mingle in all such councils, and infuse a torpor and sluggishness destructive of all military operations." These arguments apply with irresistible force to the government of a navy. Summing up, then, we are led to the conclusion that a navy department should consist of a Secretary of the Navy, to administer the civil affairs of the navy—the Admiral of the Navy, or a naval officer of high rank, to act as his executive, or assistant, in the management of the affairs of the navy proper, and the bureaus as they now exist, but with the strangely anomalous clause of the law stricken out, which makes the orders of an inferior, a chief of bureau, equal to those of his superior, the Secretary of the Navy. (See Sec. 420, Revised Statutes.)

A naval government based on such sound principles as we have endeavored to elucidate, could not fail in the desideratum we set out with:—an energetic, efficient, and economical administration of naval affairs.

MR. DARWIN ON THE FERTILIZATION OF FLOWERS.

IN 1862, Mr. Darwin's *Fertilization of Orchids* first appeared. Leading botanists knew that most of this tribe were unable to fertilize themselves, and some knew that insects were necessary agents in successful fertilization; but no one knew how varied and how beautiful were the arrangements by which fertilization was effected, and few knew that the pollen of one flower was brought to another as a regular thing by insect aid. To demonstrate these facts was Darwin's great work. He tells us that it grew out of his *Origin of Species*. He there gave general reasons for a belief that no "hermaphrodite fertilizes itself for a perpetuity of generations." Having been blamed, he says, for propounding this doctrine without giving ample facts, he issued this book "to show he had not spoken without having gone into details." Even with this work on the fertilization of orchids, he seems to have felt that something further was necessary to prove

[1] CROSS AND SELF-FERTILIZATION IN THE VEGETABLE KINGDOM. By Charles Darwin. New York: D. Appleton & Co. 1877.

ON THE FERTILIZATION OF ORCHIDS BY INSECTS. By Charles Darwin. 2d Edition. New York: D. Appleton & Co. 1877.

the point. Thus it appears, *Cross and Self-Fertilization* was suggested. The experiments on which this book is founded, were commenced a year or so afterwards, and continued for several subsequent years. This piece of history is important, as it shows that Mr. Darwin was strongly prepossessed in favor of the doctrine he propounded, before these last experiments were begun. At the same time, it is but fair to say, that the world has seen few more patient, conscientious workers than Mr. Darwin; and if it be possible for any human being to be wholly uninfluenced in his judgment by preconceived opinions, he surely is that man.

Cross and Self-Fertilization is a monument of wonderful scientific industry. Every one of its four hundred and sixty-nine pages contains some distinct fact worth weighing—and in general, there is food for reflection in every line. The student will want to read the whole carefully, but he will find it take a long time to thoroughly digest the work The general reader will, perhaps, be content with the introductory chapters, and those at the end, which give in a concise manner the conclusions drawn from the details given in the chapters that have gone before. It will be well, however, for those who are specially interested in the subject, to study the experiments as given; for, we think, that in many cases they will not draw the same conclusions from the same facts that the author does.

The general proposition as given in the last page of the new edition of "Orchids," is this: "It is hardly an exaggeration to say that nature tells us in the most emphatic manner that she abhors perpetual self-fertilization." Mr. Darwin proceeds to narrate the story, and this is about what it is:—A large number of plants have their flowers so constructed that it appears easier for them to receive pollen on their stigmas from other flowers by the agency of the wind or insects than to receive it from their own stamens. Some are so arranged that it seems impossible for them to be able in any way to make use of their own pollen; while there are many cases where flowers undoubtedly and continuously self-fertilize. The inference derived from a study of Mr. Darwin's book is that the numbers in these two classes about balance one another. Mr. Darwin it is proper to state, insists that self-fertilizers are frequently intercrosses. His work hardly proves this, but if it did there is so little chance of anything coming of it, that it is not worth considering. Supposing a plant with a thousand flowers, producing a thousand

seeds, had but ten of them influenced by cross-fertilization,—the chance of these ten in a thousand falling into conditions favorable to germination are very small indeed. Very often not ten in a thousand of seeds of any kind get any chance to grow. Hundreds of pounds of seeds are every year produced in our fields and forests for every pound—we might almost say for every single seed that gets a chance to grow.

The only material point for consideration is then this as stated by Mr. Darwin, "As plants are adapted by such diversified and effective mea ns for cross-fertilization, it might have been inferred from this fact alone that they derived some great advantage from the process, and it is the object of the present work to show the nature and importance of the benefits derived" (p. 2). Mr. Darwin frequently uses this argument, *i. e.* certain arrangements exist which produce certain results, therefore some great good must be derived by the individual possessing the arrangements whereby the results are accomplished. Students of Natural Philosophy know how defective such an argument is. Every part of nature contains within itself not only the elements of construction but of destruction. There are adaptations for gradual growth, and there are adaptations for gradual and final decay. There can be no doubt that nature intends races as well as individuals to die, and she naturally urges them onward in the belief that what they are doing is really for their good. Large numbers of male insects die very soon after having fulfilled their mission, while the females live only so much longer as will enable them to safely deposit their eggs. They were impelled to take on the family relations by an impulse which seemed pleasant enough to them, but which really terminated in their early extinction. It is as true of races—even of human races. The Indian finds himself well adapted for war. If he had chosen peace and friendship—had he the philosophy to bear the injustices heaped on him by the white man, and chosen to bear the ills he had instead of risking war, he would have been mighty in numbers to-day. But his "adaptations" have proved his ruin. Is there any *a priori* reason why the adaptations for cross-fertilization which Mr. Darwin finds, *must be* for some great good to the individual or race? It may be good in the general economy of nature, and that be all. That part of the proposition in which Mr. Darwin proposes to "show the nature and importance of the benefits derived" is the only part which is fairly within the line he has marked out for us.

We thus come directly to Mr. Darwin's experiments. He takes a large number of garden plants, applies the flower's own pollen to its own stigma in some cases, pollen from other flowers on the same plants in others, in others pollen from other plants in the vicinity, and sometimes pollen from plants brought from a distance. He sows seeds of these various classes; raises plants, sows again from them, and so on, continuing through several generations in many cases. The plants from these self-fertilized seeds and from the crossed plants are suffered to grow together under the same circumstances; and their time of seed germination, of first producing flowers, the rate and final extent of growth, the number and weight of the seeds, are carefully compared; as well as the longevity of the plants under unfavorable circumstances. Among the plants experimented with are *Linaria*, our common yellow Toad-flax; Indian corn; the common Morning Glory; the common Monkey flower (*Mimulus*); Fox-glove, a small Scarlet Sage (*Salvia coccinea*); *Thunbergia;* Cabbage; *Escholtzia Californica;* Pansy; *Hibiscus Africanus;* Geranium; *Limnanthus;* Scarlet Runner Bean; Garden Pea; Scotch; Broom; *Clarkia; Mentzelia aurea;* Parsley; a Passion Flower; *Lobelia; Nemophila;* the common Borage; *Petunia;* Tobacco; *Cyclamen; Anagallis;* Primroses; *Abutilon;* Clover; *Cineraria;* Mignonette; Madagascar Periwinkle; and some others. This list shows how varied were the families used in the experiments, and makes as fair a selection perhaps as could be made.

To determine which had the best average growth, Mr. Darwin employs a system of averages. He generally has from five to seven sets of comparative experiments with each kind in each year. He then selects an equal number of the largest plants in each set, measures the plants, and counts and weighs the seeds. There is rarely a case where some of the self-fertilized plants have not beaten the cross-fertilized, in some cases they have completely beaten them, but in the majority of cases the final figures favor the crossed plants. It is interesting to note that this final advantage is often the result of some single great stroke. It is as if we were to count up the loss by fire in a dozen cities, and just as we are finishing, get a Chicago thrown in. For instance here is a case where the average foots up 189 cross-fertilized as against 199 for self-fertilized, but some further trials are made and these give 257 for the crossed and only 176 for the selfs. The last experiments give the case to the cross-fertilized, but why should that last trial

prove a natural law any more than the first, even though it does decide the average? It is, however, a very interesting fact that though a very large number of plants showed greater advantages by self-fertilization than by cross-fertilization, the totals in the vast number of trials made give the greatest vigor to the cross-fertilized by an average equal to about one-fifth of the whole.

But here comes in another very interesting question. The crossed plants are shown to have a greater *average* growth, to produce flowers on *the average* earlier, to mature on *the average* more seeds, and to live on *the average* under a struggle better than self-fertilized ones. Are these characteristics "advantageous" when we consider all that is understood by the "struggle for life" or the "development of the race?" Cellular development—a more luxuriant growth, is by no means synonymous with that phase of vital power we recognize in endurance, and precocity is the reverse of a strong argument. So in regard to the number of seeds, the greater this be, the more draft there is on the forces of nutrition, and the general result is less power to each. The (not many) cases Mr. Darwin gives, where the plants were equally grown under unfavorable circumstances, and the average favored the cross-fertilized, may be taken as the strongest point of all.

Again it must be noted that most of the experiments were made with exotic plants, and under glass. The natures of both plants and animals change when removed from wild life. The domestic animals, now of so many colors would have been of an uniform shade if left to nature. Plants partake much in these respects of a similar character.

> "In all places then, and in all seasons,
> Flowers expand their light and soul-like wings;
> Teaching us by most persuasive reasons,
> How akin they are to human things."

Mr. Longfellow has here the poet's perception of a natural truth. Flowers pine in captivity as human beings do. Some less sensitive are resigned to fate; others, easily excited by the hopes of escape; and the act of cross-fertilization would find just the occasion for a joyous bound in their finer natures! The reader will pardon these metaphors for the sake of the truths beneath. Mr. Darwin's artificial experiments seem to show, not that self-fertilization produces any injury to the race, but that cross-fertilization brings about a more excitable condition of growth and reproduction. For the

self-fertilizers rarely went backwards. Suppose, for instance, a self-fertilized plant gave a growth related as 75 to 100, and the cross-fertilized 95 to 100; no matter how many generations of self-fertilizers were tested, the average does not decrease, while continued cross-fertilization in each succeeding generation is required to keep the other average up. Mr. Darwin, though he continually ses the expression that self-fertilizati o n must be very injurious, admits that it is only after many generations that the evil becomes apparent. His experiments show that no advantage is derived from a cross with a flower from the same plant; and yet, in large plants or trees especially, this is nearly all the cross-fertilization they can receive; as bees or other insects generally exhaust the vicinity before flying elsewhere. A tree with a thousand flowers may possibly have the first flowers that a newly visiting bee touches pollenized from another plant, but even this is dependent on the merest accident that such flower had not been previously visited. Indeed the first morning bee and the first flower visited make up all the chance for cross-fertilization. But even here the fact that perhaps only one per cent. of the seeds which mature gets the opportunity to grow, allows but a small chance to this cross-fertilized seed to be that one. And we may keep on with this calculation of chances, for if that one seed actually get the opportunity to grow, hundreds of others crowd it, and with accident on accident following, it can scarcely be the one to endure. And, when we consider that according to Mr. Darwin's experiments, cross-fertilization is only a temporary good—it must be continuous in order to be permanently effective—the theory of cross-fertilization *practically* amounts to nothing at all.

But the deductions from Mr. Darwin's experiments may be extended to a wider circle against his own theory. He tells us that "the advantages of cross-fertilization do not follow from some mysterious virtue in the 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 been in some degree differentiated" (p. 442). In regard to the marriages of cousins and closely related persons he was surprised by his son's statistical investigations to find that on the whole the injury is "very small," and even with this small degree in view he writes "from the facts given in this volume we may

infer that with mankind the marriages of nearly related persons, some of whose 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," and he adds that "widely different habits counterbalance any evil" there *might* be in these closely related marriages. So that for any benefit to the plant race from the cross-fertilization, the pollen must be brought by the insect from very distant plants, growing "under very different conditions," that is to say in ordinary cases miles away!

In the work *On the Fertilization of Orchids by Insects*, the considerations we have just entertained, must strike the reader with much more force. It is taken as a generalization that orchids cannot fertilize themselves, but Mr. Darwin shows that there are some that can. The great majority seem dependent on the aid of insects, and they "cross-fertilize;" but orchids are generally confined to special localities. They usually grow only in very peculiar situations. We find a quantity in a bog here, and then it will often be many miles before we meet the same species again. The only "cross-fertilization" can be from plants growing under the same conditions, which under Mr. Darwin's own teachings is practically not cross-fertilization at all.

We are still left with the problem on our hands, why are these peculiar arrangements? Here are plants which have their separate sexual organs perfect in the one flower, yet are unable to exercise their functions except by the agency of insects as they visit flower after flower. Mr. Darwin is evidently prepossessed by the idea that it must be useful because such arrangements exist. It may be useful,—but as we have already seen, useful in the ordination of nature, as being her mode of gradually getting rid of a tribe which she has no longer any desire to preserve! That this is just as likely as not, is rendered more than a probability by Mr. Darwin's own facts. He says that it is must be of more importance in the economy of plant-life to seed by self-fertilization than not to seed at all through failure to cross-fertilize. Yet orchids of all plants the oftenest fail to seed. "The frequency with which throughout the world members of various orchideous tribes fail to have their flowers fertilized, though these are so excellently constructed for cross-fertilization, is a remarkable fact" (p. 280). Large numbers of species have been obliterated. Of *Cypripediums* he

says, "An enormous amount of extinction must have swept away a multitude of intermediate forms, and has left this single genus, now widely distributed, as a record of a former and more simple state of the great orchidaceous order" (p. 226). And yet he thinks the order is a comparatively modern one in the line of creation. "Can we feel satisfied that each orchid was created exactly as we see it? * * Is it not a more intelligible view that all orchideae owe what they have in common, to descent from some monocotyledonous plant?" (pp. 245–246.) Evolutionists will, no doubt, assent to this view. A writer in the *Proceedings of the Academy of Natural Sciences*, of Philadelphia, some years since, suggested that orchids were but irids gone mad! They have all the elementary parts of the great Iris family, but differ mainly in having normally separated parts united and consolidated, so that it is almost impossible to detect by direct reasoning this close relationship. There is also in some irids, a tendency to "abhor self-fertilization" and coquette with the insect tribes, but some of them, and of these the pretty and very common *Sisyrinchium Bermudianum* is a notable example—have not evoluted to this modern tribe, but have preserved their original simplicity and habits of self-fertilization, and keeping *Sisyrinchium* in mind, have gained a foothold over a district thousands of square miles in extent, and which no species of orchid can ever hope to equal. There is never any difficulty in a student's finding *Sisyrinchium* for examination, but he may have to go miles for an orchid. Is it therefore not remarkable that so modern an order should be subject to these exterminating conditions, if the *usefulness* of the arrangements is to be interpreted as Mr. Darwin does? A poet would even take the extreme beauty of these flowers as in a living sense unnatural, and build on it an argument for speedy dissolution. "I trust," says Byron, in notes to *The Giaour*, "that few of my readers have ever had an opportunity of witnessing what is attempted here in description, but those who have, will probably retain a painful remembrance of that singular beauty which pervades, with few exceptions, the features of the dead, a few hours, and but a few hours, after the spirit is not there." This idea that the orchideae, with their elaborate arrangements for cross-fertilization, are on the high road to extinction, is not a new one. It is suggested in a paper on Cross-Fertilization, published in the Detroit (1875) volume of the *Proceedings*

of the American Association for the Advancement of Science, and certainly is supported by the facts and suggestions Mr. Darwin gives in the work under review. Even man takes advantage of the orchid's beauty only to destroy it. M. Ortgies, a noted collector has recently stated in the *Gardener's Chronicle*, that of some species which formerly existed in abundance, in certain districts in South America, not a single individual can now be found within a circuit of three hundred miles. If they took on beauty to shun self-fertilization, they have but hurried to a sadder fate. It is a new illustration of avoiding Scylla only to strike on Charybdis.

To review Mr. Darwin's two books properly would require space almost equal to the works themselves. The biological student will want to read them carefully for himself. He may become satisfied that nature has some great object in view by these arrangements for, and the facts of, cross-fertilization. If an enthusiastic son of science he will hardly know how to feel grateful enough for the patient, laborious work of Mr. Darwin, in piling up the facts here presented; but we shall be very much surprised if he do not conclude that there is infinitely more self-fertilization among flowers than advocates of insect agency have of late years been contending for; that cross-fertilization, as developed to advantage by Mr. Darwin's artificial experiments, is an almost impossible occurrence in most cases in nature; and where it must and does occur, the fact is capable of a very different explanation. THOMAS MEEHAN.