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DARWIN ON THE EFFECTS OF CROSS AND SELF FERTILIZATION IN PLANTS.

It is impossible to finish the perusal of any of Mr. Charles Darwin's works without a genuine feeling of admiration, not only for the manner in which the investigator pursues every branch of the great principles he has enunciated to its minutest ramification, but for the almost inconceivable patience with which he accumulates grain after grain of proof, until his position is not only firmly established but seems possessed of even a superabundant support. For eleven years he has been conducting the difficult and delicate inquiry of which his recent volume is the record; and yet the result to be adduced, from the great mass of facts so slowly and laboriously gathered, is no strikingly novel discovery, although much is embodied that is new. It is rather a substantiation of opinions already enunciated, leading to their wider generalization. His conclusion is closely connected "with various important physiological problems, such as the benefit derived from slight changes in the conditions of life, and this stands in the closest connection with life itself. It throws light on the origin of the two sexes, and on their separation or union in the same individual, and lastly on the whole subject of hybridism, which is one of the greatest obstacles to the general acceptance and progress of the great principle of evolution."

In briefly reviewing Mr. Darwin's new work, or rather its conclusions, for we cannot attempt the consideration of his countless experiments, it is best to begin by the repetition of his own statement, made to avoid misapprehension, namely, that the term "crossed plant seedling, or seed," means one of crossed parentage, that is, one derived from a flower fertilized with pollen from a distinct plant of the same species. And a self-fertilized plant seedling, or seed, means one of self-fertilized parentage, that is, one derived from a flower fertilized with pollen from the same flower, or sometimes from another flower on the same plant.

From his observations on plants, and guided to a certain extent by the experience of breeders of animals, Mr. Darwin many years ago became convinced that it is a general law of Nature that flowers are adapted to be crossed at least occasionally by pollen from a distinct plant. It often occurred to him that it would be advisable to try whether seedlings from cross-fertilized flowers were in any way superior to those from self-fertilized flowers. It so happened that, without any thought of the above inquiry, he raised close together two large beds of self-fertilized and crossed seedlings from the same plant of *linaria vulgaris*. To his surprise, the crossed plants, when fully grown, were plainly taller and more vigorous than the self-fertilized ones. As it seemed quite incredible that the difference between the two beds of seedlings could have been due to a single act of self-fertilization, Mr. Darwin attributed the fact to some accidental cause; but in order to test the matter, he prepared two more beds from the carnation *dianthus caryophyllus*, which, like the *linaria*, is almost sterile when insects are excluded; and hence the inference may be drawn that the parent plants must have been intercrossed during every, or almost every, previous generation. Nevertheless, the self-fertilized seedlings were plainly inferior in height and vigor to the others. This was the starting point of Mr. Darwin's experiments, conducted with all the refinement and minuteness necessary for the most accurate of observations.

Of the conclusions reached, the first and most important is that cross-fertilization is generally beneficial, and self-fertilization injurious. This is shown by the difference in height, weight, constitutional vigor, and fertility of the offspring from crossed and self-fertilized flowers, and in the number of seeds produced by the parent plants. The advantages of cross-fertilization do not follow from some mysterious virtue in the mere union of two distinct individuals, but from such individuals having been subjected during previous generations to different conditions, or to their having varied in a manner commonly called spontaneous; so that in either case their sexual elements have in some degree differentiated. Again, the injury from self-fertilization follows from the want of such differentiation in the sexual elements. Thus when plants of the *ipomœa* and of the *mimulus*, which had been self-fertilized for the seven previous generations, and had been kept all the time under the same conditions, were intercrossed one with another, the offspring did not profit in the least by the cross. On the other hand, as showing that the benefit of a cross depends on the previous treatment of the progenitors, plants which had been self-fertilized for the eight previous generations were crossed with plants which had been intercrossed for the same number of generations, all having been kept under the same conditions as far as possible. Seedlings from this cross were grown in competition with others derived from the self-fertilized mother-plant crossed by a fresh stock; and the latter seedlings were to the former in height as 100 to 52, and in fertility as 100 to 4.

Under a practical point of view, agriculturists and horticulturists may learn much from the above conclusions. Thus it appears that the injury from the close breeding of animals and from the self-fertilization of plants does not necessarily depend on any tendency to disease or weakness common to the constitution of the related parents, and only indirectly on their relationship, in so far as they are apt to resemble each other in all respects, including their sexual nature; and secondly, that the advantages of cross-fertilization depend on the sexual elements of the parents having become in some degree differentiated by the exposure of their progenitors to different conditions, or from their having intercrossed with individuals thus exposed, or from spontaneous variation. Animals to be paired should therefore be kept under as different conditions as possible, and excellent results have been obtained from the interbreeding of individuals reared on distant and differently situated farms. With all species of plants which freely intercross, by the aid of insects or the wind, the best plan is to secure seeds of the required variety which have been raised for some generations under as different conditions as possible, and sow them in alternate rows with seeds matured in the old garden. The intercrossing of the stocks will yield far more favorable results than any mere exchange of seeds. Florists may learn that they have the power of fixing each fleeting variety of color, if they will fertilize the flowers of the desired kind with their own pollen for half a dozen generations, and from the seedlings under the same conditions. But a cross with any other individual of the same variety must be carefully prevented, as each has its own constitution. After a dozen generations of self-fertilization, the new variety will probably remain constant, even if grown under different conditions; and there is no longer any necessity of guarding against intercrossing.

With respect to mankind, Mr. George Darwin has concluded, from a statistical investigation which has already been reviewed in these columns, that the evidence of any evil due to the intermarriage of first cousins is conflicting, and on the whole points to the same being very small. Our author infers that, with mankind, the marriages of nearly related persons, some of whose parents and ancestors had lived under very different conditions, would be much less injurious than that of persons who had always lived in the same place and followed the same habits of life. He sees no reason to doubt that the widely different habits of life of men and women in civilized nations, especially amongst the upper classes, would tend to counterbalance any evil from marriages between healthy and somewhat closely related persons.

THE TRANSMISSION OF CORRECT TIME.

The public clocks in the city of Vienna, Austria, are at present driven by a pneumatic system, actuated at the Imperial Observatory by an automatic arrangement connected with an astronomical timepiece. The idea originated with an engineer named E. A. Mayrhope, who had long experimented with the transmission of time by means of electricity, and at last gave it up in favor of pneumatic transmission, which is free from the drawbacks and uncertainties connected with the use of electric batteries, insulated wires for transmission, delicate contact breakers, and other complicated arrangements. Such annoyances have occurred in the experiments made in this country, where electric arrangements for the transmission of time have thus far never been in use for any considerable period. Some years ago, a time ball in the New York Custom House, intended to be regulated by an electric current from the Dudley Observatory at Albany, soon failed, because of the constant attention required, which could only be expected from persons specially engaged and exclusively interested in electric transmissions. Therefore it is not to be expected that such an enterprise can be successful until telegraph companies take hold of the matter; and only in such case is there possibility of a regular working of electric timepieces.

The method of Mr. Mayrhope consists in originating a wave of compressed air, which is sent through airtight tubes laid along the street gas mains to all the public clocks. This wave is transmitted once every minute, when the minute hands of all the clocks move forward the required distance. It is intended to extend this system until it includes the clocks in all the schools, public institutions, hotels, railroad depots, and the houses of such persons as desire it.

There is no doubt that this method has the enormous advantage of simplicity, especially when applied to a great number of clocks. Such a pneumatic tube may have ever so many branches; and at the end of every branch the impulse must invariably reach the moving lever which, pushed by an elastic membrane, will propel the minute hand. It must, however, be borne in mind that, by this system, the clocks will not move so instantaneously as by the electric current. Electricity is transmitted over a telegraph wire with a velocity of from 4,000 to 12,000 miles per second, according to the perfection of the insulation; therefore the motion of the various clocks will be practically isochronous. But the wave of compressed air, transmitted by the elasticity of the atmosphere, moves only with the velocity of sound, which is, on an average, only 1,100 feet, or little over one fifth of a mile, per second, *minus* the resistance in the narrow tubes, which may reduce it somewhat; so that its velocity of transmission may vary from 25,000 to 70,000 times less than that of electricity. This, however, is of little practical importance, as it would only cause the clocks to be one second behind for every 1,100 feet distance from the central station; and if in some cases seconds had to be counted, the correction would be easily applied. Clocks at a mile distance would be about five seconds behind; and the correct amount having been determined by direct observation, a constant number would have to be added to the time indicated by each clock, in order to find the correct time to within a fraction of a second.

But if we go into such close calculations, the difference in time for difference in longitude ought not to be neglected. At the latitude of Vienna, the degrees of longitude are nearly forty-six miles long: that means that meridians drawn on whole numbers of degrees are nearly forty-six miles apart.