which have been made, the true place of existence of which is the ice and the snow, must particularly be of great value. They are besides of additional interest to the expedition, as they belong to a new branch of science which has in the first instance been created by Swedish *savants*. The collections, perhaps, of most value to science have, however, been made by Dr. Nathorst from the North-West Greenland so-called basalt formation, which is remarkable for the quantity of fossil plants contained in the clay, sand, and tuff strata there. Of course some very fine palæontological collections have been brought from these parts before, especially by the Swedish expedition of 1870, and by some Danish ones under Dr. K. Steenstrup; but it is the first time that a palæontologist has visited this spot, and I am, in consequence, convinced that the objects gathered by Dr. Nathorst, when scientifically treated, will yield many new data on the copious flora which once covered the ice-laden regions round the Pole.

"Finally, the expedition has brought home some splendid specimens of the remarkable minerals found at the well known deposits at Kangerdluarsuk and Ivigtut, while I have on the inland ice collected, as previously stated, a great many samples of the dust found on the ice, and which I have named kryokonite. I hope, when this has been exhaustively analysed, to be able to furnish fresh proofs in support of the theory that this deposit is, at all events partly, of cosmic origin, and thereby contribute further materials to the theory of the formation of the earth. Dr. Nathorst was, as previously stated, prevented by the ice from reaching Cape York and examining the blocks of ironstone lying there, but their existence has been corroborated beyond doubt by the Esquimaux in the neighbourhood. Here the expedition obtained some valuable ethnographical objects, and it learnt a fact from the natives which may be of considerable importance as to the question of the wanderings of the tribes around the Pole, viz. that four 'Russian Esquimaux' had come to Wolstenholme Sound. They said they were the last survivors of a tribe which had left their place of habitation by the Behring Strait (or the northern shore of Asia?) in search of a new place of settlement, and who had at last reached Smith's Sound. These are the results of my expedition to Greenland in the *Sophia*. The scientific collections made will be distributed among the museums of my country."

A. E. NORDENSKJÖLD

## *THE ROTHAMSTED GRASS EXPERIMENTS*[1]

THERE is at Rothamsted nothing which will more impress the visitor than the seven acres of meadow land in the Park, the many years' experiments upon which with different manures constitute the subject of the above-named memoir. The twenty parallel plots into which the area is divided appeal at once and forcibly to the eye by the obvious differences in their herbage. A plot here with rich green grasses waving luxuriantly upon it; another, on which the yellow meadow vetchling apparently constitutes the leading feature; a third, irregular, patchy, and much afflicted with the sorrel-dock; and yet another, on which, at the time of our visit (August), the white-flowered umbels of the earth-nut put everything else in the shade,—these and the like appearances convince with an eloquence which the pen is powerless to imitate.

The land in Rothamsted Park has probably been laid down with grass for some centuries. No fresh seed has been artificially sown within the last fifty years certainly, nor is there record of any having been sown since the grass was first laid down. The experiments commenced in 1856, at which time the herbage appeared to be of uniform character. With few exceptions the same description of manure has been applied year after year to the same plot; and two plots, the third and twelfth, have been continuously unmanured. For the first nineteen years the first crop only was cut and carried away, and the second crop was usually fed off by sheep who were receiving at the time no other food. Of recent years it has been more and more the practice to make the second crop also into hay, and it is intended to adhere to this plan in future, weather permitting.

The produce of every plot is weighed as hay, and the result calculated per acre. Taking the average of the first twenty years, the unmanured plots, 3 and 12, gave the lowest yields of all, 21¼ and 24 cwt. respectively. Next above these is plot 5, manured with ammonia salts[1] at the rate of 400 lbs. per acre per annum, the yield giving an annual average of 26¼ cwt. per acre. The highest average recorded, 62½ cwt. per acre, resulted from a mixed manure, containing 500 lbs. sulphate of potash, 100 lbs. sulphate of soda, 100 lbs. sulphate of magnesia, 3½ cwt. superphosphate of lime, 600 lbs. ammonia salts, and 400 lbs. silicate of soda,—a tremendous dressing, by the way. The average yields on the other plots, each one of which received different manurial treatment from that of the others, range themselves between these extremes.

But the mere quantitative estimation of the results was a comparatively simple task to that of making a qualitative examination of each crop. The proximate analysis was into the three classes of gramineous herbage, leguminous herbage, and miscellaneous herbage, the last-named containing all plants not referable to the Gramineæ or the Leguminosæ; and even this task would not be a very difficult one. But when it is stated that in certain seasons a complete botanical analysis was made, whereby each species of plant was separated from all the others, then the irksomeness of the work will be appreciated. For the details of these analyses we must refer to the memoir itself, but the following is worth reproducing. "To quote an extreme case in illustration of the difference in the character of the herbage, and of the difference in the degree of difficulty of separation accordingly, it may be mentioned that whilst a sample of 20 lbs. from one plot in 1872 only occupied from four to five days in botanical analysis, a sample of equal weight from another plot in the same year occupied thirty days."

The total number of different species of plants that have been detected on the plots is 89; of these, 20 are grasses, 10 are leguminous, and the remaining 59 belong to miscellaneous orders. The 89 species comprise 59 dicotyledons, 26 monocotyledons, and 4 cryptogams, 3 of which are mosses (Hypnum); they are arranged under 63 genera and 22 orders. Of the miscellaneous plants there are 13 species of Compositæ, 6 of Rosaceæ, 5 each of Ranunculaceæ and Umbelliferæ, 3 each of Labiatæ, Polygonaceæ, Liliaceæ, Caryophylleæ, Scrophulariaceæ, and Musci, 2 each of Rubiaceæ and Plantagineæ, and 1 each of Cruciferæ, Hypericineæ, Dipsaceæ, Primulaceæ, Orchidaceæ, Juncaceæ, Cyperaceæ, and Filices. Six genera only were represented by more than one species; these were Ranunculus, 5 species, Rumex 3, and Potentilla, Galium, Leontodon, and Veronica, 2 each. The 20 species of grass comprise 14 genera; Festuca is represented by 4 species, Avena by 3, Poa by 2, and Anthoxanthum, *Alopecurus*, Phleum, *Agrostis*, Aira, *Holcus*, Briza, Dactylis, Cynosurus, *Bromus*, and Lolium by 1 each. The fact that the four genera whose names we have italicised were only represented by one species each serves to indicate somewhat the nature of the land. Had it been wet or marshy in parts, *Alopecurus geniculatus* might have been looked for as well as *A. pratensis*. Had not the plots

[1] "Agricultural, Botanical, and Chemical Results of Experiments on the Mixed Herbage of Permanent Meadow, conducted for more than twenty years in succession on the same land." Part ii., the Botanical Results. By Sir J. B. Lawes, Bart., F.R.S., Dr. J. H. Gilbert, F.R.S., and Dr. M. T. Masters, F.R.S. *Phil. Trans.*, Part iv., 1882. Pp. about 250.

[1] "Ammonia salts"—in all cases equal parts sulphate and muriate of ammonia of commerce.

been quite away from hedgerows, several species of Bromus might have accompanied *B. mollis*, while *Arrhenatherum avenaceum* and *Brachypodium sylvaticum* might also have been looked for. The total absence of Glyceria further shows the fairly dry character of the soil. Lastly, the 10 species of Leguminosæ fall under 5 genera—of Trifolium 4 species, Lotus and Vicia 2 each, Lathyrus and Ononis 1 each.

Ten species of grasses occur on all the plots: *Anthoxanthum odoratum*, *Alopecurus pratensis*, *Agrostis vulgaris*, *Holcus lanatus*, *Avena flavescens*, *Poa pratensis*, *Poa trivialis*, *Dactylis glomerata*, *Festuca ovina*, and *Lolium perenne*. *Festuca eliator* was only found in one plot, and *F. loliacea* in two. *Phleum pratense* occurred in about one-fourth the number of plots, *Aira cæspitosa* in about one-half, *Briza media*, *Cynosurus cristatus*, *Festuca pratensis*, and *Bromus mollis* in sixteen or seventeen. No leguminous plant occurred in all the plots, but *Lathyrus pratensis* was found in nineteen plots, *Trifolium repens* and *T. pratense* in seventeen, *Lotus corniculatus* in sixteen, and *T. minus*, *T. procumbens*, *L. major*, *Ononis arvensis*, *Vicia sepium*, and *V. Cracca* only in one each.

These details will serve to indicate the nature of the flora of the plots. Certain miscellaneous plants common on many old pastures in this country are conspicuous by their absence. The dry and level character of the meadow will account for the absence of Caltha and Juncus. No species of Geranium is recorded. But the most noteworthy fact appears to be the absence of certain scrophulariaceous genera, which are by no means uncommon on old grass lands, namely, Bartsia, Euphrasia, and Rhinanthus. The quality of the land is probably too good for the first two, and the application of manure would certainly be against Euphrasia, but *Rhinanthus Crista-galli* is very common on old meadows, as, for example, in Derbyshire and Worcestershire.

The object which the authors kept in view in writing this section of their report was, in their own words, "to show both the normal botanical composition of the herbage, and the changes induced by the application of the different manuring agents, and by variation in the climatal conditions of the different seasons; and, as far as may be, to ascertain what are the special characters of growth above ground or under ground, normal or induced, by virtue of which the various species have dominated, or have been dominated over, in the struggle which has ensued." At the outset it was noticed that those manures which are most effective with cereals grown on arable land were also most active in increasing the quantity of grass amongst the herbage, and that the manures which are most beneficial to beans or clover produced the greatest proportion of leguminous herbage. Thus, the highest gramineous produce resulted from a highly nitrogenous manure, such as ammonia salts or nitrate of soda, with alkaline salts, particularly potash; but side by side with the increase in the total gramineous herbage there was a decrease in the actual number of species of grass. On the other hand, the highest percentage of leguminous produce was the result of a mixed mineral manure with potash. The percentage results on the following plots illustrate these points:—

| | Plot 7 | Plots 3 and 12. | Plot 11. |
|---|---|---|---|
| Gramineæ ... | 61·78 | ... 67·43 ... | 94·96 |
| Leguminosæ ... | 22·71 | ... 8·20 ... | 0·01 |
| Other Orders... | 15·51 | ... 24·37 ... | 5·03 |
| | 100·00 | 100·00 | 100·00 |

Plot 7 was the most favourably manured for leguminous produce, it received mixed mineral manure alone, including potash; plots 3 and 12 were the two unmanured ones; plot 11 was the most favourably manured for gramineous produce, it received 800 lbs. ammonia salts with mixed mineral manure, including potash.

Special observations and complete botanical separations made at intervals of five years to determine the influence of seasonal variations show that "a given quantity of the produce grown under the same conditions as to manuring might be composed very differently in two different seasons."

The influence due to the special medium through which a particular plant-food, such as nitrogen, is presented to the plant, is aptly illustrated in the following extract:—"Because a particular grass, or other plant, is little benefited by ammonia salts for instance, it does not follow that it will not be favoured by nitrates; nor, because if while growing in association with other species it may not be specially benefited by a particular manure, does it follow that it would not derive advantage from the same substance when growing separately."

Nearly all the plants on the plots are perennials, very few are annuals, *Bromis mollis* being the only case amongst the grasses. The advantage possessed by deep-rooting over surface-rooting plants was well brought out in the droughty season of 1870, when the latter suffered considerably from lack of moisture. The locomotive power of underground stems is of great use to some plants: "the stock continues to grow at one end, year after year, the opposite end gradually dying away. In the course of a few years the plant therefore occupies quite a different position from that which it at first had." Notwithstanding the general rule that the chief effect of nitrogenous manures is to favour the extension of foliage and give it depth of colour, while that of mineral manures is to encourage stem formation and the production of seed, and notwithstanding that excessive nitrogenous manuring prolongs the development of the vegetative organs till perhaps the resources of the plant are exhausted or the season is over, while excess of mineral manures may induce premature ripening, yet so far as the experiments have gone no absolute change in the distinctive form of any plant has been effected by the prolonged use of the different manures, though changes of degree are sometimes very marked, as in the tufts of *Dactylis glomerata*.

The battle for life between the various species of plants growing in the meadow is dependent much less on the chemical composition of the soil than on its physical character, its capacity for holding water and its permeability to roots. The immediate source of victory lies very generally in the powerful root-growth of the survivors, the term "root" here covering all kinds of underground stem. The various influences affecting the struggle for existence amongst meadow plants are discussed by the authors in a fascinating manner, and this part of the memoir is of special value to the botanical student.

Every plant occurring on the plots is dealt with individually, and in the case of each grass and leguminous plant and of the more commonly occurring weeds, a table showing the relative predominance is given. The fact that plants closely allied morphologically may yet differ widely in their physiological endowments is strikingly illustrated by the two species of Poa, *P. trivialis* and *P. pratensis*. These two plants, sprung at no very distant period from a common ancestor—for this, we presume, is the morphological significance of their being placed in the same genus—differ only in the most trivial points: *P. pratensis* is smooth, stoloniferous, and has a blunt ligule; *P. trivialis* is rough, has no stolons, and possesses a long pointed ligule. We read that "the stolon-bearing *Poa pratensis* is specially benefited by nitrogenous manure in the form of ammonia salts (in combination with mineral manure), but not at all by nitrate of soda, whereas the more finely-rooted and non-stoloniferous *Poa trivialis* has declined markedly on the ammonia plots, but has remained very prominent on the nitrate plots, especially where the larger amount of nitrate was used with the mixed mineral manure." Thus in 1872, on plot 9 (mineral

manure and ammonia salts) *P. pratensis* gave 22·67 per cent. of the total produce, and *P. trivialis* only 0·64; on plot 14 (mineral manure and nitrate of soda) *P. trivialis* gave 24·76, and *P. pratensis* only 2·57 per cent. It is suggested that the relatively shallow-rooting *P. trivialis* predominates on the nitrate plots by reason of its fine surface-roots arresting and taking up the nitrate before it has had time to penetrate too deeply; this plant invariably makes rapid growth upon the application of the nitrate of soda in the spring.

The remaining portion of the memoir is devoted to a discussion of the botany of each separate plot in each season of complete botanical separation, and is carried out with the same elaborate detail as the earlier portion. No one can read this memoir without being impressed with the great power, too frequently overlooked, possessed by the subterranean members of the plant body in deciding the struggle for existence; much of the internecine warfare is carried on in the dark.

It is quite possible, and indeed probable, that, had a similar series of experiments been simultaneously carried out in another part of England with a slightly different climate, and on a different kind of soil, the results might have differed, but only in slight details. Such a splendid series of experiments on grass land has never before been consummated, and the memoir embodying the results will well repay the most careful study and perusal not only of the agriculturist, but of the botanist, the chemist, and the evolutionist. It may perhaps be long before the great lessons learnt in Rothamsted Park have filtered down to those to whom they should be of most practical value, but we do not despair of a time coming when the intelligent manuring of grass lands for very specific objects will form a part of ordinary agricultural practice. Those who will put their hands to the plough in the field of agricultural research must be content to trudge along, laboriously and unnoticed, in the furrow. Their discoveries cannot be made in a week, or a month, as are many in electricity or in chemistry, but, like those at Rothamsted, which are now in their twenty-eighth year, and are still going on, they can only be looked for, even after the expenditure of much thought and of unflagging industry and perseverance, as "the long result of time."

W. FREAM

## *PALÆOLITHIC MAN—HIS BEAD ORNAMENTS*

EVERY one who has noticed the objects found in caves of Palæolithic date knows the evidence which supports the idea that cave men wore bracelets and necklaces, but the evidence that the older river-drift men wore similar ornaments is more obscure. Still, when one notices the extreme beauty and precision of make of some Palæolithic implements, one cannot help surmising that the more ancient savages of our old river sides also had sufficient personal pride and ideas of ornament to sometimes decorate their bodies with beads in a similar fashion with the cave dwellers.

Dr. Rigollot ("Mémoire sur des Instruments en Silex," p. 16) refers to the well-known foraminiferous fossil from the chalk—*Coscinopora globularis*, D'Orb. (sometimes found in river gravels with Palæolithic implements), as beads probably used by Palæolithic men; and Sir Charles Lyell ("Antiquity of Man," p. 119) says: "Dr. Rigollot's argument in favour of their having been used as necklaces and bracelets, appears to me a sound one. He says (Dr. Rigollot) he often found small groups of them in one place—just as if, when swept into the river's bed by a flood, the bond which united them together remained unbroken." Mr. James Wyatt of Bedford, in describing these bead-like fossils (*Geologist*, 1862, p. 234), says he had examined more than two hundred specimens, and on making sections of some of them he saw markings which appeared to indicate "drilling with a tool after the object was fossilised." In specimens from the chalk the hole through the fossil, though commonly straight, exhibits of course no artificial drilling but shows the structure of the foraminifer.

I am not aware of any confirmation hitherto made of the two curious observations noted above, but so little is at present known of the habits of river-drift men that the following notes may prove of some interest. Where there is so much darkness the slightest glimmer of new light is welcome.

After long searching for the Coscinopora at Bedford without result, I lighted on many examples at Kempston in 1880. In this year I found in a few days over two hundred examples; they occurred with unabraded implements and flakes and carbonised vegetable remains. After this date the Coscinopora again ceased, and from then till now I have met with but few examples. The finding of the above-mentioned large number of specimens all congregated together appeared to lend some confirmation to Dr. Rigollot's view, for it seems unreasonable to believe that so large a number could by any natural possibility find a position in one place in any river gravel.

As my examples were found at Bedford, at a place where Mr. Wyatt must at one time also have found a considerable number, I naturally examined the specimens carefully to see if I could trace any artificial drilling or enlargement of the natural hole. I speedily noticed that the surface round each orifice in many of the beads was abraded as if by the constant contact of the bead next on a string. A few of the beads also had the hole artificially enlarged, sometimes at both ends, as at section A, sometimes in the middle, as at the section B, and sometimes at one end only, as at the section C. The dotted lines in these illustrations show the original natural orifice, the solid lines near the dotted ones show the enlargement by artificial drilling. The illustrations are all actual size. In most of the instances the drilling appears comparatively fresh, in others less so, but it must be remembered that the implements found with them were mostly unabraded, and vegetable remains were found. These specimens were found by myself. They were not touched or manipulated by the workmen. Other examples of these beads had one end near the orifice broken away as if in an attempt to enlarge the opening by breaking the substance of the fossil away as at D, E, F.

Whilst looking through the fallen material in the pit, the piece of naturally perforated fossil shell, illustrated actual size at G, attracted my attention. The hole is probably due to a shell-boring mollusk, but when I saw the object in the drift I distinctly noticed that a black substance entered at one side of the hole and emerged at the other; at the moment of picking the object up, this material fell to dust with part of the very friable surface of the fossil shell.

Some of the beads (as seen in section at H, J, K, L) also bore very distinct traces of a similar black substance within the orifice, although not seen till the sand and part of the black substance itself had fallen out. This black material I took to be the remains of part of the ligament on which the beads were originally strung by their Palæolithic owner, and with this idea in mind I sent some to an analytical chemist, who examined the material for me with the following result:—

"The testing for nitrogenous organic matters, of which animal tissues are composed, was tested in the same manner as testing water for such matter, that is, by converting it into ammonia; precautions were of course taken to eliminate from the results any ammonia already existing. The amount of ammonia was strikingly evident and showed with each bead examined separately. The blackening of the organic matter in the holes of the beads