tight as possible. These were exposed to a white heat for half an hour, and, on cooling, both the aragonite and the lithographic limestone were found to be converted into crystalline limestone, the former very much resembling Carrara marble, and the latter a grayish-white granular limestone. The change took place without any material decomposition, the resulting marble containing a trifle less carbonic acid than the lithographic limestone from which it was produced.—*Pogg. Ann.*, cxviii, 565. G. J. B.

9. *On the Flora of the Devonian Period in Northeastern America: Appendix;* by J. W. Dawson, LL.D., F.G.S., Principal of McGill University, Montreal. (Q. J. Geol. Soc., 1863. Read Dec. 17, 1862).—In a recent visit to Perry, the author (with the aid of Mr. Brown, of that place) thoroughly examined the present exposure of the plant-bearing bed. Among the specimens obtained were the following. (1.) Wood of a Conifer of the genus *Dadoxylon*. (2.) A new *Stigmaria* of the type of *S. exigua*. (3.) Specimens of *Lepidostrobus Richardsoni*, showing it to have been the fructification of a new and interesting species of *Lycopodites*. (4.) Another species of *Lycopodites* allied to *L. Erdmanni* Germar. (5.) A new species probably of the genus *Anarthrocanna* Gœppert. (6.) A new *Cordaites*. (7.) More perfect specimens of *Cyclopteris Browniana*, showing it to have been a large and beautiful flabellate leaf or frond, possibly identical with that from the Upper Devonian of Pennsylvania, figured by Prof. Rogers, in his *Pennsylvania Report*, vol. ii, part 2, pl. 22.[1] (8.) A Fern allied to *Cyclopteris Jacksoni*, but with a stem similar to that of *C. Roemeriana* Gœppert. (9.) New species of *Sphenopteris*, *Trichomanites* and *Carpolites*. (10.) Specimens of *Leptophlœum rhombicum*, showing its leaves and fructification. These, with some interesting specimens recently collected by Mr. R. Bell, of the Geological Survey, at Gaspé, Dr. Dawson hopes to describe in a future paper.

IV. BOTANY AND ZOOLOGY.

1. *Dimorphism in the Flowers of Linum.*—Referring back to our brief note upon the subject of dimorphous flowers in this *Journal* for Nov., 1862, and more particularly to Mr. Darwin's remarkable paper on the two sexual forms in *Primula* (in *Jour. of Linnæan Society*, no. 22), we wish now to call attention to some still more curious observations and experiments of Mr. Darwin, which were read to the Linnæan Society in February last, and are just published in the 26th no. of its *Journal*. The paper is entitled: "On the Existence of two forms, and on their reciprocal Sexual Relations, in several species of the genus *Linum*." The principal case is that of the crimson *Linum grandiflorum*, which is now common in gardens, and, as it flowers the whole summer long, is freely offered to the inspection of the curious. Dimorphic genitalia had hardly been noticed in the genus *Linum*. In the common cultivated Flax, it seems not to occur; but Planchon, in his Monograph, published 15 years ago, had noticed two or even three different states as to the relative length of the stamens and styles in *L. perenne* and *L. salsoloides*, and had even conjectured that this dimorphism might have some influence on the man-

[1] A portion of this figure is reproduced in *Dana's Manual of Geology*, in fig. 984, p. 750.

ner of fertilization. But this had been wholly overlooked "in such common garden-flowers as *L. grandiflorum* and *L. flavum*," until Mr. Darwin detected it, and worked out the case to the striking results which we record below, chiefly in his own words.

"The crimson *Linum grandiflorum* presents two forms, occuring in about equal numbers, which differ little in structure, but greatly in function. The foliage, corolla, stamens, and pollen (examined dry and distended with water) are alike in both forms. The difference is confined to the pistil: in the one form, which I will call "short-styled," the column formed by the united styles and the short stigmas together is about half the length of the whole pistil in the other and "long-styled" form. A more important distinction is, that the five stigmas in the short-styled form diverge greatly from each other, and pass out between the filaments of the stamens, and thus lie within the tube of the corolla. In the long-styled form the elongated stigmas stand nearly upright and alternate with the anthers. In this latter form, the length of the stigmas varies considerably, their upper extremities projecting even a little above the anthers, or reaching up only to about their middle. Nevertheless, there is never the slightest difficulty in distinguishing between the two forms; for, besides the difference in divergence, the stigmas of the short-styled form never reach even to the bases of the anthers. In the short-styled, the papillæ on the stigmatic surfaces are shorter, darker-colored, and more crowded together than in the long-styled form: but these differences seem due merely to the shortening of the stigma; for, in the varieties of the long-styled form with shorter stigmas, the papillæ are more crowded and darker-colored than in those with the longer stigmas. Considering the slight and variable differences between the two forms of this *Linum*, it is not surprising that they have been hitherto overlooked.

"In 1861, I had eleven plants growing in my garden, eight of which were long-styled, and only three short-styled. Two very fine long-styled plants grew in a bed a hundred yards off, and separated from the others by a screen of evergreens. I marked twelve flowers, and put on their stigmas a little pollen from the short-styled plants. The pollen of the two forms is, as stated, identical in appearance; the stigmas of the long-styled flowers were already thickly covered with their own pollen,—so thickly that I could not find one bare stigma; and it was late in the season, namely, September 16th. Altogether, to expect any result from this trial seemed almost childish. From my experiments, however, on *Primula*, which have been laid before this Society (*Journal*, vi. 77), I had faith, and did not hesitate to make the trial, but certainly I did not anticipate the full result. The germens of these twelve flowers all swelled, and ultimately six fine capsules (the seed of which germinated this year) and two poor capsules were produced; only four capsules shanked off. These two plants produced, before and after and at the time of the trial, a vast number of flowers, but the germens of not even one swelled. All these flowers, though their stigmas were so densely covered with their own pollen, were absolutely barren.

"The nine other plants, six long-styled and three short-styled, grew in the beds of the same flower-garden. Four of the long-styled produced no seed-capsules; one produced two; but the remaining long-styled plant grew so close to a short-styled plant that their branches touched; and this produced twelve capsules, but they were poor. The case was different with the short-styled plants. The plant which grew in juxtaposition with the long-styled plant produced ninety-four imperfectly fertilized capsules, containing a multitude of bad seeds, with a moderate number of good seeds The two other short-styled plants grew in a single clump, and were very small, being partly smothered by other plants; they did not stand very close to any long-styled plants, yet they yielded together nineteen capsules. These facts seem to show that the short-styled plants are far more fertile with their own pollen than

the long-styled. We shall immediately see that this is the case in a slight degree. But I suspect that in this instance the difference in fertility between the two forms was in part due to a distinct cause. I repeatedly watched the flowers, and only once saw a humble-bee momentarily alight on one, and then fly away, as if it were not to its taste. If bees had visited the several plants, there cannot be a doubt that the four long-styled plants which did not produce a single capsule would have borne an abundance. But several times I saw small Diptera sucking the flowers; and these insects, though not visiting the flowers with anything like the regularity of bees, would carry a little pollen from one form to the other, especially when growing close together; and the stigmas of the short-styled plants, diverging within the tube of the corolla, would be more likely than the upright stigmas of the long-styled to receive a small quantity of pollen when brought by small insects. From the much greater number of long-styled than of short-styled flowers in the garden, evidently the short-styled would be more likely to receive some pollen from the long-styled, than the long-styled from the short-styled.

"In 1862, I raised thirty-four plants of this *Linum* in a hotbed; and these consisted of seventeen long-styled and seventeen short-styled forms. Seed sown later in the flower-garden yielded seventeen long-styled and twelve short-styled forms. These facts justify the statement that the two forms are produced in about equal numbers. The first thirty-four plants were kept under a net which excluded insects. I fertilized heteromorphically fourteen long-styled flowers with pollen from the short-styled, and got eleven fine seed-capsules; these contained on an average 8·6 seeds per capsule, but only 5·6 were apparently good. It may be well to state that ten seeds is the maximum possible production for a capsule, and that our climate cannot be very favorable to this North-African plant. On three occasions, I fertilized homomorphically the stigmas of altogether nearly a hundred flowers (but did not separately mark them) with their own pollen, but taken from separate plants, so as to prevent any possible ill effects from close interbreeding; and many other flowers were produced, which, as before stated, would get plenty of their own individual pollen; yet from all these flowers, borne by the seventeen long-styled plants, only three capsules were produced; one of these included no seed, and the other two together gave only five good seeds. Nor do I feel at all sure that this miserable product of the two half-fertile capsules from the seventeen plants, each of which must have produced at least fifty or sixty flowers, is really the result of their fertilization by their own pollen; for I made a great mistake in keeping the two forms under the same net, with their branches often interlocking; and it is surprising that a greater number of flowers were not accidentaly fertilized.

"Of the short-styled flowers, I fertilized heteromorphically twelve with the pollen of the long-styled (and to make sure of the result I previously castrated the majority), and obtained seven fine seed-capsules. These included an average of 7·6 seeds, but of apparently good seed only 4·3 per capsule. At three separate times, I fertilized homomorphically nearly a hundred flowers with their own-form pollen, taken from separate plants; and numerous other flowers were produced, many of which must have received their own pollen. From all these flowers borne on the seventeen plants, only fifteen capsules were produced, of which only eleven contained any good seed, on an average 4·2 per capsule. As remarked in the case of the long-styled plants, some even of these capsules were perhaps the product of a little pollen accidentally fallen from the flowers of the other form. Nevertheless, the short-styled plants seem to be slightly more fertile with their own pollen, in the proportion of fifteen capsules to three, than the long-styled: the real proportional excess in fertility is probably a little greater, as the short-styled flowers, when not disturbed, do not so surely receive their own pollen as do the long-styled. The greater self-fertility of the short-styled flowers was, as we have seen, also

shown by the plants left to themselves, and but sparingly visited by insects, in the flower-garden in 1861, and likewise by those raised in 1862."

Next, with the view of ascertaining the immediate cause of this almost absolute sterility of long-styled pistils with their own form of pollen, and in a less degree of short-styled pistils with their own form of pollen, a series of experiments was made, in which pollen of either sort was applied to the stigmas of either sort, and the stigmas were dissected under the microscope, after an interval of 24 hours or less. When pollen of a short-styled flower was applied to the stigmas of a long-styled, and likewise when, conversely, that of a long-styled flower was applied to the stigmas of a short-styled, a microscopical dissection showed that the stigmas were freely penetrated by numerous pollen-tubes. But when homomorphic unions were attempted, no pollen-tubes, or scarcely any, were emitted; even after an interval of three days the stigmas remained straight and fresh-colored, and the pollen inactive. When two or three of the stigmas were dusted with their own form of pollen, and the others with the opposite form, the difference was striking; the former stigmas remaining straight, fresh, and unpenetrated or nearly so, while the latter were soon discolored, twisted, half-shrivelled, and penetrated by a multitude of pollen-tubes.

"This seems to me a remarkable physiological fact. The pollen-grains of the two forms are undistinguishable under the microscope; the stigmas differ only in length, degree of divergence, and in the size, shade of color, and approximation of their papillæ, these latter differences being variable and apparently simply due to the elongation of the stigma. Yet we plainly see that the two pollens and the two stigmas are widely dissimilar in action, the stigmas of each form being almost powerless on their own pollen, but causing, through some mysterious influence, by simple contact (for I could detect no viscid secretion), the pollen-grains of the opposite form to protrude their tubes. It may be said that the two pollens and the two stigmas by some means mutually recognize each other. Taking fertility as the criterion of distinctness, it is no exaggeration to say that the pollen of the long-styled *Linum grandiflorum* (and conversely of the other form) has been differentiated, with respect to the stigmas of all the flowers of the same form, to a degree corresponding with that of distinct species of the same genus, or even of species of distinct genera."

The results are nearly the same in *L. perenne*, except that pollen-tubes were found to be produced in attempted homomorphic unions, but either they did not reach the ovules, or they did not act on them. "Neither pollen when placed on its own stigma causes fertility, except occasionally and in a very moderate degree." The following remarks neatly discriminate between the action of the wind and that of insects in carrying pollen. And then the twisting of the long styles in *L. perenne* and the divergence of the short ones in both species are noteworthy:

"Botanists, in speaking of the fertilization of plants or of the production of hybrids, often refer to the wind or to insects as if the alternative were indifferent. This view, according to my experience, is entirely erroneous. When the wind is the agent in carrying pollen, either from one separated sex to the other, or from hermaphrodite to hermaphrodite (which latter case seems to be almost equally important for the ultimate welfare of the species, though occurring perhaps only at long intervals of time), we can recognize structure as manifestly adapted to the action of the wind as to that of insects when they are the carriers. We see adaptation to the wind in the incoherence of the pol-

len, in the inordinate quantity produced (as in the Coniferæ, Spinage, &c.), in the dangling anthers, well fitted to shake out the pollen, in the absence or small size of the perianth, or in the protrusion of the stigmas at the period of fertilization, in the flowers being produced before they are hidden by the leaves, in the stigmas being downy or plumose (as in the Gramineæ, Docks, and other plants) so as to secure the chance-blown grains. In plants which are fertilized by the wind, the flowers do not secrete nectar, their pollen is too incoherent to be easily collected by insects, they have not bright-colored corollas to serve as guides, and they are not, as far as I have seen, visited by insects. When insects are the agents of fertilization (and this is incomparably the more frequent case, both with plants having separated sexes and with hermaphrodites), the wind plays no part, but we see an endless number of adaptations to ensure the safe transport of the pollen by the living workers. We can recognize these adaptations most easily in irregular flowers; but they do not the less occur in perfectly regular flowers, of which those of *Linum* offer an instance, as I will almost immediately endeavor to show.

"I have already alluded to the rotation of each separate stigma in the long-styled form alone of *Linum perenne*. In the other species examined by me, and in both forms when the species are dimorphic, the stigmatic surfaces face the centre of the flower, and the furrowed backs of the stigmas, to which the styles are attached, face the circumference. This is the case, in the bud, with the stigmas of the long-styled flowers of *L. perenne*. But, by the time the flower in this form has expanded, the five stigmas, by the torsion of that part of the style which lies beneath the stigma, twist round and face the circumference. I should state that the five stigmas do not always perfectly turn round, two or three often facing only obliquely towards the circumference. My observations were made during October; and it is not improbable that earlier in the season the torsion would have been more perfect; for after two or three cold and wet days the movement was very incomplete. The flowers should be examined shortly after their expansion; for their duration is brief, and, as soon as they begin to wither, the styles become spirally twisted together, and the original position of the parts is lost.

"He who will compare the structure of the whole flower in both forms of *L. perenne* and *grandiflorum*, and, I may add, of *L. flavum*, will, I think, entertain no doubt about the meaning of this torsion of the styles in the one form alone of *L. perenne*, as well as the meaning of the divergence of the stigmas in the short-styled forms of all three species. It is absolutely necessary, as we now know, that insects should reciprocally carry pollen from the flowers of the one form to those of the other. Insects are attracted by five drops of nectar, secreted exteriorly at the base of the stamens, so that to reach these drops they must insert their proboscides outside the ring of broad filaments, between them and the petals. In the short-styled form of the above three species, the stigmas face the axis of the flower; and had the styles retained their original upright and central position, not only would the stigmas have presented their backs to insects as they sucked the flowers, but they would have been separated from them by the ring of broad filaments, and could never have been fertilized. As it is, the styles diverge greatly and pass out between the filaments. The stigmas, being short, lie within the tube of the corolla; and their papillous faces, after the divergence of the styles, being turned upwards, are necessarily brushed by every entering insect, and thus receive the required pollen.

"In the long-styled form of *L. grandiflorum*, the parallel anthers and stigmas, slightly diverging from the axis of the flower, project only a little above the tube of the somewhat concave corolla; and they stand directly over the open space leading to the drops of nectar. Consequently, when insects visit the flowers of either form (for the stamens in this species occupy the same position in both forms), they will get their proboscides well dusted with the

coherent pollen. As soon as the insect inserts its proboscis to a little depth into the flower of the long-styled form, it will necessarily leave pollen on the faces and margins of the long stigmas; and as soon as the insect inserts its proboscis to a rather greater depth into the short-styled flowers, it will leave pollen on their upturned stigmatic surfaces. Thus the stigmas of both forms will indifferently receive the pollen of both forms; but we know that the pollen of the opposite form alone will produce any effect and cause fertilization.

"In the case of *L. perenne*, affairs are arranged a little more perfectly; for the stamens in the two forms stand at different heights, and pollen will adhere to different parts of an insect's body, and will generally be brushed off by the stigmas of corresponding height, to which stigmas each kind of pollen is adapted. In this species, the corolla is flatter, and in the one form the stigmas and in the other form the anthers stand at some height above the mouth of the corolla. These longer stigmas and longer stamens do not diverge greatly; hence insects, especially rather small ones, will not insert their proboscides between the stigmas or between the anthers, but will strike against them, at nearly right angles, with the back of their head or thorax. Now, in the long-styled flowers of *L. perenne*, if each stigma had not rotated on its axis, insects in visiting them would have struck their heads against the backs of the stigmas; as it is, they strike against the papillous fronts of the stigmas, and, their heads being already charged with the proper coherent pollen from the stamens of corresponding height borne by the flowers of the other form, fertilization is perfectly effected. Thus we can understand the meaning of the torsion of the styles in the long-styled flowers alone, as well as their divergence in the short-styled flowers."

Linum Lewisii is inferred to be distinct as a species from *L. perenne* on the ground of Planchon's remark, that the styles are in the same specimen sometimes equalling, sometimes shorter, and sometimes longer than the stamens. The inference may not be correct: and although the plant is said to extend northward even to the shores of the Arctic sea, it does not specially belong to the "Arctic Zone," but abounds on the Western plains.

A remark in this interesting paper lets us know that Mr. Darwin has detected *trimorphism*, viz: three distinct forms, each of which produces two kinds of pollen, in *Lythrum Salicaria*, neither pollen when placed on its own stigma producing fertility, "except occasionally and in a very moderate degree; yet the pollen-tubes in each case freely penetrate the stigmatic tissue." Here the number of heteromorphic and therefore fertile unions possible is largely increased. These degrees of sterility in homomorphic unions,—from complete inertness of the pollen to the occasional production of an inefficient pollen-tube, to the copious production of inefficient pollen-tubes penetrating the style, and to the occasional fertilization of an ovule,—are very noteworthy, and Mr. Darwin will some day turn them to account in his own way. "*Natura non agit saltatim.*" Let us add, in conclusion, that when such fine biological discoveries are so readily made by the study of some of the commonest plants, no botanical student, however restricted his range, need slumber for lack of occupation, nor suppose that the field is exhausted. Out of old fields, indeed, not only comes all this new corn from year to year, but such gleanings as these are richer far in interest than any crop of new species from a virgin soil.

A. G.