be derived from the analogy of the quadrangular steles with four bundles. In these cases I have never seen any indication of the bundle being double. Dr. Scott, in the new edition of his "Studies," states that "there are usually six, sometimes eight" bundles (Scott, :08, p. 51, 52), but I presume that he merely considers that in the latter case there may be *theoretically* eight. In his well-known monograph with Prof. Williamson (Williamson and Scott, '94, p. 905), he says, of the quadrangular steles, "There is no reason to suppose, in this case, that more than one bundle was present at each corner." This statement is certainly true of the great majority of cases. Now, where there are four bundles there are always eight sporangiophores. Hence it would be curious if, in cases where the number of sporangiophores is reduced to six, the number of bundles should be increased to six!

This last argument is considerably strengthened by the fact that the same cone which has a quadrangular stele with four bundles and eight sporangiophores in its lower part, may have a triangular stele with six sporangiophores above. Together with the other evidence, this leaves no doubt, in my mind, that the normal number of bundles in triangular steles is three*.

The discovery that the number of sporangiophores and of bundles in the stele was variable within the individual cone, resulted from the preparation by Mr. Lomax of a fine series of eight sections, giving serial sections of four distinct cones. Three of the four series show this change, the best cone being that marked A, which

* It appears to me that in any case the expression "partially fused pairs," commonly applied to the bundles, is objectionable, since one feels little doubt that tne change which was taking place in the evolution of these cones was a gradual division of the bundles. The three groups of tracheids are certainly not the result of the fusion in pairs of six primitive groups.

is well preserved in six successive sections. In two it has definitely four bundles in a quadrangular stele. The next section has a more or less triangular stele with six bundles, while the remaining sections have triangular steles which appear to have three bundles. One of these latter shows six sporangiophores. The other two series showing the change have only four sections each, and are less well-preserved. Subsequently I found the same change exhibited in a series of five sections cut from a Halifax cone (Manchr. Museum Coll., Q. 288—292). Four of these have triangular steles, the fifth a quadrangular one. This series was formerly described by Hick (Hick '93A), and this point was noted, but it seems to have been entirely overlooked since that time. A series of three sections in the Manchester Museum collection (R. 107, 109, 110) have each triangular steles, with six bundles in two cases, and seven in the third.

In six sets of serial sections which I have examined, therefore, the stele changes from the triangular to the quadrangular type in four, and shows indication of a change in a fifth (the last-mentioned above).

It is perhaps noteworthy that in the best series of sections we have, between the part of the cone with four bundles and the part with three, one section in which there are distinctly six. Some indication of the same thing is found in the series marked C. Hence it may be possible that six bundles are produced in the readjustment of the stele in this intermediate region. This would explain the occurrence of a small number of sections in which there certainly are six distinct bundles, and some cases in which the bundles are irregular. I had hoped to be able to determine this point by means of serial sections made by the Sollas method, but have so far been unable to obtain a block containing a suitable cone.

The remaining point to be mentioned is the vascular supply of the bracts. In one transverse section in the Manchester Museum collection, this is extremely well shown (R. 120), and it is interesting to note that the traces do not come off quite symmetrically from the four

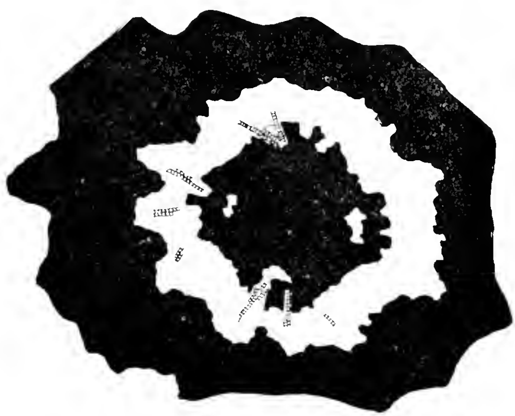

FIG. 3.

Transverse section through node, immediately below bracts, showing origin of bract-traces. Note that each bundle appears to give off its traces somewhat unsymmetrically.

× 36 dia.

Manchr. Museum Coll. R. 120.

bundles present (of which three each supply three traces, the other, four), as may be seen in the accompanying figure (*Fig.* 3), where the traces appear as if dragged round by a slight anti-clockwise movement. This slight asymmetry is in agreement with what appears to me to be the only possible explanation of a well-known difficulty in the morphology of this cone—viz., the combination of superposed sporangiophores and non-alternating bundles, with alternating bracts. The relation of the sporangiophores with the bundles is very definite—each bundle stands opposite a pair of sporangiophores ; and it appears to me in the highest degree probable that the primitive position of the bracts was similarly opposite the bundles, they having reached their present position by slight lateral shifting of each whorl to right or left.

As it has been clearly pointed out before, no definite relation can now subsist between the bracts and either the sporangiophores or the bundles, since the number of the bracts in a whorl is variable, and its variation bears no definite relation to the number of bundles or sporangiophores. Thirteen appears to be the commonest number of bracts.

Phylogenetic Position of the Cone.

This question may be briefly discussed in the light of the present communication.

Neglecting the doubtful types *Bornia* and *Cingularia*, we have three types of Calamitean fructification, *Calamostachys*, *Stachannularia*, and *Palæostachya*. The type which Weiss (Weiss '76) describes as *Stachannularia* is defined as having its sporangiophores inserted slightly above the middle of the internode, and by the sporangiophores possessing a wing-like-expansion on their upper side, which, in some cases, appears united with the bracts of the whorl above. It seems probable that this is really the same type which Renault has described from structural material as *Bruckmannia Grand' Euryi* and *Bruckmannia Decaisnei,* in which the sporangiophores are similarly adherent to the bracts of the next superior whorl. If so, this type is essentially similar to *Calamostachys*. *Palæostachya* I have elsewhere fully described (Hickling, :07).

So far as is known, the successive whorls of sporangiophores in all types of calamite cone were superposed, and from their constant relation to the primary vascular bundles this raised a strong presumption that the bundles were in all cases non-alternating. This was certainly the case in *C. Binneyana.* Renault states that the same was the case in his cone of *Annularia longifolia* (Renault '73). It was evidently so in *Calamostachys Ludwigii*, and Weiss states that in impressions of *C. superba* the ribs on the axis do not alternate at the nodes. His figures show the same condition in *Stachannularia tuberculata.* The only doubtful cases seem to be Renault's cones described in his "Flore Fossile"; regarding these neither the text nor the illustrations are very satisfactory on this point, but as a whole the evidence seems to favour superposition.

If the contentions in this paper are correct, we may say that it is a further general characteristic of calamitean cones that the vascular supply of the sporangiophores arises from the same node which supplies the whorl of bracts below. This is the case in *Palæostachya*, Renault shows it to be the case in *Bruckmannia* (*Arthropitostachys*) *Decaisnei* and *B. Grand'Euryi*, as well as in *Calamodendrostachys Zeilleri* (Renault '96), and I have endeavoured to show that it is the case also in *Calamostachys Binneyana.* Hence it holds for all the principle types of calamitean cone.

The point of insertion of the sporangiophores in the internode is obviously very variable. In the *Palæostachya* type they are adherent to the bracts below, in the *Stachannularia* type to the whorl above, and in *Calamostachys* more or less in the middle.

The number of appendages in a whorl, and the number of bundles in the stele are likewise very variable features. All that can be said is that multiples of three predominate.

There are two points of morphological importance in which *Calamostachys Binneyana* and its close ally *C. Ludwigii* are contrasted with the other cones whose structure is known (except, of course, *C. Casheana* and

C. Oldhamia)—the small number of appendages and of primary vascular strands, and the solid medulla. I think it will be generally admitted that in these respects, these cones are more primitive than the rest, and I would regard *Calamostachys Binneyana* as the most primitive calamitean cone yet known. One can scarcely believe that the striking similarities of this cone, as here interpreted, with the cones of *Sphenophyllum* are purely accidental. The stele is still characteristically triarch, and the vascular strands non-alternating. As regards the stele, I would suggest that in the Sphenophylls and Calamites we have a course of evolution parallel with that which Dr. Scott (Scott :02) has so well described in another group; that in *Sphenophyllum* we have the primitive type with entirely centripetal primary xylem, that in *Calamostachys Binneyana* we have the centripetal tissue reduced to a somewhat peculiar medulla and centrifugal xylem replacing the old wood functionally, while in the more advanced types of *Calamostachys* we have the medulla still further degenerating, and the old triarch condition gradually lost as the result of multiplication of the appendages in the manner suggested by Lignier (Lignier :03). In all the cones of Calamites the primitive direct course of the bundles appears to have been maintained, that only vanishing in the less conservative vegetative shoots.

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EXPLANATION OF PLATE.

PHOTO. 1.—T.S. axis of cone just above sporangiophores with tissues complete. × 32 dias.

px.c. = protoxylem ("carinal") canal.

i.c. = inner cortex.

The two small protoxylem canals are very sharply defined. Manchr. Mus. Coll., R. 801 A.

PHOTO. 2.—L.S. cone with well preserved medulla. Section nearly median. × 18 dias.

nod. med. = nodal medullary tissue.

in. med. = internodal medullary tissue.

The contrast between the medulla at the level of the bracts ("nodal") and that at the level of the sporangiophores ("internodal") is very well-marked. "Cash" Coll., Manchr. Museum, Q. 295.

PHOTO. 3.—T.S., slightly oblique, just below sporangiophores on right, slightly lower on left. × 32 dias.

Sp tr. = sporangiophore trace.

The traces project more strongly from the stele as the plane of the section rises towards the sporangiophores. Manchr. Mus. Coll., R. 139.

PHOTO. 4.—Section photographed by reflected light from a solid block of material. This is one of a series of 22 sections of the same cone, the entire series covering about two internodes. The set was obtained by slowly grinding down the block and photographing at intervals. The one here reproduced is next but one in the series above that from which Fig. 2 *c* is drawn. It is introduced only to illustrate the method. × 15 dias.

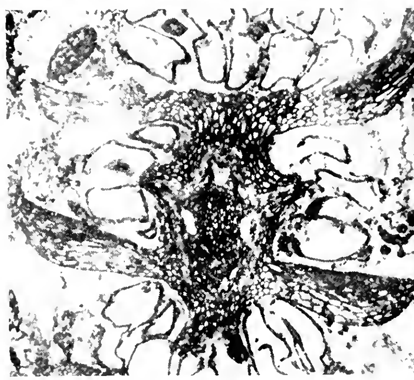
PHOTO. 5.—Section of stele just above node. × 80 dias.

Sp. px. c. = Protoxylem canal of sporangiophore trace.

The two examples marked seem fairly definite; indications of similar canals are seen in one or two other places. Manchr. Mus. Coll., R. 139.

1

3



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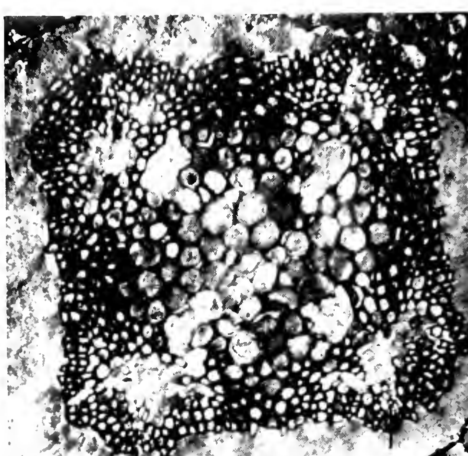

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Manchester Memoirs, Vol. liv. (1910), *No.* **18**.

XVIII. Note on the Variability in the Colour of the Flowers of a Tropæolum Hybrid.

By F. E. WEISS, D.Sc., F.L.S.

Read January 11th, 1910. Received for publication July 22nd, 1910.

In the summer of 1908 my attention was attracted to a plant among the Nasturtiums in my garden, which bore flowers of different colours, some quite light yellow with dark honey guide, while one was of red colour. The plant was still young, so I potted it up and watched its later developments. During the summer it produced a large number of flowers, apparently with complete irregularity, as could be seen from a diagrammatic plan of the different branches, on which the different coloured flowers were indicated. It became apparent also that the flowers were not all of two distinct types, but shaded off from one extreme to the other. Thus, besides the completely yellow flowers, some appeared with slight red blotches at the edge of the petals, and these increasing in size and extending to the base of the petals were found in every stage until the whole petal was scarlet, the last part to become scarlet being the little fringe at the base of the expanded portion of the petal. In the autumn brownish patches became frequent on the petals leading to a darker coloured flower. But though this was the case both in the autumn, and as long as the plant remained alive during the winter, some yellow flowers were always to be found among the parti-coloured ones. The yellow colour of the petals is due to yellow chromoplasts, while the supervening red or brown colour is due to coloured cell sap.

August 31st, 1910.

As it seemed likely that this Tropæolum was of hybrid nature, and that its flowers partook in varying degree of the character of the two parents, it seemed to be of interest to find out what would be the result of self-fertilising the various flowers and examining the resultant offspring.

This was done with a number of flowers, both of the red and yellow, and also of the intermediate forms. The plants grown from these seeds showed an interesting series of forms, indicating a segregation of parental characters in this (probably the f2) generation, but it was at once noticeable that the colour of the flower of the previous (f1) generation did not determine the floral colour of the offspring, yellow flowers yielding both plants which bore red flowers and also others with yellow flowers.

A segregation of forms seemed to have taken place, however, in this (f2) generation, both as to tallness and as to colour. The parent plant, though purchased as *Tropæolum minor*, grew ultimately to fairly large size. Of its offspring two were distinctly dwarf forms, while eight were tall. Both the dwarf forms had red flowers, one of them of a very dark shade, while of the tall forms four were red and four were yellow, though these latter were, as will be stated later, plants of two distinct types.

It would appear from this segregation, as is indicated by other experiments on *Tropæolum*, that in this genus dwarfness is recessive to tallness, as is the case in Sweet Peas.

As regards the colour of the flowers of the ten plants raised from the seeds of the original hybrid parent, as indicated above, one of the dwarf forms had dark claret-coloured flowers, which accounted probably for the brown blotches in some of the later flowers of the hybrid parent.

This dark flowered offspring (F) remained dwarf, and only produced a comparatively small number of flowers. Both its stem and the ribs of its fruits developed anthocyanin. The other dwarf descendant (A) had small leaves and anthocyanin developed in its stem. Its flowers were red, but it ceased flowering in the first week of August, and so produced very few offsprings.

Of the tall descendants, the four which produced red flowers were all very much alike (D, E, H, I). Both stems and peduncles developed anthocyanin, and, though not very tall plants, were distinctly not of dwarf habit, and produced an elongated main stem some two feet in height. The flowers were bright red, very fertile, but some of them stopped flowering after the second week in August, when cold wet weather set in.

The four yellow-flowered offspring (B, C, G, K) agreed in their general vegetative characters, tallness and absence of anthocyanin, but were of two distinct types, as indicated by their flowers. Two of them (B and C) had light yellow-coloured petals, with dark claret-coloured honey guides, which were, however, slightly lighter in one case (C) than in the other (B). They agreed also in the fact that they remained practically sterile, as hardly any of their stamens produced ripe pollen.

In the two other yellow-flowered forms (G and K) the honey guides were bright red, not claret-coloured, and these plants were quite fertile, maturing their pollen quite freely. At the end of the first week of August, which was hot and sunny, one of the plants (G) produced a few parti-coloured flowers, and in the second week in August some completely red flowers. Even though completely red, an undercurrent of yellow was sometimes visible, there being often a yellow fringe at the inside of the petals. As in the parental form, the red colouring always commenced at the margin of the petal, and extended in successive flowers more and more towards the base.

About the same time, second week of August, plant K, which in other respects agreed with the above plant (G), showed indications of a few parti-coloured flowers, and a little later the flowers were completely red. As the season progressed some of the flowers produced were deeper coloured, almost claret, and in their later stages of expansion practically brown. This change was not noted in plant G, but its occurrence in K pointed to its retaining more than any of the other plants the characters of the original parental hybrid.

Towards the end of August, when the wet weather had again set in, the plant went back to its original yellow flowers.

Though the hybrid parent showed no marked periodicity in the bearing of differently coloured flowers, this was apparent in those of its offspring (G and K), which inherited this variability, the red flowers coinciding with the brightest and hottest weather.

This peculiar feature is in agreement with the Tropæolum hybrid described by Gærtner, which at the commencement of the flowering season produced orange-coloured flowers like those of its male parent (*T. majus*), while towards the close of the season, with decreasing temperature, yellow flowers, like those of the maternal parent (*T. minus*) were produced. In the experiments described above the plants, however, commenced with yellow flowers, proceeded during the very short hot weather of the beginning of August to produce red flowers, and then went back to yellow.

It would appear, therefore, that in the case of the original hybrid and in two of its offspring we have not got a segregation of parental characters in the flower buds (a form of bud variation which is not infrequent in some groups of plants) but that the flowers are potentially red, and that a certain factor, or several factors, probably dependent on the metabolic processes of the plant, determine the formation or the non-formation of anthocyanin.

That we have no segregation of characters is borne out by the observation of the offspring resulting from self-fertilising the flowers of different colours, while the return of the yellow-coloured flowers during the late autumn seems to point to an external controlling factor.

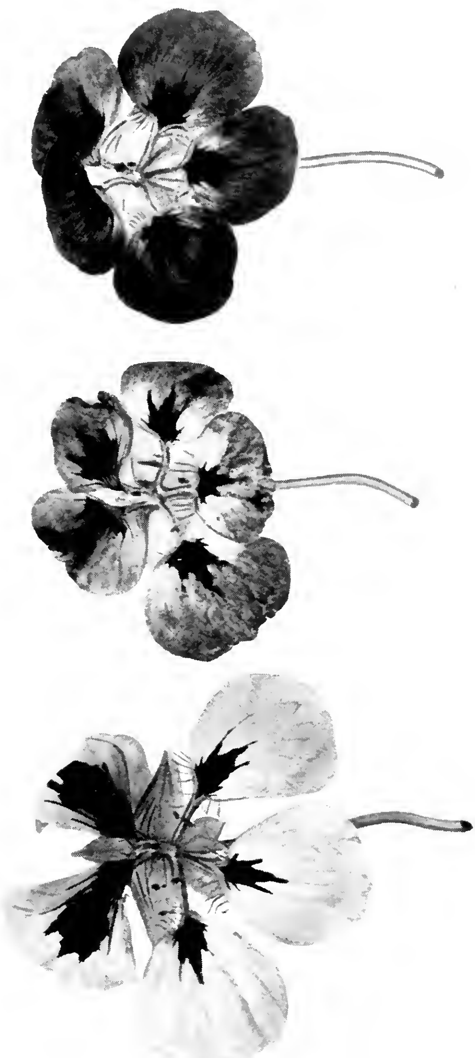
It is interesting in this connection to remember the experiments by Rawson on the effect of light of different refrangibility on the colour of Nasturtium flowers.*

A variety of *Tropæolum minus* and *majus* is now on the market, called "Chamæleon," and I am at present engaged in comparing the change in colour of this variety with the hybrid described above. I am also continuing the experiments with the later generations of the plants referred to, so that the present communication must be taken to be of a preliminary nature only.

* *British Association Report, South Africa*, 1905.

PLATE.

Three flowers from the same plant showing variability of colour. The flower to the left was light yellow in colour with dark claret honey guides. The flower to the right was dark red, while the median flower showed the red colouration commencing near the edge of the petals.



PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 5th, 1909.

Mr. Francis Jones, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were among the recent accessions to the Society's Library: "*A Discussion of Australian Meteorology*," by W. J. S. Lockyer (fol., London, 1909), presented by the Solar Physics Committee, South Kensington; "*Guide to the Specimens of the Horse Family...in the British Museum (Natural History)*" (8vo., London, 1907), "*Guide to the Elephants (recent and fossil) in the British Museum (Natural History)*" (8vo., London, 1908), "*Guide to the Gallery of Fishes in the British Museum (Natural History)*" (8vo., London, 1908), "*Guide to the Domesticated Animals (other than Horses) in the British Museum (Natural History)*" (8vo., London, 1908), "*Guide to the Exhibited Series of Insects in the British Museum (Natural History)*" (8vo., London, 1908), "*Guide to the Specimens illustrating the Races of Mankind in the British Museum (Natural History)*" (8vo., London, 1908), "*Guide to the Whales, Porpoises, and Dolphins in the British Museum (Natural History)*," (8vo., London, 1909), "*Introduction to the Study of Rocks*," by L. Fletcher (8vo., London, 1909), and "*Synopsis of the British Basidiomycetes*," by W. G. Smith (8vo., London, 1908), presented by the Trustees of the British Museum;

"*Codex of Resolutions adopted at International Meteorological Meetings 1872-1907*," by H. H. Hildebrandsson and G. Hellmann (8vo., London, 1909), presented by the Meteorological Office; "*Report on Tertiary Plants of British Columbia*," by D. P. Penhallow (4to., Ottawa, 1908), and "*Preliminary Report on Gowganda Mining Division District of Nipissing, Ontario*," by W. H. Collins (8vo., Ottawa, 1909), presented by the Geological Survey of Canada; "*Darwin and Modern Science*," ed. by A. C. Seward (4to., Cambridge, 1909), and "*Classified Catalogue of Works on Architecture, etc., in the Libraries of Manchester and Salford*," by H. Guppy and G. Vine (8vo., Manchester, 1909), purchased; "*Low-temperature Research at the Royal Institution of Great Britain 1900-07*," by H. E. Armstrong (8vo., London, 1909), presented by the Royal Institution of Great Britain; "*Precise Leveling in the United States 1903-07*," by J. F. Hayford and L. Pike (4to., Washington, 1909), presented by the U.S. Department of Commerce and Labor; "*Third Annual Report on...Bacteriological Examination of London Waters, 1908-09*," and "*Fourth Report on Research Work...on the Vitality of the Cholera Vibrio in Artificially Infected samples of Raw Thames, etc., Water...*" by Dr. A. C. Houston (fol., [London], 1909), presented by the Metropolitan Water Board; "*Subject List of Works on the Laws of Industrial Property*" (16mo., London, 1909), presented by the Patent Office, London; "*Parallelbedrijf van Wisselstroommachines*," door J. W. van Dijk (8vo., Rotterdam, 1909); "*Over Rietwas en de Mogelijkheid zijner technische Gewinning*," door A. Wijnberg (8vo., Amsterdam, 1909), and "*Bibliotheek der...Hoogeschool.. Lijst der Periodieken*," 2e uitg. (4to., Delft, 1909, presented by the Technische Hoogeschool, Delft; "*History of the Geological Society of Glasgow, 1858-1908*," by P. Macnair and F. Mort (8vo., Glasgow, 1908), presented by the Society; "*Report of a Magnetic Survey of S. Africa*," by J. C. Beattie (fol., London, 1909), presented by the Royal Society of London; the following 8 works by G. L. Raymond: "*Art in Theory*," 2nd ed. (8vo., New York, 1909), "*The*

Representative Significance of Form," 2nd ed. (8vo., New York, 1909), "*Poetry as a Representative Art*," 5th ed. (8vo., New York, 1909), "*Painting, Sculpture, and Architecture as Representative Arts*," 2nd ed. (8vo., New York, 1909), "*The Genesis of Art Form*," 3rd ed. (8vo., New York, 1909), "*Rhythm and Harmony in Poetry and Music*," 2nd ed. (8vo., New York, 1909), "*Proportion and Harmony of Line and Colour*," 2nd ed. (8vo., New York, 1909), and "*Dante and Collected Verse*" (16mo., New York, 1909), presented by the author; "*Report on the Waverley or Siberia District*" (8vo., Perth, 1909), and "*Report on the Progress of Mining in the Districts between Leonora and Wiluna*" (8vo., Perth, 1909), by A. Montgomery, presented by the Agent General for Western Australia; "*The Figure of the Earth and Isostasy from Measurements in the United States*," by J. F. Hayford (4to., Washington, 1909); "*The Libraries of London: a Guide for Students*," by R. A. Rye (8vo., London, 1908), "*Hand-catalogue of the University of London*" (8vo., London, 1908), presented by the University of London.

Dr. HENRY WILDE, F.R.S., read a paper entitled: "**On a New Binary Progression of the Planetary Distances, and on the Mutability of the Solar System.**"

The paper, which is printed in the *Memoirs*, gave rise to an interesting discussion in which Mr. T. Thorp, Mr. C. E. Stromeyer, Mr. W. H. Todd, Mr. G. Hickling, and Mr. H. Bateman, and others took part.

General Meeting, October 19th, 1909.

The President, Mr. FRANCIS JONES, M.Sc., F.R.S.E., in the Chair.

Mr. H. GEORGE A. HICKLING, M.Sc., was elected Secretary in the place of Dr. C. Gordon Hewitt, who has been appointed Entomologist to the Dominion of Canada.

Ordinary Meeting, October 19th, 1909.

The President, Mr. FRANCIS JONES, M.Sc., F.R.S.E., in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Mr. E. F. LANGE, M.I.Mech.E., exhibited photographs of M. Bleriot and Baron de Caters navigating the air on aeroplanes during the competition for the £2,000 prize at Frankfort on October 10th. Baron de Caters, on a Voisin biplane, carrying a 75 h.p. engine, won the prize after a flight of 1 hr. 7 min., during which he travelled at an average speed of 44 miles. M. Bleriot, in a monoplane with a 25 h.p. Anzani motor, remained in the air 1 hour at a speed of 47 miles.

The PRESIDENT exhibited lantern slides of three granite monoliths situated in a peat bog near Tormore, Shiskine, in the Isle of Arran, which were supposed to be the remains of a former stone circle 60 feet in diameter. They are from 18 to 20 feet in height, and in the peat near them sepulchral remains were found some years ago. The granite was stated to be different from that found in the immediate neighbourhood, and it was a point of interest how such large masses could have been transported over the marshy ground.

Mr. D. M. S. WATSON thought it probable that the stones had been placed in position before the bog was formed, and that if the age of the stones could be made out, it might provide a clue as to the rate of formation of the peaty deposit.

Mr. T. A. COWARD read a paper written by Mr. LIONEL E. ADAMS, and communicated by Dr. C. GORDON HEWITT, entitled "**Some Notes on the Breeding Habits of the Common Mole.**" The paper is printed in the *Memoirs*.

General Meeting, November 2nd, 1909.

The President, Mr. FRANCIS JONES, M.Sc., F.R.S.E., in the Chair.

Mr. W. H. LANG, D.Sc., M.B., C.M., Barker Professor of Cryptogamic Botany in the University of Manchester, and Sir THOMAS HENRY HOLLAND, K.C.I.E., D.Sc., F.R.S., Professor of Geology and Mineralogy in the University of Manchester, late Director of the Geological Survey of India, were elected ordinary members of the Society.

Ordinary Meeting, November 2nd, 1909.

The President, Mr. FRANCIS JONES, M.Sc., F.R.S.E., in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

The PRESIDENT announced that Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S., Professor of Geology and Mineralogy in the Manchester University, had agreed to deliver the Wilde Lecture for 1910.

Professor SYDNEY J. HICKSON, D.Sc., F.R.S., exhibited a specimen of a double hen's egg and contributed the following note upon it.

A specimen of a double hen's egg was sent to the Manchester Museum on September 8th of this year. The outer shell is approximately 80 mm. × 60 mm., the inner shell 50 mm. × 40 mm.

The inner shell contained yolk, with, probably, a little albumen, and the space between the inner and outer shell contained albumen only. I am, unfortunately, unable to say whether there were two yolks or only one in the inner shell. Both shells are well formed.

Double eggs of this description have been frequently recorded before, and the only point of real interest about the specimen is that it was laid in the autumn. According to Parker* "double eggs, so far as the records go, are limited exclusively to the winter and spring."

The egg was presented to the Manchester Museum by Mrs. Nathan, of Didsbury.

Professor F. E. WEISS, D.Sc., F.L.S., exhibited a medal bearing in the centre of both sides a head of Linnaeus, and, arranged round it, the names of the several orders, each having an illustration of its classificatory character, into which Linnaeus divided the vegetable kingdom.

Mr. H. S. LEIGH exhibited a frog that had been found near Tyldesley at the bottom of a hole which was full of water after the recent heavy rains. The hole had been dug six months previously for the planting of a tree. The frog was remarkable for being devoid of colour, with the exception of one small patch, which was slightly mottled, and also for the clear red colour of the eyes.

Mr. T. G. B. OSBORN, B.Sc., read a paper entitled, "**A Note on the Staminal Mechanism of** *Passiflora cærulea.*" The paper is printed in the *Memoirs.*

Mr. D. M. S. WATSON, B.Sc., read a paper entitled "**A Preliminary Note on two new genera of Upper Liassic Plesiosaurs.**" The paper is published in the *Memoirs.*

General Meeting, November 16th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

Mr. ALBERT MALINS SMITH, M.A., Lecturer in Plant Physiology in the University of Manchester, was elected an ordinary member of the Society.

* *The American Naturalist*, vol. 40, 1906, No. 469.

Ordinary Meeting, November 16th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT made reference to the death on November 9th of Mr. Thomas Worthington, F.R.I.B.A., who had been a member of the Society from 1865.

Mr. FRANCIS NICHOLSON, F.Z.S., read a summary of a paper entitled "**Some early correspondence between Mrs. Hemans and Mr. Matthew Nicholson, a former member of the Society**." The paper will appear in full in the *Memoirs*.

Mr. Nicholson also exhibited several of Felicia Browne's autograph letters, a manuscript collection of her poems in Matthew Nicholson's handwriting, and two volumes of silhouettes made by the same gentleman, all being in his own possession. He also showed a drawing of Bronwhilfa made by Captain Hemans.

Mr. C. E. STROMEYER, M.Inst.C.E., read a paper on the "**Relative Periods of Revolution of Planets and Satellites**."

Ordinary Meeting, November 30th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were amongst the recent donations to the Society's Library: "*Chapters from the Evolution of Plants*," by F. E. Weiss (8vo, Manchester, 1909), presented by the Manchester Museum; "*Antiquities of the Mesa Verde National Park*," by J. W. Fewkes (8vo., Washington, 1909), and "*Tuberculosis among certain Indian Tribes of the United States*," by A. Hrdlicka (8vo., Washington, 1909), presented by the Bureau of American Ethnology; "*Scientific Papers*," by Sir W. Huggins (fol., London, 1909), presented by the author; "*A Barometer Manual for the use of Seamen*," 6th ed. (8vo., London, 1909), presented by the Meteorological Office; and "*The Coal-fields of Manitoba, Saskatchewan, Alberta and E. British Columbia*," by D. B. Dowling (8vo., Ottawa, 1909), "*Reports on a Portion of Algoma and Thunder Bay Districts, Ontario*," by W. J. Wilson (8vo., Ottawa, 1909), "*Catalogue of Publications of the Geological Survey, Canada*" (8vo., Ottawa, 1909), and "*The Whitehorse Copper Belt, Yukon Territory*," by R. G. McConnell (8vo., Ottawa, 1909), presented by the Geological Survey of Canada.

Mr. FRANCIS NICHOLSON, F.Z.S., presented to the Society's Library a copy of a work entitled "Loch Etive and the Sons of Uisnach," by R. Angus Smith. New ed., 1885.

The thanks of the members were accorded to Mr. Nicholson for his gift.

Professor E. RUTHERFORD, F.R.S., read a paper entitled, "**The Action of the α rays on Glass.**"

Illustrations of halos were shown on the screen, and a capillary tube was exhibited under the microscope.

Dr. B. B. BOLTWOOD read a paper, written in conjunction with Professor RUTHERFORD, entitled, "**Production of Helium by Radium.**"

Both papers are printed in the *Memoirs*.

Dr. A. N. MELDRUM read a paper, communicated by Professor H. B. DIXON, M.A., F.R.S., entitled "**Development of the Atomic Theory: 1. Berthollet's Doctrine of Variable Proportions.**" The paper will be printed in the *Memoirs*.

Ordinary Meeting, December 14th, 1909.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT made reference to the loss the Society had sustained by the deaths of Mr. A. J. S. Bles and Dr. Ludwig Mond, F.R.S. Dr. Mond had been a member from 1881 and Mr. Bles from 1901.

Dr. H. STANSFIELD exhibited a lantern slide of a photograph of lightning flashes. The photograph was taken in Bruges, with a small camera held in the hand, during an August thunderstorm in which the display of lightning took place after dark. The principal photograph represented a vertical flash, a fainter image produced by two inclined flashes being superposed upon it. One of the two inclined flashes was recorded on the plate by a double line, indicating that two discharges, separated by an interval of time during which the camera moved appreciably, had followed the same path.

Mr. FRANCIS NICHOLSON, F.Z.S., communicated the following biographical details concerning the French chemist, Berthollet :—

CLAUDE LOUIS BERTHOLLET, a chemist who made researches in both theoretical and applied chemistry, was born 9th November, 1748. In 1790 he was already distinguished enough to be elected an Hon. Member of the Literary and Philosophical Society of Manchester. He held official scientific posts under the French Government, and in 1798, together with Monge, the mathematician, and other scientific men, he accompanied the French expedition to Egypt. Berthollet also accompanied the army up the Nile, and was present at the battle of Chebreis. On this occasion he is said to have filled his pockets with stones, so that if he was killed, and the boats sank, he would remain below water. He became a leading member of the Institute of Egypt, which was founded during the French expedition of 1798, the decree of institution being dated 3 Fructidor year VI. Bonaparte had taken with him a corps of savants, who were to study on the spot the antiquities, history, geography, and the physical state of Egypt, a country then little known in Europe. All the savants who accompanied the expedition were not members of the Institute, for Bonaparte wished membership to be a reward for work done in Egypt. During the Cairo rebellion several members of the Institution were killed. According to a footnote on p. 1 of the English translation of the "Researches into the Laws of Chemical Affinity,"* the reading of that treatise was commenced in the Institution of Cairo, June, 7th year (*i.e.*, 1799). The sudden departure from Egypt of Bonaparte in the following August put an end to Berthollet's connection with Cairo. He and Monge accompanied Bonaparte to France, but the Institute continued at Cairo until 1801, when, the French having evacuated Egypt, its members were transferred to Paris, where the work of publishing the results of their Egyptian labours was continued until 1828. Of the work of the Institute a modern Mohammedan writer (Haji Browne) says they "commenced the labours which were to give to the world the vast, though unhappily incomplete, description of Egypt, which is unquestionably the most marvellous work of the kind ever undertaken. Of these men it may be said that they represented all that is best and noblest in the French nation and the higher aspirations of the revolution." From Napoleon Berthollet received the title of Count, and on one occasion the gift of 200,000 francs for the equipment of a chemical laboratory. When the monarchy was restored, Berthollet was made a peer of France. He died in 1822.

Dr. SIDNEY RUSS read a paper entitled "**A Note on Radio-active Recoil.**"

Mr. D. M. S. WATSON, B.Sc., gave an account of his paper entitled "**A Preliminary Account of the Bibliography of the Post-Triassic Sauropterygia.**

* A copy of this work, translated by Dr. M. Farrell, and dated 1804, is to be found in the Manchester Free Reference Library, King Street.

Ordinary Meeting, January 11th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President
in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Professor F. E. WEISS, D.Sc., F.L.S., read a paper entitled, "**Variability in the Flowers of Tropæolum Hybrids.**"

The paper will be printed in full in the *Memoirs*.

Ordinary Meeting, January 25th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the meeting were voted to the donors of the books upon the tables.

Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., read a paper, written in conjunction with Mr. F. BROTHERTON, on "**The Electrical Resistance of the Human Body.**"

The paper will be printed in full in the *Memoirs*.

Ordinary Meeting, February 8th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were amongst the recent accessions to the Society's Library: "*Descriptive Sketch of the*

Geology, and Economic Minerals of Canada," by G. A. Young (8vo., Ottawa, 1909), and "*Catalogue of Canadian Birds*," [new ed.] by J. Macoun and J. M. Macoun (8vo., Ottawa, 1909), presented by the Geological Survey of Canada; "*Catalogue du Cabinet Numismatique...*" 2nd ed. (4to., Harlem, 1909), presented by the Fondation Teyler à Harlem; "*The Free Atmosphere in the Region of the British Isles*," by W. H. Dines and W. N. Shaw (4to., London, 1909), presented by the Meteorological Office of London; "*The British Freshwater Rhizopoda and Heliozoa*," vol. 2, by J. Cash and J. Hopkinson (8vo., London, 1909), purchased from the Ray Society; "*Reports to the Evolution Committee. Report V.*" (8vo, London, 1909), presented by the Royal Society; "*Unwritten Literature of Hawaii...*," collected and translated by N. B. Emerson (8vo, Washington, 1909), and "*Tlingit Myths and Texts*," recorded by J. R. Swanton (8vo., Washington, 1909), presented by the Bureau of American Ethnology; "*Catalogue of the Library of the American Mathematical Society*" (8vo., New York, 1910), presented by the American Mathematical Society; "*Die baugeschichtliche Entwickelung von Kamenz*," von Dr. Ing. W. Scheibe (4to., Görlitz, 1909), "*Geschichte der Rittergüter u. Dörfer Lomnitz u. Bohra*," von P. R. Doehler (8vo., Görlitz, [1909]), "...*Friedrich von Uechtritz als dramatischer Dichter*," von W. Steitz (8vo., Görlitz, 1909), and *Codex Diplomaticus Lusatiae Superioris III....*," Hft. III., von Dr. R. Jecht (8vo., Görlitz, 1909), presented by the Oberlausitzische Gesellschaft der Wissenschaften, Görlitz.

Mr. D. M. S. WATSON, B.Sc., and Mr. J. H. WOLFENDEN, B.Sc., were nominated auditors of the Society's accounts for the session 1909-1910.

Mr. C. E. STROMEYER, M.Inst.C.E., exhibited a few samples of mild steel which had been immersed in hot caustic soda. Those samples which were subjected to compression stresses retained their ductility, whereas those which had been subjected to tension stresses were of a brittle nature.

Mr. GEORGE HICKLING, M.Sc., read a paper entitled, "**The Anatomy of *Calamostachys Binneyana*, Schimper.**"

The paper will be printed in full in the *Memoirs.*

Mr. T. A COWARD, F.Z.S., communicated and read a paper by Mr. LIONEL E. ADAMS, B.A., entitled "**A Hypothesis as to the cause of the Autumnal Epidemic of the Common and the Lesser Shrew.**"

The paper is published in full in the *Memoirs.*

Ordinary Meeting, February 22nd, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Mr. A. BROTHERS read the following note on "**Halley's Comet as seen in 1835, compared with Donati's in 1858.**"

The numerous notices of Halley's Comet which have appeared within the last few months have referred mainly to the time when it might be expected to become visible without a telescope. Now that there is the prospect of its being seen within a very few weeks, it is perhaps natural to anticipate a little as to what it will be like.

During some of its visits to our hemisphere it has been spoken of as a brilliant object, but, as is usually the case in the return visits of comets, the brightness has lessened with each return. Good drawings or sketches of Halley's Comet seem to be rare, I know of only two or three. Sir John Herschel saw it at the Cape of Good Hope, and from his sketches it was not very conspicuous. Struve in 1835 gives a sketch which shows it to have been bright, probably when it was near the sun, but as a brilliant object it must have been very inferior to several which were seen during the 19th century.

I have a distinct recollection of seeing the Comet in 1835. It was pointed out to me by my father. I was nine years old at the time, and of couise old enough to remember an object so remarkable as the one in question, remarkable that is, from the fact that its return was expected. The sketch I give in the accompanying plate is from recollection, and is only for comparison with Donati's, which I saw in 1858, when it was near the bright star Arcturus.

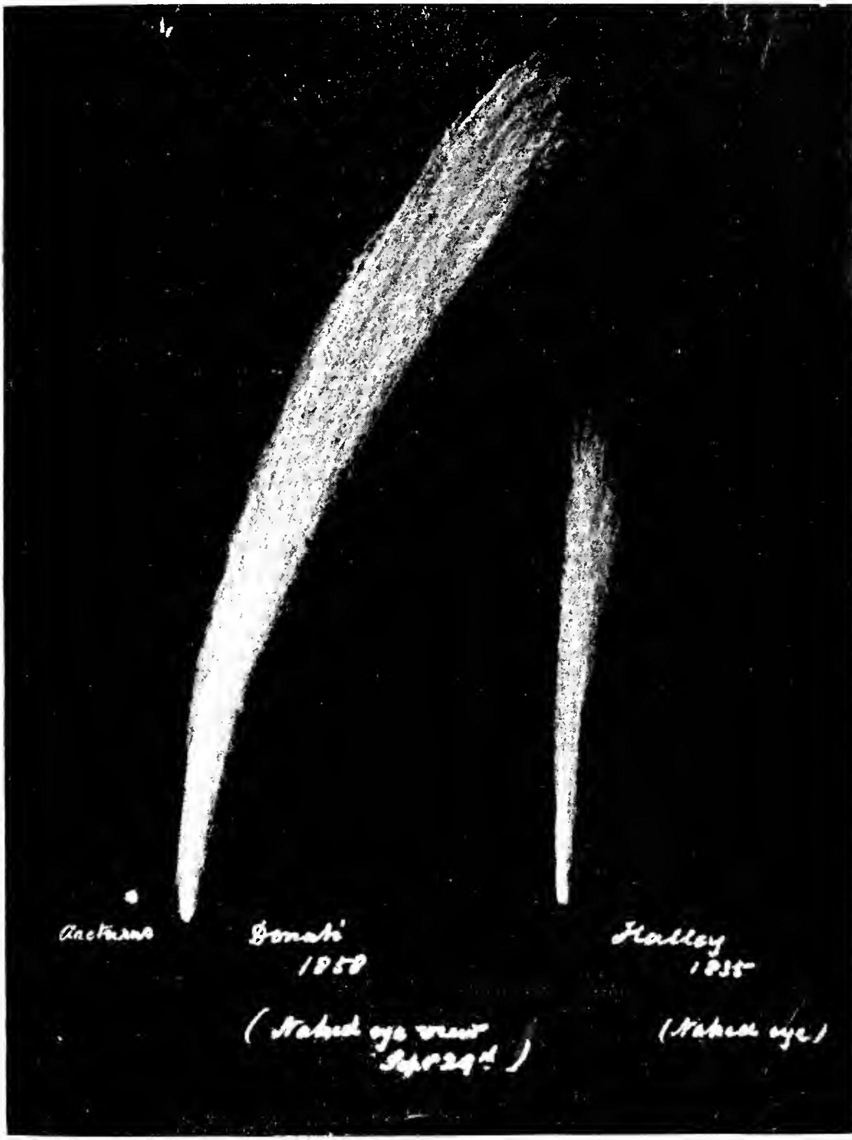
From its position in the sky, I think the time when I saw the Halley's Comet must have been in the Spring, and some time before the perihelion passage, as the object certainly was not so bright as Struve shows it to have been, and was still more inferior to the Donati. It is generally spoken of now as likely to appear as a brilliant object, but it seems to me that there is very little evidence for the assertion.

The sky was dark when I saw the Comet, and it was comparatively bright. It now appears that its advent wili be later in the year, and if visible at all to the naked eye its brightness will be lessened by twilight.

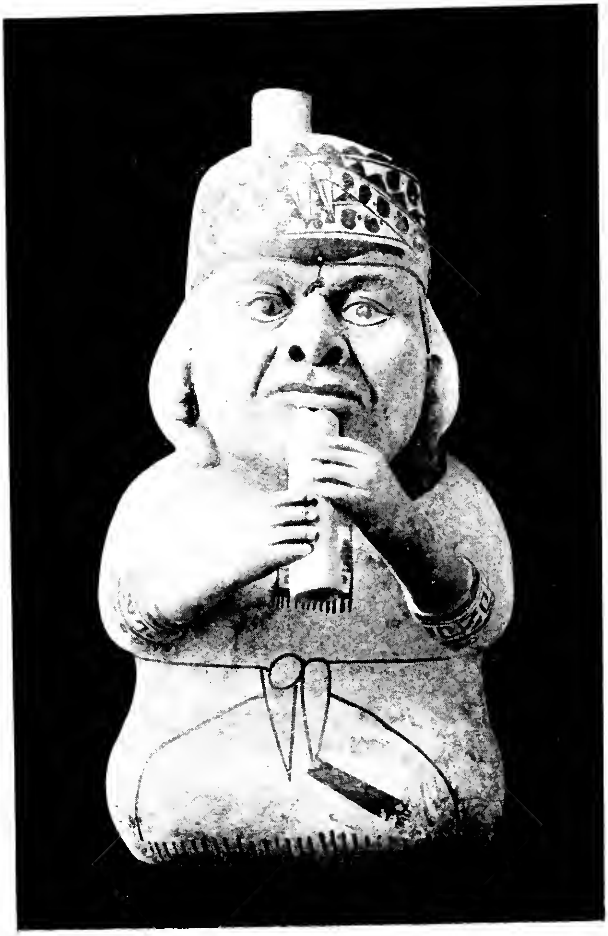
The earliest picture of the Comet is that shown in the Bayeux tapestry, but there is very little more to be seen in it than a figure which for some centuries seemed to be sufficient to indicate an unusual object in the sky, such as a flaming sword or other grotesque figure.

Dr. H. F. COWARD read a paper entitled "**The Inflammability of Gas-Mixtures**."

Hydrogen and Oxygen mixtures were shown to be capable of inflammation at a much lower pressure than had been imagined previously if the igniting spark were produced in the most suitable manner. Minima for sparks of various nature with electrodes of various kinds were given.

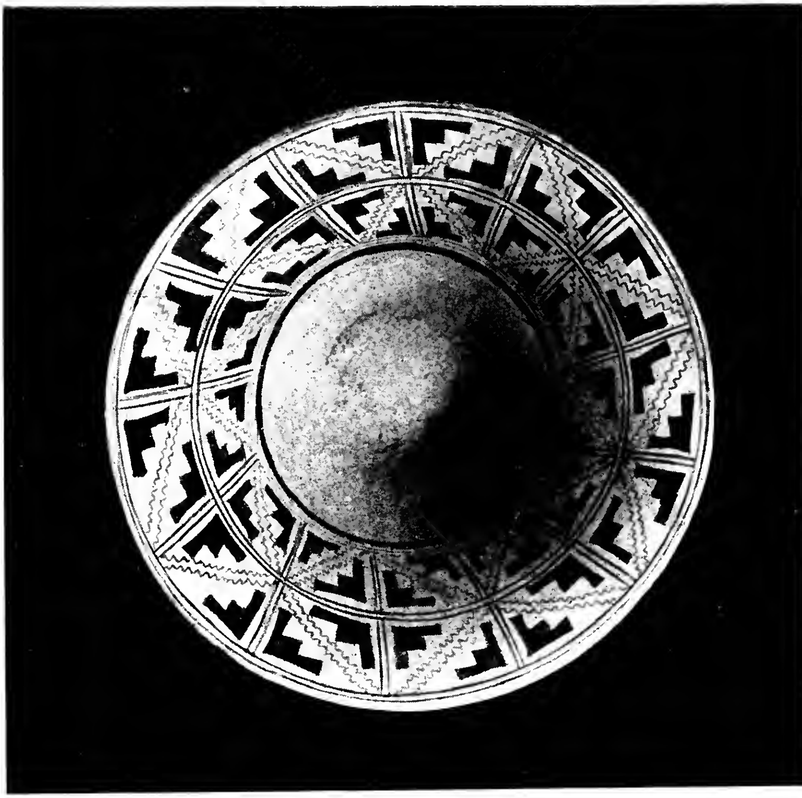

Arcturus
Donati
1858
(Naked eye view
Halley
1835
(Naked eye)

Chimu Jugs.



CHIMU MUSICIAN.

Supposed Chimu Chieftain.



CHIMU BASIN.
About 12 inches diameter × 4 inches deep.

Ordinary Meeting, March 8th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the Members were voted to the donors of the books upon the tables.

Mr. D. M. S. WATSON, B.Sc., read a paper entitled "**Upper Liassic Reptilia. Part II. The Sauropterygia of the Whitby Museum.**" The paper is printed in full in the *Memoirs.*

Sir WILLIAM H. BAILEY read the following paper :—"**Mr. Hewitt Myring's Discoveries of Pre-Historic Pottery in Peru.**"

Pre-historic man and his methods of life may be best studied by his pottery; it is one of the earliest and simplest of crafts, for by means of baked clay, with his fingers and the most elementary tools of wood or stone he could shape his cooking pots or gods, his jugs, bottles and urns, and these have as much interest to the archæologist and art student as earthenware fossil plants, and those fossils of animal life which

> "Through the ages lying
> In the buried past of the earth"

have to the geologist and students of the botany of the ancient world.

I have seen the pottery discovered by Mr. Hewitt Myring, and he has been good enough, at short notice, to lend me many photographs.

I hope that we may, before long, see some of his specimens in Manchester.

Mr. Myring is a mineralogist and mine owner, and while waiting for assistant engineers' reports, he, being in South America, visited the Chucana Valley in Peru, and, seeing some sand ridges, he there obtained assistance and explored them with a view to finding something in the Inca graves. But the race before the Incas, the ancient people the Chimus, had used this valley as a cemetery, and the result has been the discovery of many hundred pieces of probably the most ancient pottery in the world, the product of a lost civilisation and possibly 5,000 to 10,000 years old.

The pieces are in the best state of preservation, for there is no rain in that part of Peru, and the silicates in the earth have arrested decay; even metals thus buried oxidize very slowly.

The climate in the valleys of Peru is similar to that of Egypt and probably drier. It is an accepted fact that iron resists oxygen except when damp, for moisture acts like glue: iron does not rust in dry oxygen. Even sycamore planks and cases in the Cairo Museum have no sign of decay although 4,000 years old. There is an arm chair there nearly as good as new about 3,000 years old; I saw it the other day.

All writers agree that the Chimus were the ancient rulers of Peru until defeated about 500 or 600 years ago by the Incas. The Spaniards conquered the Incas and destroyed their leaders about 400 years ago. Sir Clements Markham says: "The Chimus were a highly civilised people. We know this from the remains of their systems of irrigation works, their vast and elaborate palaces, factories, and places of sepulture, and from their works of art; but we know next to nothing of their origin or history or their beliefs." Sir Clements Markham, I may say, has travelled in Peru; he has written books on his travels and on the antiquities of Peru, and probably he is the greatest living authority on Peruvian lore.

No Chimu alphabet has yet been discovered, no language has been found, and, in the absence of proof, opinions differ about the age of this pottery. Symbolism is the parent of the alphabet, and we owe much to China and Egypt, for there it took thousands of years to blossom, and the supreme partnership between the tongue, the eye, the ear, and the hand at last gives us the written word that will, in scorn of time, for ever silently speak to man.

When the Spaniards destroyed the Inca civilization and their leaders, even then the native language was uncouth, and calculations and accounts were kept by knotted cords.

It is difficult for us to believe that these people, with their symbolism in this pottery, should have had no alphabet and no method of record. They must have had some, unknown at present, and that is the quest that should crown Mr Myring's work, if his health permits; then we shall hail him as another Young, who discovered in the Rosetta stone the key to unlock the doors of ancient Bablyon.

When looking at the Peruvian pottery we cannot escape the feeling of Chinese and Indian influence, and then again, in looking at the head gear of some, we feel an Egyptian bias; indeed, the Egyptian pottery of any dynasty is not equal to the best of these Peruvian specimens, for the modelling of the human face is human and startling in its art; there we find dignity and even laughter; the muscles of the cheeks, and the wrinkles in the skin, and the flexibility of the nostrils, all show great care, skill and art.

The signs on some of the figures suggest Egyptian influence, but the resemblance may be due to natural independent evolution: it makes us wonder, however, if Atalanta was not more than a dream of Plato's, who wrote that beyond the pillars of Hercules (Gibraltar) there was a large island in the sea. Peruvian and Mexican art bear traces of evolution and progress almost identical with early Egyptian work, but stopped half way. Professor Zerffi, in "The Historical Development of Art," says:—"By some means Atalanta was separated from the East, and the pyramids, temples and palaces of Central America remained in the same relation to the pyramids, temples and palaces of Egypt, as the tapir to the elephant, the alligator to the crocodile, and the llama to the camel."

One of the gods discovered in Peru, carved from a lava block, has a head strip like a sphinx and is also like the goddess Isis. The word God is similar in the west to the Deus of the east, for in Peru it is Teotl. Sepulchral mounds are similar. Astronomy had made similar progress in both east and west.

As I have said, wood and clay were shaped by primitive man before he began to use iron or bronze; pottery is the easiest handicraft, for few tools are required; those who could mould and shape clay were in the right way to make bronze statuary. The artists of Samos were the first to run metal round a clay model, probably about 600 years before our era; but it may have been anticipated by China, as they were far in advance of the Greeks, and probably also the Egyptians, in pottery, and are yet; but the bronze age follows that of the clay if the right metal is available.

This pottery discovered by Mr. Myring has one remarkable and important quality—*no two pieces are alike.* We see that the ancient moulders had made one great step in human progress, for they did not copy each other. There is individuality in each figure; the serfdom of habit and custom and tradition did not govern their work; such workers must have had intellectual liberty and original genius, which might have made a great future, but from some unknown cause that progress seems to have been destroyed, and has left little trace behind.

As I have stated, they did not copy each other, and they did not make their plaster and clay ornaments from moulds, as sometimes the Egyptians did, in producing the effigies of the mummies which have the beautiful blue enamel. The artists were the mere unconscious tools of the priests, and the Sphinx, half brute and half human, symbolises the serfdom of their art. The people were kept in obedience and terrified into slavish subjection by huge stone monsters which filled them with horror. Art was the exclusive property of the Machiavellian priesthood, whose religion was the mere tool of tyranny, and was divorced from all pretence of morality.

About one-third of the pottery discovered by Mr. Myring has been secured for the British Museum, and may be seen any day in the cases in the porcelain rooms.

The Sun God in Mr. Myring's private collection has a helmet and a number of serpents with their heads at the outside edge of the nimbus.

These pots were buried with the dead and, like wreaths a our funerals, are supposed to be evidences of love and respect of friends and relations.

They vary in shape and size. Some are portraits, some are animals, birds and fishes: the turtle, the owl, and men and women are here. Some laugh and others are full of dignity; one is the face of a man winking with one eye, one face is asleep, it may be the sleeping sickness, while others show signs of misfortune and of disease; it has been surmised that such indicate the cause of death. Others seem to provide for the comfort of the departed in the spirit world, some for food, others for water; others have copper and silver pellets, probably for fare money at the ferry. No stamped coinage has been found. The copper and silver is hermetically sealed in the false bottoms of the jugs and vases, for the bottoms have been baked into position.

Some jugs have a whistle in the spout; pandean pipes are represented, and one is the figure of a man playing a flute, and there are bugle horns made of terra cotta that make a pleasant sound. One figure shows a man with cymbals.

Weapons are not much in evidence; one man has a mace, and the spear and shield seem to be the only weapons. Neither bows nor arrows have been discovered. No horses are to be found. There is a beast like a hornless antelope. Birds are somewhat abundant with several owls and a bat-like beast, and stags and frogs are imitated. The bugles end with a dog's head. There is a walrus, and something like a Welsh heraldic lion is biting a man. Parrots are represented, and also ducks and fish are here. One head is a learned doctor with a plumed head dress; one—probably the finest—is believed to represent a Chimu Chief or a wealthy law giver; one represents a seal eating a fish, and known and unknown effigies of the animal kingdom are in this collection.

The faces represented are doubtless portraits, and look English or German. Some would be taken as easy-going Dutchmen sitting in the market place at Haarlem, waiting for custom; broad faces and intellectual, the workmanship being equal to any of the portrait jugs in vogue in this country in the 18th century, and in some cases better art. The vases and dishes are beautiful specimens of ancient ware.

We can only guess at their meaning. Some are painted as well as moulded, but all bear scarcely any indication of what we call the hand of time.

The bars of silver that were buried with this pottery have corroded nearly away. Some bars that were about an inch square have dwindled down to about one eighth of an inch; there was probably an alloy of copper in the silver. Comparisons have been made with the corrosion of similar bars buried 400 years ago by the Incas in the same soil, which, being so full of silicates, preserves metal: the silver is only slightly tarnished. This and the utter disappearance of the baser metals give reasons for assuming the age of the pottery to be anything between 5,000 and 10,000 years old.

Mr. Myring compared the remains of the dead of this ancient people with those of the Incas. The soil that preserves precious metals from quick decay has very little influence on the bodies of the Incas buried 400 or more years ago. It appears to mummify them, but those of the Chimus, discovered with this ancient pottery, were absolutely dust, with the exception of the skulls and large bones. If the explorer had had some gelatine with him in which such things could be preserved, he would have been able to bring the remains to this country. He informed me that he put two dozen skulls carefully into sacks, but they were so decayed that, after going a few miles packed on the backs of the mules, they became dust, and unfortunately he could not bring any with him from which casts could be taken.

Mr. Myring has also discovered other Peruvian antiquities of later date, a large silver god and a gold crown of one of the Inca Kings and some jewellery.

All archæologists and students of art and antiquity are indebted to Mr. Hewitt Myring for his great and priceless work in Peru, carried out single-handed, at great personal danger and cost. He has contributed to our knowledge of ancient man and a buried civilization, earning our gratitude, and making a reputation which will cause his name to rank in history with those of Layard, Rawlinson, Loftus, Young, Professor Flinders Petrie, and other illustrious explorers.

Special Meeting, March 22nd, 1910.

The President, Mr. FRANCIS JONES, M.Sc., F.R.S.E.,
in the Chair.

The Wilde Lecture, on "**Recent Contributions to Theories regarding the Internal Structure of the Earth,**" was delivered by Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S., Professor of Geology and Mineralogy in the University of Manchester.

General Meeting, April 5th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

Geh. Prof. Dr. WALTER NERNST, Director of the Physikal.-chemisches Institut in the University of Berlin was elected an honorary member of the Society.

Ordinary Meeting, April 5th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President,
in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

Mr. THOMAS THORP, F.R.A.S., exhibited some stereoscopic photographs of the Morehouse Comet, taken by Prof. E. E.

Barnard, of the Yerkes Observatory, which showed very clearly the peculiarly twisted form of the comet's tail.

Mr. R. L. TAYLOR read a paper entitled "**A Preliminary Note on the Action of Carbon Dioxide and of Air on Bleaching Powder and similar substances.**"

Contrary to what is generally supposed, carbon dioxide, in presence of moisture, liberates no hypochlorous acid from bleaching powder, either solid or in solution, but only chlorine. Similarly, carbon dioxide liberates nothing but bromine from a mixture of a bromide and a hypobromite. When air, freed from carbon dioxide, is passed through a solution of bleaching powder, it slowly sweeps out hypochlorous acid, which is present in the free state in the solution, being produced by the action of water on the calcium hypochlorite. If, however, moist air containing the usual small amount of carbon dioxide is passed through bleaching powder, either solid or in solution, a mixture of chlorine and hypochlorous acid is given off, the chlorine usually largely predominating. In the case of the solid substance, after the moist air has been passed through for a considerable time, and the bleaching powder has thus become quite wet, there is no hypochlorous acid produced, but only free chlorine.

When bleaching powder, mixed with about thirty times its weight of water, is heated with boric acid, practically pure hypochlorous acid is given off, no matter what proportion of boric acid is used. This forms a convenient method of preparing a solution of hypochlorous acid. Under similar conditions, a mixture of a bromide and a hypobromite evolves nothing but bromine.

Annual General Meeting, April 19th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved:—"That the

Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings.*"

Mr. H. E. SCHMITZ, M.A., B.Sc., and Mr. CHARLES LEIGH were appointed Scrutineers of the balloting papers.

The following members were elected officers of the Society and members of the Council for the ensuing year.

President: FRANCIS JONES, M.Sc., F.R.S.E.

Vice-Presidents: THOMAS THORP, F.R.A.S.; ERNEST RUTHERFORD, D.Sc., F.R.S.; ARTHUR SCHUSTER, Sc.D., Ph.D., F.R.S.; FRANCIS NICHOLSON, F.Z.S.

Secretaries: R. L. TAYLOR, F.C.S., F.I.C.; GEORGE HICKLING, M.Sc.

Treasurer: ARTHUR McDOUGALL, B.Sc.

Librarian: C. L. BARNES, M.A.

Other Members of the Council: ERNEST F. LANGE, F.C.S., M.I.Mech.E.; W. H. TODD; EDMUND KNECHT, Ph.D.; WILLIAM BURTON, M.A., F.C.S.; SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.; Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

Ordinary Meeting, April 20th, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables.

PROFESSOR S. J. HICKSON, D.Sc., F.R.S., exhibited a piece of wood stained green by a fungus that he had found at Lamplugh, in Cumberland.

MR. T. G. B. OSBORN, B.Sc., said that the fungus was *Peziza Aeruginosa* which is not infrequently to be found growing as a saprophyte on dead oak wood. The wood thus stained was formerly used in the manufacture of "Tonbridge ware."

MR. G. P. VARLEY, M.Sc., gave an account of some interesting observations he had made on the state of magnetisation of the iron boundary fence on the ridge between Black Sail Pass and the top of the Pillar Fell in the Lake district. The heavier iron uprights which were firmly fixed in the rock showed a north polarity below and south polarity above, while the floating uprights used for spacing the wires had, with few exceptions, the south pole below and the north above. The magnetisation of the heavy fixed bars was what one would expect from the action of the earth, but that of the floating uprights was not readily explicable.

PROF. S. J. HICKSON, D.Sc., F.R.S., read a paper entitled **"A New Octoradiate Coral."**

The paper, which is printed in the *Memoirs*, was illustrated with a number of lantern slides, and a specimen of the coral was exhibited under a dissecting microscope.

An interesting discussion followed in which Dr. F. H. Bowman, Mr. D. M. S. Watson and others took part.

Ordinary Meeting, May 3rd, 1910.

Mr. FRANCIS JONES, M.Sc., F.R.S.E., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the tables. The following were amongst the recent accessions to the Society's Library: "*Precession Tables... in connection with the third ten-year Catalogue 1910*" (fol., London, 1909), and "*Second nine-year Catalogue of Stars for the Epoch 1900·0*" (fol., Edinburgh, 1909), presented by the Royal Observatory, Greenwich; "*Bibliography: Papers and Records published with respect to the Geology and Palæontology of N. of England 1902-08*," by T. Sheppard (8vo., Hull, 1909) presented by the author; "*Meridian-Beobachtungen von Sternen in der Zone 65°-70° nördlicher Declination... I.*", von H. Geelmuyden and J. Fr. Schroeter (fol., Christiania, 1909), presented by the Univ.—

Observatorium in Kristiania; "*Rapporten van de Commissie in Nederlandsch-Indië voor Oudheidkundig, Onderzoek... 1907*" (4to., Batavia, etc., 1909), and "*De Java-Oorlog van 1825-'30*"... Zesde Deel, door E. S. de Klerck (4to., Batavia, 1909) presented by the Bataviaasch Genootschap van Kunsten en Wetenschappen; "*The Choctaw of Bayou Lacomb St. Tammany Parish Louisiana,*" by D. I. Bushnell (8vo., Washington, 1908) presented by the Bureau of American Ethnology; "*A Geological Reconnaissance of the region... between Lake Nipigon and Clay Lake, Ontario,*" by W. H. Collins (8vo., Ottawa, 1909), presented by the Geological Survey of Canada; "*Le Opere di Galileo Galilei,*" ed. naz. vol. xx. (4to., Firenze, 1909), presented by the Italian Embassy; "*Founders' Week Memorial Volume containing an account of the 225th Anniversary of the Founding of the City [of Philadelphia],*" ed. by F. P. Henry (8vo., Philadelphia, 1909) presented by the Committee of Scientific Institutions, Philadelphia; "*A Bibliography of Persius,*" by M. H. Morgan (8vo., Cambridge, Mass., 1909), presented by the Library of Harvard University.

Mr. HENRY SIDEBOTTOM read a paper entitled "**Report on the Recent Foraminifera from the Bay of Palermo, Sicily, 14-20 fms. (Off the Harbour).**"

Examples of the clusters of the genus *Lagena* were shown under the microscope, and many carefully executed drawings were exhibited.

The paper is published in the *Memoirs.*

Professor F. E. WEISS, D.Sc., F.L.S., in the absence of the author, read a paper written by Mr. CHARLES BAILEY, M.Sc., F.L.S., entitled "**A Third List of the Adventitious Vegetation of the Sandhills of St. Annes-on-the-Sea, North Lancashire, Vice County 60.**"

The paper is printed in full in the *Memoirs.*

Mr. H. BATEMAN, M.A., read a paper entitled "**The Physical Aspect of Time.**"

The paper is printed in the *Memoirs.*

Annual Report of the Council, April, 1910.

The Society began the session with an ordinary membership of 161. During the present session three new members have joined the Society. Fifteen resignations have been received, and there have been three deaths, *viz.:* Mr. A. J. S. Bles, Dr. Ludwig Mond, F.R.S., and Mr. Thomas Worthington, F.R.I.B.A., whilst one member has been removed from the list for non-payment of his subscription. This will leave on the roll at the end of the session 145 ordinary members. The Society has also lost, by death, four honorary members, *viz.:* Dr. Anton Dohrn, For. Mem. R.S., Professor G. Neumayer of Neustadt, For. Mem. R.S., Professor Simon Newcomb, For. Mem. R.S., and Dr. R. Bowdler Sharpe. Memorial notices of these gentlemen appear at the end of this report.

The average attendance at the meetings was 21 as compared with 30 for the session 1908-09.

The Society commenced the session with a balance in hand of £278. 1s. 6d., from all sources, this amount being made up of the following balances:—

At the credit of	General Fund	£46	10	10
,, ,,	Wilde Endowment Fund	114	2	2
,, ,,	Joule Memorial Fund	79	10	10
,, ,,	Dalton Tomb Fund	37	17	8
		£278	1	6

The total balance in hand at the close of the session amounted to £368. 3s. 4d., and the amounts standing at the credit of the separate accounts, on the 31st March, 1910, are the following:—

At the credit of	General Fund	£102	9	9
,, ,,	Wilde Endowment Fund	179	9	7
,, ,,	Joule Memorial Fund	86	4	0
Balance 31st March, 1910		£368	3	4

The Wilde Endowment Fund, which is kept as a separate banking account, shows a balance of £179. 9s. 7d. in its favour, as against £114. 2s. 2d. at the beginning of the financial year, there being a further increase of ten pounds in the receipts from the invested funds as compared with the receipts for the previous year.

The Joule Memorial Fund has this year incurred an expenditure of one guinea by the provision of a silver plate with inscription for Dr. Joule's chronometer-watch.

It will be observed that the Dalton Tomb Fund no longer appears in the year's statement of accounts as a separate Fund, it having been merged in the General Funds of the Society. The Council have passed a resolution undertaking to use that sum in keeping the tomb in a state of repair.

The Society has to thank Dr. Henry Wilde, F.R.S. for his generous donation of £50 to the Funds of the Society for general purposes.

The Librarian reports that during the session 829 volumes have been stamped, catalogued and pressmarked, 761 of these being serials, and 68 separate works. There have been written 317 catalogue cards, 213 for serials, and 104 for separate works. The total number of volumes catalogued to date is 32,378 for which 11,542 cards have been written.

Satisfactory use is made of the library for reference purposes. During the session, 202 volumes have been borrowed from the library, as compared with 175 in the previous session.

Further attention has been given to the completion of sets, 12 volumes having been obtained, which complete one set and partly complete another. Of these, one volume was purchased, and the rest were presented by the society publishing them.

A smaller amount of binding has been done this session, 207 volumes having been bound in 168.

A record of the accessions to the library shows that, from April, 1909, to March, 1910, 762 serials and 95 separate works were received, a total of 857 volumes. The donations during the session (exclusive of the usual exchanges) amount to 90 volumes and 143 dissertations; five volumes have been purchased (in addition to the periodicals on the regular subscription list).

During the past session the Society has arranged to exchange publications with the following:—Laboratorio di Zoologia generale e agraria di Portici; Illinois State Geological Survey; Royal Society of South Africa, Cape Town; Liverpool Botanical Society; and the State University of Oklahoma, Norman.

The *Proceedings of the Dorset Natural History and Antiquarian Field Club* and the *Pharmaceutical Journal* are no longer received by the Society's Library, and the publication of the *Technology Quarterly*, of Boston, U.S.A., has been discontinued.

The publication of the *Memoirs and Proceedings* has been continued under the supervision of the Editorial Committee.

The Society is indebted to the following for the under-mentioned gifts:—

Mr. Francis Nicholson, F.Z.S., for a copy of Dr. Angus Smith's "Loch Etive and the Sons of Uisnach."

Mr. Thomas Thorp, F.R.A.S., for a specimen of his new silvered concave grating and for a case in which to keep Dr. Joule's Chronometer-watch.

Sir Thomas H. Holland, K.C.I.E,, D.Sc., F.R.S., Professor of Geology and Mineralogy in the Manchester University, was invited to deliver the Wilde Lecture for 1910. The Lecture, on "Recent Contributions to Theories regarding the Internal Structure of the Earth," was delivered on Tuesday, March 22nd, 1910.

The University of Cambridge celebrated the Darwin Centenary in June, 1909, and this Society was represented by the

Hon. Secretary, Dr. F. W. GAMBLE, F.R.S., who presented the following address which had been approved by the members :—

"The Manchester Literary and Philosophical Society "sends cordial greetings to the University of Cambridge on "the occasion of the commemoration of Charles Darwin.

"We honour Darwin as an investigator whose boldness "and insight won from Nature answers to all his questions; "whose achievements range so widely and on such diverse "fields of knowledge, that each aspect of them increases "wonder and lessens astonishment. We acknowledge him "as the thinker whose modest appeal to the judgment of "the laity has transformed that judgment and now governs "the mode in which we conceive the problems and effect "the conduct of life. And we look upon Darwin as upon "one who, by his lovableness, endurance, and courage, has "endeared himself to succeeding generations. Of Darwin "it may be said, not only that all he touched he illuminated, "but that his reflections have enlightened all other fields of "knowledge.

"The bequest of Darwin to learning is assurance of faith "in scientific method; his message to investigators, hope in "the solution of vital problems; and his gift to his fellows, "the long-suffering charity that triumphs over opposition.

"'Qui autem docti fuerint fulgebunt quasi
splendor firmamenti.'"

Signed on behalf of the Manchester Literary and Philosophical Society;

FRANCIS JONES, *President.*
R. L. TAYLOR, }
C. G. HEWITT, } *Hon. Secs.*

Dr. ANTON DOHRN who was elected an honorary member of the Society in April, 1892, died in Münich on September 27th, 1909, at the age of 68 years. It is no exaggeration to say that Dr. Dohrn raised for himself during his lifetime an enduring monument which will be regarded as the most remarkable achievement in biological science of the nineteenth century. The foundation of the famous Zoological station at Naples was entirely due to his energy, ability, and devotion to science, and, although it has since received financial support from foreign governments—among which the English government forms a notable exception,—and from many scientific societies, it was Dohrn's guiding hand that led the institution to the proud position it now occupies as *facile princeps* of the zoological stations of the world. It is almost impossible to estimate the value of the work that has been done at the station since its foundation in 1872. The thirty great quarto volumes of the series entitled *Fauna und Flora des Golfes von Neapel* and the nineteen volumes of the *Mittheilungen aus der Zoologischen Station zu Neapel* represent only a part of the elaborate researches that have been rendered possible by the facilities afforded at the station. Zoologists, botanists, and physiologists from all parts of the world have been attracted to the station, and have frequently published the results of the researches they have carried out, amid the invigorating intellectual surroundings that the station provides, in the scientific journals of their own countries.

Such an achievement as that of Dr. Dohrn was only possible for a man who combined in himself the qualities of great scientific ability and strong administrative power. As a great deal of his time was necessarily occupied in the duties of management and in missionary efforts to obtain the cooperation and support of other countries, the amount of scientific work that stands in his name is not large, but some of it, and in particular his "Studien über Urgeschichte des Wirbelthierkörpers," shows marked originality, and is of great scientific value.

Dr. Dohrn was the son of a wealthy sugar-refiner of Stettin, in North Germany, himself a well-known coleopterist, who encouraged his son in his zoological studies. In 1870 he was a private docent in the University of Jena, where he met and cultivated the friendship of Gegenbaur, Haeckel, Kleinenberg, Lankester, and others. It was there that he conceived the idea of his great zoological station, which he fortunately lived to see accomplished on such a magnificent scale. Lankester tells us that at first his intention was to place the laboratory on the south coast of France, but the outbreak of the Franco-Prussian war necessitated an alteration of this plan, and after much deliberation and endless difficulties the station was erected at Naples.

Dohrn was a man of very charming personality, and he gained the respect and admiration of those who worked in the laboratory. Some few zoologists have perhaps gained a greater reputation for their scientific work, but probably no one has ever enjoyed so much personal esteem. Whereas all zoologists of every nationality owe to him a debt of gratitude for the valuable services rendered to the biological sciences, there are several young Englishmen who have received at his hands the timely help and generous hospitality which often turn the scales of a man's career. If Dohrn had done no more for our countrymen than he was strictly bound to do in response to the meagre subscriptions he received from Great Britain, the history of zoological research by Englishmen would have been much less gratifying for us to read than it is. S. J. H.

Georg Balthasar von Neumayer was elected an honorary member of this society on the 17th of April, 1894. He was born at Kirchheimbolanden, in Bavaria, on the 21st of June, 1826, so that he was within a few weeks of completing his eighty-third year at the time of his lamented death on May 24th, 1909. Attracted always by the sea and the many problems which it presents to the scientific mind, he made a special study of the practice of navigation and nautical astronomy, abandoning his University studies at Munich in order to ship as a common sailor before the mast, that he might gain practical experience of seamanship. In 1856 he went out to Tasmania to devote himself to magnetic work at the observatory which Sir John Ross had started at Hobart Town, and in the next year, with the assistance of King Maximilian of Bavaria, and Alexander von Humboldt, he founded the Flagstaff Magnetical and Meteorological Observatory at Melbourne, of which he remained Director till 1864. In 1872 he was appointed Hydrographer to the Imperial Navy, a post which he occupied till 1876, when he was promoted to the Directorship of the Deutsche Seewarte, at Hamburg, an institution the establishment of which, in 1868, he had strenuously advocated. He remained at the head of this observatory till his retirement in 1903, and its development to its present unique position may be considered his life's work. Keenly interested always in Polar exploration from the scientific side, and recognising the importance of increasing our knowledge of the physical and magnetic conditions at the poles, he exercised his influence in promoting investigations in all parts of the world,—in the international circumpolar expeditions of 1882-3, in the fitting out of the German Antarctic expedition on the Gauss—to mention but two of the many expeditions to which he devoted special attention. It is a pleasure to know that his work has received the recognition and just reward which it undoubtedly deserved. He was made a Privy Councillor of the German Empire, and on his retirement was awarded the honour of the ennobling title "von." The German Meteorological Society unanimously elected him as its first president on its foundation in 1883, and in 1899 he was president of the German Association. Abroad, no less than at home, his great services to meteorology were appreciated. He was elected an honorary member of the Royal Meteorological Society of London in 1874, and a Foreign member of the Royal Society in 1899. His death will be mourned by a world-wide circle of scientific men, to a very large number of whom he was known for his sterling qualities, his genial urbanity, the warmth of his friendship and his kindly disposition, more especially towards young men entering upon a scientific career. His services to the German Empire can scarcely be overestimated. During his Directorship of the Seewarte he was indefatigable in his labours to introduce the best scientific methods into all work performed in the German naval and mercantile services, and to-day, thanks to his guidance, both may be said to be second to none in the accuracy and trustworthiness of their contributions to scientific progress. W. M. T.

Simon Newcomb was born at Wallace, Nova Scotia, March 12th, 1835, his father being John Burton Newcomb, a country school teacher. Young Newcomb was privately educated by his father, and when about 18 years of age commenced to teach in schools himself. Some four years later he received an appointment on the U.S. Nautical Almanac at Cambridge, Mass., and at the same time attended the Lawrence Scientific School, graduating B.Sc. at Harvard in 1858. In 1861 he was appointed Professor in the U.S. Navy, and Astronomer at the Naval Observatory in Washington. Two years later he married Mary Caroline Hassler (daughter of Dr. Charles A. Hassler, of the U.S. Navy) who, with his three daughters, survives him.

Newcomb remained in the Navy till 1877, when he was appointed Director of the U.S. Nautical Almanac, retiring from that post, in accordance with the regulations, in 1897, at the age of 62. During his Directorship of the Nautical Almanac in 1884 he accepted the Chair of Mathematics and Astronomy in the Johns Hopkins University, Baltimore, retaining it until 1895. After his retirement from office he continued to live and follow his bent (which included not only Mathematics and Astronomy but Political Economy and Psychology) at Washington. He died on July 11th, 1909.

His first publication was an answer to a "crank" theorist on the Copernican doctrine. In 1860 he published his first elaborate work, "Secular Variations and Mutual Relations of the Orbits of the Asteroids." In this work he applied to the asteroids the theory of perturbations with a view to proving or disproving Olber's explosion theory; but although carried back many thousands of years, no indication was found of any such origin. Whilst Newcomb could not be said to have settled the matter one way or the other by the investigation, he clearly showed in it that grasp of the general principles of celestial mechanics which was the keynote of his life's work.

Whilst engaged in the Observatory at Washington he appears to have formed two plans for his future work, one being the preparation of constants of astronomy, and the other the theory of the moon's motion. In connection with the first he took up the question of the sun's distance, which from observations of Mars in 1862 he made out to give a parallax of $8''\cdot848$. This, however, he abandoned later for the value $8''\cdot790$, which is very close to the latest determination by Hinks. His paper on the Asteroids was followed by "An Investigation of the Orbit of Neptune" in 1867 and "An Investigation of the Orbit of Uranus" in 1874.

In 1870 he took up the important subject of the Moon's motion, and his results were published eight years later, some of them being used in our own Nautical Almanac. In this year he first visited Europe and was introduced to many eminent Astronomers both in this country and on the Continent. The Franco-German war was proceeding, but facilities were afforded him for inspecting the Paris Observatory records of the moon's motion, and much of this investigation was made within hearing and sight of the guns around Paris.

In the period between 1861 and 1877 short notes from him appeared on a variety of subjects—optics, finance, taxation, social science, the labour question, copyright, political economy, non-Euclidean geometry, besides numerous reviews and popular articles.

Whilst at the Naval Observatory he played a very important part in connection with the 26 inch telescope, the then largest instrument in the world, having to select and test the glasses. Later he was also consulted by the Russian and Japanese governments in a similar connection. In 1878 he published his "Popular Astronomy," and in 1884 his "Measure of the

Velocity of Light." His next published work was "The Stars" in 1901, in which he discussed the construction of the Stellar Universe, arriving at the conclusion that we must abandon the idea of the infinity of our Universe. These conclusions did not, however, take into account the fact of absorptive matter which has been shown to exist by Kapteym and others. The article on Astronomy in the "Encyclopædia Britannica" (1902) was from his pen. His work "Astronomy for Everybody" appeared in 1903 as also his "Reminiscences of an Astronomer."

All the investigations undertaken by him were extremely laborious but they are of enduring value. In much of his work he clung to his own methods, sometimes losing much valuable time and assistance by not seeing what could be learned from the labours of others, and in a letter to Professor Brown he stated that he was always repelled by intricate algebraic expressions, and was simply tired out before getting to the end.

Many honours were bestowed on him for his labours in the science of Astronomy. In 1872 he was elected an Associate of the Royal Astronomical Society, and two years later the gold medal of the Society was awarded to him. The gold Huyghens Medal which is given only once in twenty years was presented to him by the University of Leyden. Many Universities, including Edinburgh, Heidelberg, and Padua conferred on him honorary degrees. He was the first American to be elected as an Associate of the Institute of France, and became a member of the National Academy of Sciences of Washington in 1869, being Vice-President from 1883 to 1889. In 1877 and 1878 he was President of the American Association for the Advancement of Science. He was elected an honorary member of this Society, April 19th, 1887.

His reminiscences convey the impression that he never really cared for Observational Astronomy, his work lying in the comparison of observation with theory.

In his death science has lost a man of brilliant parts, an indefatigable worker, and one who has left his enduring mark on many branches of knowledge. T. T.

Richard Bowdler Sharpe, LL.D., F.L.S., F.Z.S., an honorary member of this Society, died at his home in Chiswick, on Christmas Day, 1909, at the age of 62 years, after a brief illness, from pneumonia.

He was born in London, November 22nd, 1847, the eldest son of Thomas Bowdler Sharpe, a well-known publisher in London, and grandson of the Rev. Lancelot Sharpe, Rector of All Hallows, Staining, London, and for many years headmaster of St. Saviour's Grammar School, Southwark. At the age of sixteen he took a clerkship in the establishment of W. H. Smith and Son, and two years later entered the employment of B. Quaritch, the eminent publisher and bookseller. At the age of nineteen he was appointed Librarian to the Zoological Society, which office he held for five years, when in 1872 he accepted the post of Senior Assistant to the Department of Zoology at the British Museum, vacant by the death of that eminent ornithologist, George Robert Gray: In November, 1895, he was promoted to be Assistant-Keeper in charge of the Vertebrate section of the Zoological Department, which position he held till his decease. After taking up his official duties as head of the Ornithological Department of the British Museum his ability was so quickly appreciated that he was entrusted with the preparation of the first volume of the "British Museum Catalogue of Birds" published in 1874, which gigantic work (8vo., 27 vols., 1874-1898), the most exhaustive undertaking of the kind in existence, employed the chief part of his time and energies, apart from the official routine of his curatorship, for a quarter of a century. The Catalogue embraces not only a list of the specimens contained in the Museum itself, but it gives a full description of every bird known in the world at the time of publication, whether in the Museum or in any other collection; its changes of plumage and the literature referring to its history and determination, together with a brief record of the geographical range of each species, and an enumeration of the specimens in the British Museum. The stupendous character of the task may be realised, and it says much for the extraordinary industry and power of work possessed by Dr. Sharpe that he prepared personally nearly one-half of the 11,500 species contained in the entire work.

Following the "Catalogue" Dr. Sharpe was also responsible for the "Hand-list of the Genera and Species of Birds" (8vo., 5 vols., 1899), the last volume having been finished and issued within a few weeks of his death.

These two undertakings, the "Catalogue" and the "Hand-list" published during the thirty-seven years of his official life as Curator of the British Museum Department of Birds, are only a part, although a considerable part, of his ornithological output during this long period, for he found time to complete the unfinished works of several of his ornithological colleagues, and to write a large number of special publications on birds which alone might be considered a remarkable series to be produced by a single author. His ornithological papers in scientific journals, beginning in 1866, number nearly four hundred, and some of them are of considerable length, while for fifteen years he was the recorder for the Class Aves in the *Zoological Record.* He also wrote and published various popular works and delivered many courses of lectures on birds, all in addition to his multifarious duties in the Bird Room of the British Museum, involving among other things constant personal attention to the many enquiries addressed to him and to the numerous visitors to the Department who daily go there seeking information.

"His remarkable success in building up the national collection of birds, from 35,000 in 1872 to about 500,000 in 1909, despite the weeding out of many duplicates, is well known. Many of the important collections that were transferred to the British Museum by their donors, were avowedly contributed to this institution in consequence of the presence of Dr. Sharpe at the head of the Ornithological Department, as notably the great Hume and Tweedale collections and others."

"Those who only met Dr. Sharpe during the last ten years of his life cannot realize the extraordinary energy he formerly possessed, and the enormous amount of work he was able to undertake and successfully accomplish. His immense and almost boyish enthusiasm never failed him to the end; but during the last few years of his life one could not help noticing, with sorrow, that his health was beginning to fail, and that the strain of many years of unremitting labour at high pressure had at last worn him out. Kind-hearted, almost to a fault, his unfailing courtesy, good temper, and readiness to assist all those who sought information and help endeared him to every one both at home and abroad. The cares of life, which in his case were many, and the deceitfulness of riches, which were few, hardly affected his exuberant spirits, and he was always cheery and full of good-natured chaff. His generosity was such that he was always ready to offer pecuniary assistance in any case of trouble that came under his notice, and it was, therefore, not surprising that he was frequently imposed upon."

Dr. Sharpe's death is a great loss to science, and an almost irreparable one to the British Museum Department of Birds, which has acquired its pre-eminence among the great ornithological collections of the world mainly through his efforts; while his long series of contributions to the literature of ornithology will be his enduring memorial to the end of time." F. N.

By the death of Dr. Ludwig Mond, F.R.S., the Society is poorer through the loss not only of a man of wide scientific knowledge and of keen chemical insight, but of one whose wealth, acquired by ability and perseverance, was used in the promotion of far-sighted schemes for the advancement of science.

Born at Cassel in 1839, Ludwig Mond studied at Marburg under Kolbe, and then at Heidelberg under Bunsen. Turning to technical chemistry after his graduation he worked out a process for the recovery of sulphur from the alkali waste produced in the Le Blanc method of soda manufacture. He came to England to establish this process, which was adopted in many works and with considerable success in South Lancashire. For a short time he went to Holland in charge of a Le Blanc soda works, and it was at this period he examined and convinced himself of the possibilities of the ammonia-soda process of the brothers Solvay. Returning to England he persuaded Mr. J. T. Brunner to enter into partnership with him to carrry out the Solvay process. After a few years of engineering and experimental difficulties the commercial success of the Winnington works was triumphantly established, and it has since become one of the largest alkali works in the world.

Dr. Mond's endeavours to recover the chlorine, run to waste in the Solvay process, led to great improvements in the Weldon-Pechiney "magnesia" method, and incidentally to the discovery of nickel-carbonyl—a discovery which Mond elaborated into a commercial process for the extraction of nickel from its ores now carried out by the Mond Nickel Company at Swansea.

Another industry we owe to Dr. Mond is the production of a cheap power-gas from coal, so effected that the nitrogen of the coal is largely made available as ammonia.

Those who had the pleasure of Dr. Mond's friendship knew him as a man of artistic tastes, of broad-minded and enlightened views, and of a generous hospitality. His house near the Regent's Park in London—adorned with splendid paintings by early Italian masters—was a rendezvous for British and foreign men of science. There are many in the ranks of pure chemistry, and of chemical industry who owe their position to timely help given them by Dr. Mond; and his aid and encouragement were given to many scientific institutions and laboratories, among which may specifically be mentioned the laboratory erected in the Owens College as a memorial to his friend, Professor Schorlemmer. But the two benefactions which stand out as remarkable even among Dr. Mond's generous gifts to science are the Davy-Faraday Research Laboratory, which he equipped and endowed, and the fund for completing the Royal Society Catalogue of Scientific Papers. Dr. Mond never sought for honours, though he accepted the distinctions awarded him by Universities and Scientific Societies. Some years ago he was pressed to accept the

Presidency of this Society, of which he had been a member since 1881, but for reasons of health he could not accept; for the same reason he declined two years ago the Presidency of the Chemical Society.

Dr. Mond died at his house in London on December 11th, 1909, and was buried at East Finchley. Few men have lived a fuller life: very few have been able to take so active a share in the promotion of pure science as well as of its industrial application. H.B.D.

THOMAS WORTHINGTON, F.R.I.B.A., a member of the Society for nearly 45 years (elected on 21st February, 1865), was born 11th April, 1826, at the Crescent, Salford, his father being Thomas Worthington, merchant, a native of Nottingham.

He attended the well-known school of the Rev. J. R. Beard, D.D., in Broughton, where so many Manchester men of the last generation received their early education.

Mr. Worthington was articled in 1840 to Mr. Henry Bowman, a Manchester architect (a member of our society), joint author with his partner Mr. J. S. Crowther (also a member of the Society) of "The Churches of the Middle Ages," in the illustration of which Mr. Worthington assisted.

While a student Mr. Worthington won the Isis Gold Medal of the Society of Arts. Having completed his articles he spent a considerable time on the Continent, the year 1848 being devoted to gaining a knowledge of Italian architecture. Incidentally he had some interesting experiences in that year of continental revolution.

In 1849 he began practice as an architect in Manchester, and had a successful career, amongst his works being the Overseers' offices in Fountain Street, the City Police Courts, Nicholl's Hospital, the Memorial Hall, the Manchester Albert Memorial, and also the beautiful buildings of Manchester College, Oxford. He designed many hospitals, and was one of the first to introduce the "pavilion" method of hospital construction, now universally adopted. Besides public buildings he designed many private residences. He was interested in sanitation, and was amongst the few architects to devote attention to the housing of the working classes. He wrote little, but a few of his papers and addresses were printed in separate form.

He was elected a Fellow of the Royal Institute of British Architects in 1865, was President of the Manchester Society of Architects from 1875 to 1877, and a member of numerous other societies.

His principal public interest was in connection with the Royal Manchester Institution. He was its President for some years, and to him was very largely due the transfer in 1882 to the city of the Mosley Street building and its contents, which thus became the City Art Gallery. To his death Mr. Worthington remained a member of the Art Gallery Committee, as a representative of the Governors of the Institution.

Mr. Worthington was twice married. His son, Mr. Percy Scott Worthington, M.A., F.R.I.B.A., is the present President of the Manchester Society of Architects. He died at his residence, Broomfield, Alderley Edge, on 9th November, 1909, in his 84th year, and is buried at Dean Row Chapel. F. N.

THOMAS WINDSOR, M.R.C.S. (England), 1853, L.S.A. 1854, who died at his residence, Brownslow, Great Budworth, on April 13th, in his 79th year, and was cremated at the Manchester Crematorium on April 16th, was elected an ordinary member of this Society March 8th, 1864, and Honorary Librarian October 4th, resigning his membership in 1866. In 1865 he compiled an alphabetical Catalogue of the Books and Journals in the Library which was printed.

Mr. Windsor had a most successful career as an ophthalmic surgeon in Manchester, but retired from practice many years ago. He held many important posts, amongst others he was surgeon to the Salford and Pendleton Royal Hospital and Dispensary, to the Manchester Eye Hospital, to the Southern Hospital for Women and Children, Ophthalmic Surgeon to the

Manchester Royal Infirmary (1874), Lecturer on Ophthalmology at the Owens College in 1875, author of numerous medical papers, and one of the editors of the *Ophthalmic Review*, 1864-66.

He had a marvellously wide acquaintance with medical bibliography, and it is to him more than any other man that the Library of the Manchester Medical Society owes its excellence. He became its Honorary Librarian in 1858, when the Library contained 2,558 vols. and pamphlets, and resigned in 1863 when their number was 12,594. He prepared a Catalogue of the Library in 1858 which was published. He was again Hon. Librarian from 1879 to 1881, and was afterwards for two years Chairman of the Library Committee.

Whether in office or out of it, Mr. Windsor was a most enthusiastic worker for the Medical Society, and a very generous donor to its Library. F. N.

NOTE.—The Treasurer's Accounts of the Session 1909-1910, of which the following pages are summaries, have been endorsed as follows:

April 13th, 1910. Audited and found correct.

We have also seen, at this date, the certificates of the following Stocks held in the name of the Society:—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294, and 12,323; £258 Twenty years' loan to the Manchester Corporation, redeemable 25th March, 1914 (No. 1,564); £7,500 Gas Light and Coke Company Ordinary Stock (No. 6,389); and the deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declaration of Trust.

Leases and Conveyance dated as follow:—

22nd Sept., 1797.
23rd Sept., 1797.
25th Dec., 1799.
" " "
22nd Dec., 1820.
23rd Dec., 1820.

Declarations of Trust:—

24th June, 1801.
23rd Dec., 1820.
30th April, 1851.
8th Jan., 1878.

We have also verified the balances of the various accounts with the bankers' pass books.

(*Signed*) D. M. S. WATSON.
J. H. WOLFENDEN.

MANCHESTER LITERARY A[illegible]

Dr. *Arthur McDougall, Treasurer, in Account wi[illegible]*

				£	s. d.
	£	s.	d.	£	d.
To Cash in hand, 1st April, 1909 ..				126	[illegible]
To Members' Subscriptions:—					
Half Subscriptions, 1908-09, 2 at £1. 1s. od. ..	2	2	0		
,, ,, 1909-10, 15 ,, ,, ..	15	15	0		
Subscriptions:— 1906-07, 2 ,, £2. 2s. od. ..	4	4	0		
,, 1907-08, 4 ,, ,, ..	8	8	0		
,, 1908-09, 8 ,, ,, ..	16	16	0		
,, 1909-10, 117 ,, ,, ..	245	14	0		
,, 1910-11, 1 ,, ,, ..	2	2	0		
				295	[illegible]
To Transfers from the Wilde Endowment Fund ..				82	[illegible]
To Donation from Dr. H. Wilde, F.R.S. ..				50	[illegible]
To Transfer from Dalton Tomb Fund ..				38	[illegible]
To Sale of Publications ..				17	[illegible]
To Dividends:—					
Natural History Fund ..	57	16	1		
Joule Memorial Fund ..	7	5	10		
				65	[illegible]
To Income Tax Refunded:—					
Natural History Fund ..	3	3	10		
Joule Memorial Fund ..	0	8	4		
Wilde Endowment Fund ..	17	19	7		
				21	[illegible]
To H. Sidebottom for plates ..				5	[illegible]
To Discount on Megson's a/c ..				0	[illegible]
				£701	[illegible]

NATURAL HISTO[illegible]

	£	s. d.
To Balance, 1st April, 1909 ..	7	[illegible]
To Dividends on £1,225 Great Western Railway Company's Stock ..	57	[illegible]
To Remission of Income Tax, 1909 ..	3	[illegible]
	£68	[illegible]

JOULE MEMORI[illegible]

	£	s. d.
To Balance, 1st April, 1909 ..	79	[illegible]
To Dividends on £258 Loan to Manchester Corporation ..	7	[illegible]
To Remission of Income Tax, 1909 ..	0	[illegible]
	£87	[illegible]

WILDE ENDOWME[illegible]

	£	s. d.
To Balance 1st April, 1909 ..	114	[illegible]
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock ..	330	[illegible]
To Remission of Income Tax, 1909 ..	17	[illegible]
To Bank Interest ..	1	[illegible]
To Discount on Newton, Chambers & Co.'s a/c ..	0	[illegible]
	£463	[illegible]

ILOSOPHICAL SOCIETY.

ty, from 1st April, 1909, to 31st March, 1910. **Cr.**

	£ s. d.	£ s. d.
harges on Property :—		
hief Rent (Income Tax deducted)	12 3 10	
nsurance against Fire	11 0 0	
		23 3 10
Iouse Expenditure :—		
oals, Gas, Electric Light, Water, &c.	41 19 4	
'ea, Coffee, &c., at Meetings	12 19 6	
leaning, Sweeping Chimneys, &c.	4 17 9	
eplacements of mantles, crockery, towels, table cloths, dusters, etc.	0 13 10½	
		60 10 5½
dministrative Charges :—		
Iousekeeper	66 5 0	
'ostages, and Carriage of Parcels and of "Memoirs"	32 6 4½	
tationery, Cheques, Receipts, and Engrossing	10 0 9	
'rinting Circulars, Reports, &c.	11 6 6	
xtra attendance at Meetings, and during housekeeper's holidays	3 17 6	
nsurance against Liability	0 12 0	
Iedical advice and attendance for Mrs. Kelly	1 2 6	
ratuity to Mrs. Kelly	5 0 0	
liscellaneous Expenses	1 6 7	
		131 17 2½
'ublishing :—		
'rinting "Memoirs and Proceedings"	134 9 6	
llustrations for "Memoirs" (except Nat. Hist. papers)	5 16 0	
inding "Memoirs"	2 0 0	
		142 5 6
ibrary :—		
ooks and Periodicals (except those charged to Natural History Fund) ..	77 0 3	
'eriodicals formerly subscribed for by the Microscopical and Natural History Section	3 16 3	
atalogue Cards	1 10 0	
		82 6 6
Natural History Fund :—		
Items shown in the Balance Sheet of this Fund below)		53 8 9
Ioule Memorial Fund :—		
Items shown in the Balance Sheet of this Fund below)		1 1 0
Vilde Endowment Fund (Income Tax refunded)		17 19 7
alance at Williams Deacon's Bank, 1st April, 1910	140 1 0	
,, in Treasurer's hands	10 0 0	
ransfer from Dalton Tomb Fund	38 16 2	
		188 17 2
		£701 10 0

ND, 1909—1910. (Included in the General Account, above.)

	£ s. d.
Natural History Books and Periodicals	43 12 2
llustrations for papers on Nat. Hist. in "Memoirs"	9 16 7
alance, 1st April, 1910	15 3 5
	£68 12 2

ND, 1909—1910. (Included in the General Account, above.)

	£ s. d.
Inscription for Chronometer belonging to Dr. J. P. Joule	1 1 0
alance, 1st April, 1910	86 4 0
	£87 5 0

ND, 1909—1910.

	£ s. d.
Assistant Secretary's Salary, April, 1909, to March, 1910	150 0 0
Maintenance of Society's Library :—	
Binding and Repairing Books	23 15 9
Repairs and Improvements to Society's Premises	2 9 7
Repairing Copper Urns	1 1 3
New Grate and Fender	8 14 11
Honorarium to Wilde Lecturer, 1910	15 15 0
Transfers to Society's Funds	82 11 0
Cheque Book	0 2 6
Balance at District Bank, 1st April, 1910	179 9 7
	£463 19 7

THE COUNCIL
AND MEMBERS
CF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

(Corrected to August 5th, 1910.)

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FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.

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A. P. HUNT, B.A.

ORDINARY MEMBERS.

Date of Election.

1901, Dec. 10. Adamson, Harold. *Oaklands Cottage, Godley, near Manchester.*

1902, Mar. 18. Allen, J. Fenwick. 147, *Withington Road, Whalley Range, Manchester.*

1870, Dec. 13. Angell, John, F.C.S., F.I.C. 6, *Beaconsfield, Derby Road, Withington, Manchester.*

1865, Nov. 14. Bailey, Charles, M.Sc., F.L.S. *Haymesgarth, Cleeve Hill S.O., Gloucestershire.*

1888, Feb. 7. Bailey, Alderman Sir William H., M.I.Mech.E. *Sale Hall, Sale, Cheshire.*

1895, Jan. 8. Barnes, Charles L., M.A. 9, *York Place, Chorlton-on-Medlock, Manchester.*

1903, Oct. 20. Barnes, Jonathan, F.G.S. *South Cliff House*, 301, *Great Clowes Street, Higher Broughton, Manchester.*

1908, Feb. 11. Bateman, H., M.A., Reader in Mathematical Physics in the University of Manchester. *The University, Manchester.*

1895, Mar. 5. Behrens, Gustav. *Holly Royde, Withington, Manchester.*

1898, Nov. 29. Behrens, Walter L. 22, *Oxford Street, Manchester.*

1868, Dec. 15. Bickham, Spencer H., F.L.S. *Underdown, Ledbury.*

1896, Oct. 6. Bowman, F.H., D.Sc., F.R.S.E. 4, *Albert Square, Manchester.*

1875, Nov. 16. Boyd, John. *Barton House*, 11, *Dusbury Park, Didsbury, Manchester.*

1889, Oct. 15. Bradley, Nathaniel, F.C.S. *Sunnyside, Whalley Range, Manchester.*

1861, April 2. Brogden, Henry, F.G.S., M.I.Mech.E. *Hale Lodge, Altrincham, Cheshire.*

1889, April 16. Brooks, Samuel Herbert. *Slade House, Levenshulme, Manchester.*

1860, Jan. 24. Brothers, Alfred. *Handforth, near Manchester.*

1886, April 6. Brown, Alfred, M.A., M.D. *Sandycroft, Higher Broughton, Manchester.*

1889, Jan. 8. Brownell, Thomas William, F.R.A.S. 64, *Upper Brook Street, Manchester.*

1889, Oct. 15. Budenberg, C. F., M.Sc., M.I.Mech.E. *Bowdon Lane, Marple, Cheshire.*

Date of Election

1906, Feb. 27. Burton, Joseph, A.R.C.S. Dublin. *Tile Works, Clifton Junction, near Manchester.*

1894, Nov. 13. Burton, William, M.A., F.C.S. *The Hollies, Clifton Junction, near Manchester.*

1904, Oct. 18. Campion, George Goring, L.D.S. 264, *Oxford Street, Manchester.*

1907, Jan. 15. Carpenter, H. C. H., M.A., Ph.D., Professor of Metallurgy in the University of Manchester. 11, *Oak Road, Withington, Manchester.*

1899, Feb. 7. Chapman, D. L., M.A., Fellow of Jesus College, Oxford. *Jesus College, Oxford.*

1901, Nov. 26. Chevalier, Reginald C., M.A., Mathematical Master at the Manchester Grammar School. 103, *Clyde Road, West Didsbury, Manchester.*

1907, Nov. 26. Clayton, Robert Henry, B.Sc., Chemist. *Woodleigh, Blackfield Lane, Kersal, Manchester.*

1895, April 30. Collett, Edward Pyemont. 8, *St. John Street, Manchester.*

1903, Oct. 20. Core, William Hamilton, M.Sc. *Groombridge House, Withington, Manchester.*

1906, Oct. 30. Coward, H. F., D.Sc., Assistant Lecturer in Chemistry in the University of Manchester. *Municipal School of Technology, Sackville Street, Manchester.*

1906, Nov. 27. Coward, Thomas Alfred, F.Z.S. *Brentwood, Bowdon, Cheshire.*

1908, Nov. 3. Cramp, William, M.Sc.Tech., M.I.E.E., Consulting Engineer. 20, *Mount Street, Manchester.*

1895, Nov. 12. Crossley, Sir W. J., M.I.Mech.E. *Openshaw, Manchester.*

1895, April 9. Dawkins, W. Boyd, M.A., D.Sc., F.R.S., Honorary Professor of Geology in the Victoria University of Manchester. *Fallowfield House, Fallowfield, Manchester.*

1894. Mar. 6. Delépine, A. Sheridan, M.B., B.Sc., Professor of Pathology in the Victoria University of Manchester. *The University, Manchester.*

1887, Feb. 8. Dixon, Harold Baily, M.A., M.Sc., F.R.S., F.C.S., Professor of Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1906, Jan. 30. Dunkerley, Stanley, D.Sc.

Date of Election.

1906, Oct. 30. Edgar, E. C., D.Sc., Assistant Lecturer and Demonstrator in Chemistry in the University of Manchester. *The University, Manchester.*

1907, Nov. 26. Flatters, Abraham, F.R.M.S. *Sydlal Cottage, Bramhall, Cheshire.*

1908, Mar. 10. Fowler, W. H., M.Inst.C.E. *Sale Lodge, Sale, Cheshire.*

1908, Jan. 28. Fox, Thomas William, M.Sc.Tech., Professor of Textiles in the School of Technology, Manchester University. 15, *Clarendon Crescent, Eccles.*

1909, Mar. 23. Gee, W. W. Haldane, B.Sc., M.Sc.Tech., A.M.I.E.E., Professor of Pure and Applied Physics in the School of Technology, Manchester University. *Oak Lea, Whalley Avenue, Sale.*

1908, Oct. 6. Gibson, A. H., D.Sc., Assoc.M.Inst.C.E., Professor of Engineering in the University College of Dundee. *West Bank, Abercromby Street, Broughty Ferry.*

1896, Nov. 17. Gordon, Rev. Alexander, M.A. *Summerville, Victoria Park, Manchester.*

1907, Oct. 15. Gravely, F. H., M.Sc. *Natural History Dept., Indian Museum, Calcutta.*

1907, Oct. 29. Gwyther, Reginald Felix, M.A., Secretary to the Joint Matriculation Board. 21, *Booth Avenue, Withington, Manchester.*

1902, April 29. Herbert, Arthur M., B.A. *Frankwyn, Hale, Cheshire.*

1902, Jan. 7. Hewitt, David B., M.D. *Grove Mount, Davenham, Cheshire.*

1907, Oct. 15. Hickling, H. George A., D.Sc., Assistant Lecturer and Demonstrator in Geology in the University of Manchester. 50, *Lancaster Road, Fallowfield, Manchester.*

1895, Mar. 5. Hickson, Sydney J., M.A., D.Sc., F.R.S., Professor of Zoology in the Victoria University of Manchester. *The University, Manchester.*

1884, Jan. 8. Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street, Manchester.*

1909, Jan. 12. Hoffert, Hermann Henry, D.Sc. (Lond.), A.R.S.M., His Majesty's Inspector of Schools. *Lime Grove, Brooklands, Sale.*

Date of Election.

1909, Nov. 2. Holland, Sir Thomas H., K.C.I.E., D.Sc., F.R.S., Professor of Geology and Mineralogy in the University of Manchester, late Director of the Geological Survey of India. *Westwood, Alderley Edge, Cheshire.*

1905, Oct. 16. Holmes, H. T., M.A. (Cantab.). *Eastnor*, 77, *Wellington Road, Heaton Chapel.*

1905, Nov. 14. Holt, Alfred, M.A., D.Sc., Research Fellow of the University of Manchester. *Crofton, Aigburth, Liverpool.*

1898, Nov. 29. Hopkinson, Sir Alfred, K.C., M.A., LL.D., Vice-Chancellor of the Victoria University of Manchester. *Fairfield. Victoria Park, Manchester.*

1896, Nov. 3. Hopkinson, Edward, M.A., D.Sc., M.Inst.C.E. *Ferns, Alderley Edge, Cheshire.*

1909, Feb. 9. Howles, Frederick, M.Sc., Analytical and Research Chemist. 20, *Moxley Road, Crumpsall, Manchester.*

1889, Oct. 15. Hoyle, William Evans, M.A., D.Sc., F.R.S.E., Director of the Welsh National Museum, Cardiff. *City Hall, Cardiff.*

1907, Oct. 15. Hübner, Julius, M.Sc.Tech., F.I.C., Lecturer in the Faculty of Technology in the University of Manchester. *Ash Villa, Cheadle Hulme, Cheshire.*

1899, Oct. 17. Ingleby, Joseph, M.I.Mech.E. *Summer Hill, Pendleton, Manchester.*

1901, Nov. 26. Jackson, Frederick. 14, *Cross Street, Manchester.*

1870, Nov. 1. Johnson, William H., B.Sc. *Woodleigh, Altrincham.*

1878, Nov. 26. Jones, Francis, M.Sc., F.R.S.E., F.C.S. *Manchester Grammar School*, and *Beaufort House, Alexandra Park, Manchester.*

1886, Jan. 12. Kay, Thomas. *Moorfield, Stockport, Cheshire.*

1895, Nov. 12. Kirkman, William Wright. *The Grange, Timperley, Cheshire.*

1903, Feb. 3. Knecht, Edmund, Ph.D., Professor of Chemistry in the School of Technology, Manchester University. *Beech Mount, Marple, Cheshire.*

1902, Feb. 4. Kolp, Noah. *Woodthorpe, Victoria Park, Manchester.*

Date of Election.

1893, Nov. 14. Lamb, Horace, M.A., LL.D., D.Sc., Sc.D., F.R.S., Professor of Mathematics in the Victoria University of Manchester. 6, *Wilbraham Road, Fallowfield, Manchester.*

1909, Nov. 2. Lang, William H., D.Sc., M.B., C.M., Barker Professor of Cryptogamic Botany in the University of Manchester. 2, *Heaton Road, Withington, Manchester.*

1902, Jan. 7. Lange, Ernest F., M.I.Mech.E., F.C.S. *Fairholm,* 3, *Willow Bank, Fallowfield, Manchester.*

1904, Mar. 15. Lea, Arnold W. W., M.D. 246, *Oxford Road, Manchester.*

1903, Nov. 17. Leigh, Charles W. E., Librarian of the University. *The University, Manchester.*

1907, Oct. 29. Leigh, Harold Shawcross. *Brentwood, Worsley.*

1908, Oct. 20. Liebert, Martin, Ph.D., Managing Director of Meister Lucius, and Brüning, Ltd., Manchester. *Swinton House, Wilmslow Road, Withington, Manchester.*

1908, Jan. 14. Littlewood, J. E., B.A., Richardson Lecturer in Mathematics in the University of Manchester. *The University, Manchester.*

1902, Jan. 7. Longridge, Michael, M.A., M.Inst.C.E. *Linkvretten, Ashley Road, Bowdon, Cheshire.*

1857, Jan. 27. Longridge, Robert Bewick, M.I.Mech.E. *Yew Tree House, Tabley, Knutsford, Cheshire.*

1866, Nov. 13. McDougall, Arthur, B.Sc. *Lyndhurst, The Park, Buxton.*

1905, Oct. 31. McNicol, Mary, M.Sc. 182, *Upper Chorlton Road, Manchester.*

1904, Nov. 1. Makower, Walter, B.A., D.Sc. (Lond.), Lecturer in Physics in the University of Manchester. 214, *Upper Brook Street, Manchester.*

1902, Mar. 4. Mandleberg, Goodman Charles. *Redclyffe, Victoria Park, Manchester.*

1875, Jan 26. Mann, J. Dixon, M.D., F.R.C.P. (Lond.), Professor of Medical Jurisprudence in the Victoria University of Manchester. 16, *St. John Street, Manchester.*

1901, Dec. 10. Massey, Herbert. *Ivy Lea, Burnage, Didsbury, Manchester*

Date of Election.

1864, Nov. 1. Mather, Sir William, M.Inst.C.E., M.I.Mech.E. *Iron Works, Salford.*

1873 Mar. 18. Melvill, James Cosmo, M.A., D.Sc., F.L.S. *Meole-Brace Hall, Shrewsbury.*

1894, Feb. 6. Mond, Robert Ludwig, M.A., F.R.S.E., F.C.S. *Winnington Hall, Northwich, Cheshire.*

1902, Feb. 18. Moss, William E., B.A. *C/o Messrs. Davies, Benachi & Co., 7, Rumford Street, Liverpool.*

1908, Jan. 28. Myers, William, Lecturer in Textiles in the School of Technology, Manchester University. *Stone Edge, Marple.*

1873, Mar. 4. Nicholson, Francis, F.Z.S. *The Knoll, Windermere, Westmorland.*

1900, April 3. Nicolson, John T., D.Sc., Professor of Engineering in the School of Technology, Manchester University. *Nant-y-Glyn, Marple, Cheshire.*

1884, April 15. Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon, Cheshire.*

1907, Oct. 29. Osborn, Theodore George Bentley, B.Sc., Lecturer in Economic Botany in the University of Manchester. *Windlehurst, Anson Road, Victoria Park, Manchester.*

1892, Nov. 15. Perkin, W. H., Sc.D., Ph.D., M.Sc., F.R.S., Professor of Chemistry in the Victoria University of Manchester. *The University, Manchester.*

1901, Oct. 29. Petavel, J. E., B.A., D.Sc., F.R.S., Professor of Engineering in the Victoria University of Manchester. *The University, Manchester.*

1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. *Lynwood, Turton, nr. Bolton, Lancs.*

1903, Dec. 15. Prentice, Bertram, Ph.D., D.Sc., Lecturer in Chemistry, Royal Technical Institute, Salford. *Isca Mount, Manchester Road, Swinton.*

1901, Dec. 10. Ramsden, Herbert, M.D. (Lond.), M.B., Ch.B. (Vict.). *Sunnyside, Dobcross, near Oldham, Lancs.*

Date of Election.

1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 15, *Mauldeth Road, Withington, Manchester.*

1908, Nov. 3. Reekie, J. A., Manager of the Hayfield Printworks. *Woodhouse, Hayfield.*

1869, Nov. 16. Reynolds, Osborne, M.A., LL.D., F.R.S., M.Inst.C.E. *St. Decuman's, Watchet, Somerset.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S.E., F.R.C.P. (Lond.). *Ravenswood, Broughton Park, Manchester.*

1897, Oct. 19. Rothwell, William Thomas. *Heath Brewery, Newton Heath, near Manchester.*

1907, Oct. 15. Rutherford, Ernest, M.A., F.R.S., Langworthy Professor of Physics in the University of Manchester. 17, *Wilmslow Road, Withington, Manchester.*

1909, Jan. 26. Schmitz, Hermann Emil, M.A., B.Sc., Physics Master at the Manchester Grammar School. 12, *Lime Grove, Chorlton-on-Medlock, Manchester.*

1873, Nov. 18. Schuster, Arthur, Sc.D., Ph.D., F.R.S., F.R.A.S., Honorary Professor of Physics in the Victoria University of Manchester. *Kent House, Victoria Park, Manchester.*

1898, Jan. 25. Schwabe, Louis. *Hart Hill, Eccles Old Road, Pendleton, Manchester.*

1908, Nov. 17. Schwartz, Alfred, A.K.C., M.Sc.Tech., M.I.E.E., Assoc.M.Inst.C.E., Professor of Electrical Engineering in the School of Technology, Manchester University. *Mourne Lodge, Buxton.*

1890, Nov. 4. Sidebotham, Edward John, M.A., M.B., M.R.C.S. *Erlesdene, Bowdon, Cheshire.*

1903, April 28. Sidebottom, Henry. *Woodstock, Bramhall, Cheshire.*

1909, Nov. 16. Smith, Albert Malins, M.A., Lecturer in Plant Physiology in the Manchester University. *The University, Manchester.*

1908, Nov. 3. Smith, Charles Frederick, M.Sc.Tech., M.I.E.E., Lecturer in Electrical Engineering in the School of Technology, Manchester University. 10, *Athol Road, Alexandra Park, Manchester.*

1906, Nov. 27. Smith, Norman, D.Sc., Assistant Lecturer in Chemistry in the Victoria University of Manchester. *The University, Manchester.*

Date of Election.

1895, Nov. 12. Southern, Frank, B.Sc. *Moatfield, Wash Lane, Timperley.*

1896, Feb. 18. Spence, David. *Lowood, Hindhead, Haslemere, R.S.O., Surrey.*

1901, Dec. 10. Spence, Howard. *Audley, Broad Road, Sale, Cheshire.*

1904, Nov. 1. Stansfield, Herbert, D.Sc. (Lond.), A.I.E.E., Assistant Lecturer and Demonstrator in Physics in the University of Manchester. *The University, Manchester.*

1897, Nov. 30. Stromeyer, C. E., M.Inst.C.E. *Steam Users' Association, 9, Mount Street, Albert Square, Manchester.*

1905, Nov. 1. Sutcliffe, William Henry, F.G.S. *Shore, Littleborough, Lancs.*

1895, April 9. Tatton, Reginald A., M.Inst.C.E., Engineer to the Mersey and Irwell Joint Committee. *Manor House, Chelford, Cheshire.*

1893, Nov. 14. Taylor, R. L., F.C.S., F.I.C. *Municipal Secondary School, Whitworth Street*, and 4, *St. Werburgh's Road, Chorlton-c.-Hardy, Manchester.*

1906, April 10. Thewlis, Councillor J. H. *Daisy Mount, Victoria Park, Manchester.*

1873, April 15. Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution, Manchester.*

1896, Jan. 21. Thorburn, William, M.D., B.Sc. 2, *St. Peter's Square, Manchester.*

1896, Jan. 21. Thorp, Thomas, F.R.A.S. *Moss Bank, Whitefield, near Manchester.*

1899, Oct. 17. Todd, William Henry. *Rivington, Irlam Road, Flixton, near Manchester.*

1909, Jan. 26. Varley, George Percy, M.Sc. (Vic.), Assistant Master in the Municipal Secondary School, Manchester. 18, *Victoria Road, Whalley Range, Manchester.*

1873, Nov. 18. Waters, Arthur William, F.L.S., F.G.S. *Alderley, McKinley Road, Bournemouth.*

Date of Election.

1906, Nov. 13. Watson, D. M. S., B.Sc. *Windlehurst, Anson Road, Victoria Park, Manchester.*

1892, Nov. 15. Weiss, F. Ernest, D.Sc., F.L.S., Professor of Botany in the Victoria University of Manchester. 30, *Brunswick Road, Withington, Manchester.*

1909, Feb. 9. Weizmann, Charles, Ph.D., D.Sc., Senior Lecturer in Chemistry in the University of Manchester. *The University, Manchester.*

1908, May 12. Welldon, Rt. Rev. J. E. C., D.D., Dean of Manchester. *The Deanery, Manchester.*

1907, Oct. 29. Whitehead, Thomas, B.Sc., Chemist to the Manchester Steam Users' Association. 89, *Kenworthy Street, Stalybridge.*

1901, Oct. 1. Wild, Robert B., M.D., M.Sc., M.R.C.P., Professor of Materia Medica and Therapeutics in the Victoria University of Manchester. *Broome House, Fallowfield, Manchester.*

1859, Jan. 25. Wilde, Henry, D.Sc., D.C.L., F.R.S. *The Hurst, Alderley Edge, Cheshire.*

1905, Oct. 31. Willis, Ethel G., M.A., B.Sc., Science Mistress, Manchester High School for Girls. *The High School, Dover Street, Manchester.*

1901, Nov. 26. Wilson, William, M.A. *Carron Vale*, 80, *Fitzwarren Street, Pendleton, Manchester.*

1907, Oct. 15. Winstanley, George H., F.G.S., M.I.M.E., Lecturer in Mining Engineering and Mine Surveying in the University of Manchester. *Wigshaw Grange, Culcheth, near Warrington.*

1909, Jan. 26. Wolfenden, John Henry, B.Sc. (Lond.), A.R.C.S. (Lond.), Assistant Master in the Municipal Secondary School, Manchester. 13, *Pole Lane, Failsworth.*

1903, Oct. 20. Wood, Harry Edwin, B.Sc., Assistant to the Government Meteorological Department, Johannesburg.

1905, Oct. 31. Woodall, Herbert J., A.R.C.S. 32, *Market Place, Stockport.*

1860, April 17. Woolley, George Stephen. *Victoria Bridge, Manchester.*

1863, Nov. 17. Worthington, Samuel Barton, M.Inst.C.E., M.I.Mech.E. *Mill Bank, Bowdon*, and 37, *Princess Street, Manchester.*

Date of Election.

1895, Jan. 8. Worthington, Wm. Barton, B.Sc., M.Inst.C.E. *Kirkstyles, Duffield, near Derby.*

1897, Oct. 19. Wyatt, Charles H., M.A., *Chelford, Cheshire.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore life members:—

Bailey, Charles, M.Sc., F.L.S.
Bradley, Nathaniel, F.C.S.
Brogden, Henry, F.G.S.
Ingleby, Joseph, M.I.Mech.E.
Johnson, William H., B.Sc.
Worthington, Wm. Barton, B.Sc.

HONORARY MEMBERS.

Date of Election.

1892, April 26. Abney, Sir W. de W., K.C.B., D.Sc., F.R.S. *Rathmore Lodge, Bolton Gardens South, South Kensington, London, S.W.*

1892, April 26. Amagat, E. H., For. Mem. R.S., Memb. Inst. Fr. (Acad. Sci.), Examinateur à l'École Polytechnique. *Avenue d'Orléans,* 19, *Paris.*

1894, April 17. Appell, Paul, Membre de l'Institut, Professor of Theoretical Mechanics. *Faculté des Sciences, Paris.*

1892, April 26. Ascherson, Paul F. Aug., Professor of Botany in the University of Berlin. *Universität, Berlin.*

1889, April 30. Avebury, John Lubbock, Lord, D.C.L., LL.D., F.R.S. *High Elms, Down, Kent.*

1892, April 26. Baeyer, Adolf von, For. Mem. R.S., Professor of Chemistry in the University of Munich. 1, *Arcisstrasse, Munich.*

1886, Feb. 9. Baker, John Gilbert, F.R.S., F.L.S. 3, *Cumberland Road, Kew.*

1889, April 30. Carruthers, William, F.R.S., F.L.S. 14, *Vermont Road, Norwood, London, S.E.*

1903, April 28. Clarke, Frank Wigglesworth, D.Sc. *United States Geological Survey, Washington, D.C., U.S.A.*

1866, Oct. 30. Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Oxford. 3, *Bardwell Road, Banbury Road, Oxford.*

1892, April 26. Curtius, Theodor, Professor of Chemistry in the University of Kiel. *Universität, Kiel.*

1892, April 26. Darboux, Gaston, Membre de l'Institut, Professor of Geometry, Faculté des Sciences, Secrétaire perpétuel de l'Académie des Sciences. 36, *Rue Gay Lussac, Paris.*

Date of Election.

1894, April 17. Debus, H., Ph.D., F.R.S. 4. *Schlangenweg, Cassel, Hessen, Germany.*

1900, April 24. Dewar, Sir James, M.A., LL.D., D.Sc., F.R.S., V.P.C.S., Fullerian Professor of Chemistry at the Royal Institution. *Royal Institution, Albemarle Street, London, W.*

1892, April 26. Edison, Thomas Alva. *Orange, N.J., U.S.A.*

1895, April 30. Elster, Julius, Ph.D. 6, *Lessingstrasse, Wolfenbüttel.*

1900, April 24. Ewing, James Alfred, C.B., M.A., LL.D., F.R.S., Director of Naval Education to the Admiralty. *Royal Naval College, Greenwich.*

1889, April 30. Farlow, W. G., Professor of Botany at Harvard College. *Harvard College, Cambridge, Mass., U.S.A.*

1900, April 24. Forsyth, Andrew Russell, M.A., Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge. *Trinity College, Cambridge.*

1892, April 26. Fürbringer, Max, Professor of Anatomy in the University of Heidelberg. *Universität, Heidelberg.*

1900, April 24. Geikie, James, D.C.L., LL.D., F.R.S., Murchison Professor of Geology and Mineralogy in the University of Edinburgh. *Kilmorle, Colinton Road, Edinburgh.*

1895, April 30. Geitel, Hans. 6, *Lessingstrasse, Wolfenbüttel.*

1894, April 17. Glaisher, J. W. L., Sc.D., F.R.S., Lecturer in Mathematics. *Trinity College, Cambridge.*

1894, April 17. Gouy, A., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics in the University of Lyons. *Faculté des Sciences, Lyons.*

1900, April 24. Haeckel, Ernst, Ph.D., Professor of Zoology in the University of Jena. *Zoologisches Institut, Jena.*

1894, April 17. Harcourt, A. G. Vernon, M.A., D.C.L., F.R.S., V.P.C.S. *St. Clare, Ryde, Isle of Wight.*

1894, April 17. Heaviside, Oliver, F.R.S. *Homefield, Lower Warberry, Torquay.*

1892, April 26. Hill, G. W. *West Nyack, N.Y., U.S.A.*

1888, April 17. Hittorf, Johann Wilhelm, Professor of Physics at Münster. *Polytechnicum, Münster.*

1892, April 26. Hoff, J. van't, Ph.D., For. Mem. R.S., Professor of Chemistry. 2, *Uhlandstrasse, Charlottenburg, Berlin.*

Date of Election.

1892, April 26. Hooker, Sir Joseph Dalton, G.C.S.I., C.B., O.M., D.C.L., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *The Camp, Sunningdale, Berks.*

1892, April 26. Klein, Felix, Ph.D., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Mathematics in the University of Göttingen. 3, *Wilhelm Weber Strasse, Göttingen.*

1894, April 17. Königsberger, Leo, Professor of Mathematics in the University of Heidelberg. *Universität, Heidelberg.*

1892, April 26. Ladenburg, A., Ph.D., Professor of Chemistry in the University of Breslau. 3, *Kaiser Wilhelm Strasse, Breslau.*

1902, May 13. Larmor, Sir Joseph, M.A., D.Sc., LL.D., Sec. R.S., F.R.A.S. *St. John's College, Cambridge.*

1892, April 26. Liebermann, C., Professor of Chemistry in the University of Berlin. 29, *Matthäi-Kirch Strasse, Berlin.*

1887, April 19. Lockyer, Sir J. Norman, K.C.B., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Science School, South Kensington, London, S.W.*

1902, May 13. Lodge, Sir Oliver Joseph, D.Sc., LL.D., F.R.S., Principal of the University of Birmingham. *The University, Birmingham.*

1900, April 24. Lorentz, Henrik Anton, Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Physics in the University of Leyden. *Hooigracht*, 48, *Leyden.*

1892, April 26. Marshall, Alfred, M.A., formerly Professor of Political Economy in the University of Cambridge. *Balliol Croft, Madingley Road, Cambridge.*

1901, Apri 23. Metschnikoff, Élie, D.Sc., For. Mem. R.S. *Institut Pasteur Paris.*

1895, April 30. Mittag-Leffler, Gösta, D.C.L. (Oxon.), For. Mem. R.S., Professor of Mathematics in the University of Stockholm. *Djursholm, Stockholm.*

1894, April 17. Murray, Sir John, K.C.B., LL.D., D.Sc., F.R.S. *Challenger Lodge, Wardie, Edinburgh.*

1910, April 5. Nernst, Geh. Prof. Dr. Walter, Director of the Physikal-Chemisches Institut in the University of Berlin. *Am Karlsbad 26a, Berlin W. 35.*

Date of Election.

1902, May 13. Osborn, Henry Fairfield, Professor of Vertebrate Palæontology at Columbia College. *Columbia College, New York, U.S.A.*

1894, April 17. Ostwald, W., Professor of Chemistry. *Groszbothen, Kgr. Sachsen.*

1899, April 25. Palgrave, Sir R. H. Inglis, F.R.S., F.S.S. *Henstead Hall, Wrentham, Suffolk.*

1894, April 17. Pfeffer, Wilhelm, For. Mem. R.S., Professor of Botany in the University of Leipsic. *Botanisches Institut, Leipsic.*

1892, April 26. Poincaré, H., For. Mem. R.S., Membre de l'Institut, Professor of Astronomy in the University of Paris. 63, *Rue Claude Bernard, Paris.*

1892, April 26. Quincke, G. H., For. Mem. R.S., Professor of Physics in the University of Heidelberg. *Universität, Heidelberg.*

1899, April 25. Ramsay, Sir William, K.C.B., Ph.D., F.R.S., Professor of Chemistry in University College, London. 12, *Arundel Gardens, Notting Hill, London, W.*

1886, Feb. 9. Rayleigh, John William Strutt, Lord, O.M., M.A., D.C.L. (Oxon.), LL.D. (Univ. McGill), F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Terling Place, Witham, Essex.*

1900, April 24. Ridgway, Robert, Curator of the Department of Birds, U.S. National Museum. *Brookland, District of Columbia, U.S.A.*

1897, April 27. Roscoe, Sir Henry Enfield, P.C., B.A., LL.D., D.C.L., F.R.S., V.P.C.S., Corr. Memb. Inst. Fr. (Acad. Sci.). 10, *Bramham Gardens, Earl's Court, London, S.W.*

1902, May 13. Scott, Dukinfield Henry, M.A., Ph.D., F.R.S., F.L.S. *East Oakley House, Oakley, Hants.*

1892, April 26. Solms, H., Graf zu, Professor of Botany in the University of Strassburg. *Universität, Strassburg.*

1886, Feb. 9. Strasburger, Eduard, D.C.L., For. Mem. R.S., Professor of Botany in the University of Bonn. *Universität, Bonn.*

1895, April 30. Suess, Eduard, Ph.D., For. Mem. R.S., For. Assoc. Inst. Fr. (Acad. Sci.), Professor of Geology in the University of Vienna. 9, *Africanergasse, Vienna.*

Date of Election.

1892, April 26. Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., M.A., Sc.D., Ph.D., LL.D., F.R.S. Lately Director Royal Botanic Gardens, Kew. *The Ferns, Witcombe, Gloucester.*

1895, April 30. Thomson, Sir Joseph John, M.A., Sc.D., F.R.S., Professor of Experimental Physics in the University of Cambridge. 6, *Scrope Terrace, Cambridge.*

1894, April 17. Thorpe, Sir T. E., C.B., Ph.D., D.Sc., LL.D., F.R.S., V.P.C.S. *Government Laboratory, Clement's Inn Passage, Strand, London, W.C.*

1894, April 17. Turner, Sir William, K.C.B., M.B., D.C.L., F.R.S., F.R.S.E., Professor of Anatomy in the University of Edinburgh. 6, *Eton Terrace, Edinburgh.*

1886, Feb. 9. Tylor, Edward Burnett, D.C.L. (Oxon), LL.D. (St. And. and McGill Univs.), F.R.S., Professor of Anthropology in the University of Oxford. *Museum House, Oxford.*

1894, April 17. Vines, Sidney Howard, M.A., D.Sc., F.R.S., Sherardian Professor of Botany in the University of Oxford. *Headington Hill, Oxford.*

1894, April 17. Warburg, Emil, Professor of Physics at the Physical Institute, Berlin. *Physikalisches Institut, Neue Wilhelmstrasse, Berlin.*

1894, April 17. Weismann, August, Professor of Zoology in the University of Freiburg. *Universität, Freiburg i. Br.*

1888, April 17. Zirkel, Ferdinand, For. Mem. R.S., Professor of Mineralogy in the University of Bonn. *Königstrasse 2a, Bonn am Rhein.*

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.

1900. Sir HENRY E. ROSCOE, F.R.S.

1903. Prof. OSBORNE REYNOLDS, LL.D., F.R.S.

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1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S. (*46 pp.*)

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1910. (March 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

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1787-1789.	JAMES MASSEY.
1789-1804.	THOMAS PERCIVAL, M.D., F.R.S.
1805-1806.	Rev. GEORGE WALKER, F.R.S.
1807-1809.	THOMAS HENRY, F.R.S.
1809.	*JOHN HULL, M.D., F.L.S.
1809-1816.	THOMAS HENRY, F.R.S.
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1844-1847.	EDWARD HOLME, M.D., F.L.S.
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1870-1871.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
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1878-1879.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
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1886.	ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.
1887.	BALFOUR STEWART, LL.D., F.R.S.

* Elected April 28th; resigned office May 5th.

1888-1889. Osborne Reynolds, LL.D., F.R.S.
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