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DEPARTMENT OF EXPERIMENTAL EVOLUTION.*

C. B. Davenport, Director.

Certain portions of that unending stream of reproductive matter which has come down to us from the time when life began on earth and by changes in which all evolution has taken place are now under our careful observation and to a large extent under our control. It is the business of the Department of Experimental Evolution to study the behavior of this germ-plasm and to note its reaction to the conditions we impose.

At present our index of the qualities of any germ-plasm is the collection of characteristics shown by the individuals (somas) that arise from it. Each soma is the biological analysis of its germ-plasm. The breeder as he examines his produce selects blood lines or strains on the basis of that produce. And in nature, by the acceptance or rejection of particular individuals, any peculiarities that arise in the germ-plasm are preserved or destroyed.

As just stated, evolution consists of changes in the germ-plasm. These changes are chemically appreciable, for, as Reichert and Brown† have shown, the hæmoglobins of different genera of mammals crystallize in a characteristic manner, and T. B. Osborne has demonstrated‡ that the proteins of various grains are chemically unlike. These changes are biologically appreciable in the variations of the somas that result. Formerly it was held that the germ-plasm is undergoing a slow change and by a selection of streams varying in the right manner we might, in the course of time, build up a new and favorable characteristic. To-day a hopeful hypothesis is that changes occur in the germ-plasm suddenly and in large amount, so that each results in a new characteristic.

While the soma is for us the analysis of the germ-plasm we are studying, we have to recognize that this analysis is subject to certain errors. Of these one of the most difficult to eliminate is the error of variation of the soma under different environmental conditions. This is the "ontogenetic variation" of certain authors and the "fluctuation" of others. Current hypothesis is that fluctuations are not indicative of the constitution of the germ-plasm, but only of the external conditions in which the soma has developed; but this hypothesis is too simple, for external conditions do not produce always the

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† E. T. Reichert and A. P. Brown: The crystallography of hemoglobins. Proc. Soc. Exper. Biol. and Med., v, pp. 66–68.

‡ Amer. Jour. of Physiology, 1906–07.

same result on all developing somas, but, on the contrary, the result varies with the responsiveness of the soma and this is a function of the germ-plasm. A large series of investigations into the laws of fluctuations and the relations of fluctuations to varying nutrition are being carried out by Dr. J. Arthur Harris at this Station.

Another error in the soma as an index of the characters of the germ-plasm is possible whenever the germ-plasm contains the potentiality for a low degree, or the absence, of a quality as well as for a high degree. A particular soma will frequently show only the higher degree—the lower degree is veiled by the higher. This error may be corrected by the study of a large number of somas from the given germ-plasm, since some of these will lack the higher quality and reveal the lower. Thus, pigmented flowers or hair may veil a potential albinism in the germ-plasm, but a certain proportion of the offspring will, under proper breeding, be albinos. Again, it frequently happens that two or more factors are required to produce a visible result. If one factor alone is present in the germ-plasm it will not be revealed in the soma. The germ-plasm first reveals this factor by its behavior when the missing factor is added by crossing. Thus, the germ-plasm of the yellow canary has a pattern but no pigment to reveal it in the soma. When to this germ-plasm is added the pigment-forming quality of the "green" canary, or of some other species of finch, the pattern is revealed in the soma of the hybrid. From a consideration of the foregoing facts it is plain that a single soma does not afford a complete analysis of its germ-plasm; but by using special methods many somas may, together, be made to reveal the complete content of the germ-plasm.

Using, with proper care, the soma as the analysis of its germ-plasm, we seek to study the origin of changes in germ-plasm. First, we have paid attention to cases where, it is alleged, the germ-plasm is undergoing a sort of natural, one might say spontaneous, change. The most famous case of this is that of the evening-primrose, to which de Vries called attention. We are breeding evening-primroses extensively, and some of the results of our work have been published in conjunction with studies made by Dr. MacDougal.* The capacity of this wonderful plant for inciting investigations upon itself seems unlimited. We have only begun an era of investigation into its germ-plasm; and in this plant the structure of the germ-plasm of different species exhibits peculiarities that can readily be seen with the microscope. Miss Anne M. Lutz has devoted much time to the study of the stainable bodies (chromosomes) of the various species and has found the number to vary greatly, as, *e. g.*, 14, 15, 28, 29, 30. When a species with 15 chromosomes is crossed by one having 30 the hybrid offspring have 22, being half-way between the parental numbers, but a few show the ancestral group numbers

* Carnegie Institution of Washington, Publications Nos. 24 (1906) and 81 (1907).

of 15 and 30 again. The structures in the germ-plasm are thus inherited exactly like the somatic characters; and this is the first time that such parallelism has been traced.

What induces mutations in the germ-plasm is not exactly known, yet it can not be doubted that they frequently result from the direct action of certain environmental agents. Years ago Bonnier transplanted alpine plants to the lowland and *vice versa* and got certain modifications of their germ-plasm as a result, so that their descendants, when reared in their former ancestral homes, for a generation or two at least, were quite dissimilar from their cousins that had not been transplanted. Tower (Carnegie Institution of Washington publication 48) states that he found a similar effect on the color of transplanted potato-beetles. Dr. F. E. Lutz finds reason for concluding that climatic conditions similarly have determined the shortening of the wings of the northern crickets. The view is strengthened by the results of experiments which seek to modify the germ-plasm directly. Some years ago our correspondents, M. Standfuss and E. Fischer, of Zurich, were able, by abnormal temperature, to alter permanently the germ-plasm of certain moths. Tower has done the same with beetles, MacDougal with plants by chemical means, and R. H. Johnson has gained results still unpublished that are probably similar to those of Tower. Some efforts were made during the year with the assistance of Prof. C. C. Guthrie, of St. Louis, to influence the germ-plasm of poultry directly by chemical means, but without result. It is proposed to extend at this Station next year the work of inducing mutations.

The modification of the germ-plasm by the action upon it of the soma is still believed in by most people, as well as a respectable body of biologists. Recently Prof. C. C. Guthrie (Jour. Exper. Zoology) of the Medical School of Washington University engrafted ovaries from a black hen upon a white one and *vice versa*. He is confident that the transplanted ovaries were functional and produced eggs which, however, showed in the embryo that developed from them some influence of the foster-mother. His work, involving a somewhat difficult technique, is important, although I disagree with Guthrie's interpretation. Upon my invitation, Dr. Guthrie spent some time at the Station during the winter. Experiments somewhat in this line were started here and future lines of work considered. At present no satisfactory proof that the germ-plasm derives specific characteristics from the soma is forthcoming.

In contrast with the foregoing still difficult and uncertain method of influencing the germ-plasm is a method of very great certainty, yielding results of such interest that the great bulk of our studies so far have been made with it. I have spoken of the stream of germ-plasm; in reality it is a very complicated affair, composed of many tributary, parallel streams, cross-cuts, and anastomoses. They resemble rather the inextricable network of bayous, characteristic of deltas or other flat, irrigated countries. For in all sexually reproducing organisms there is a constant interchange of materials from one stream to another. As one sometimes sees a muddy red stream emptying into a clear river and can trace the color for miles, so in the mingling of germ-plasms in sexual reproduction a single character may be traced through generations. In most organisms the mingling of germ-plasms is immediately followed by the development of a new soma; and this is fortunate for the biologist, since there is the least delay between making his mixture and learning the result of the mixture as revealed by the somas. In the new soma the germ-plasm remains for a time in an immature condition, incapable of further mixing. The usual period required for ripening is a year—and this fact limits the speed of our progress. But in certain species generations succeed each other with great rapidity; thus the vinegar-fly takes only 10 days between generations. This material has proved very valuable in the hands of Dr. Lutz, who has reared over 40 generations in the last 2 years.

From the study of mingled germ-plasms it appears that the same laws hold whether the components be very unlike or differ in only a single character; for we have studied the effect of crossing distinct species and varieties, and the behavior of individual differences in ordinary matings. The study of hybridization is of prime importance for evolution, for it appears to be a common rule that a character that has arisen in one species of a genus is by hybridization engrafted on to some of the individuals of various other species, thus multiplying the number of species. This has been worked out by Dr. Shull, of this Station, for the common shepherd's purse, *Bursa*. The same thing is being worked out by Dr. Ezra Brainerd, of Middlebury, Vermont, in the violets. And the lady-bird bettles (coccinellids) that Mr. Roswell Hill Johnson has been working with since his connection with this Station prove the same thing to be true for a large group of insects. These results could hardly have been achieved, however, without a thorough knowledge of the laws of inheritance of characteristics, and this Station has sought since its inception to contribute to the determination of these laws. To this end experiments have been made on crossing poultry, canaries, cats, sheep, and goats, insects of several species, and many species of plants, and we have had associated with us Dr. Castle, of Harvard University, who is working on mice, rats, guinea-pigs, and rabbits. The general outcome of this work is the accumulation of a lot of pedigree data—much of it quantitative—the like of which exists, I venture to think, nowhere else in the world. These data have as yet been only partially worked up,* but in general they confirm the fundamental importance of Mendel's law; they support, in many cases, the theory of factors by the union of which alone visible qualities appear and they have led to a general theory of "dominance" in Mendelian inheritance according to which a quality present in a higher degree dominates over the lower degree or the entire absence of the quality.

* Carnegie Institution of Washington Publications Nos. 23, 24, 49, 52, 70, 81, 95.

In connection with Mrs. Davenport I have begun a series of studies into normal human inheritance. A paper on inheritance of human eye-color was published last autumn (Science, Nov. 1, 1907), in which it was shown that blue-eyed parents can have only blue-eyed children, but that if either parent has brown eyes the children may be also of that type. With these results the work of C. C. Hurst, of England, published this spring, is in full accord. In May we published in the American Naturalist results of our studies on the inheritance of the form of the hair, proving that two straight-haired parents have only straight-haired children, but that if either parent is curly-haired at least some of the children may be of that type also. The results of studies on hair-color—a very complex subject—are nearly ready for publication and show that the amount of black pigment in the children does not ordinarily exceed that of the darker parent. Much additional data is at hand and will be reduced as fast as possible. The practical importance of the proof of the application of the modernized Mendelian law of inheritance to man is that it enables us to predict the marriage matings that may be expected to yield a particular type of offspring. If we have hitherto made little progress in eugenics it is because there has been little precise knowledge as to the result of any mating. When such knowledge has been gained and formulated we may expect educated persons to take advantage of it.

Our generalization that the quality of a character tends to rise in the offspring to no higher a grade than in the parent helps account for the facts of the frequent injurious effects of continued inbreeding. If in both parents any organ stands at a low level it will stand at that level or lower in the children; if relatives, with the diminished grade, be again inbred the organ drops to a still lower grade or may in time disappear altogether. Of the injurious effects of inbreeding Dr. Shull has again brought evidence in the case of corn; there is evidence in poultry; even in the vinegar-flies (*Drosophila*) Dr. Lutz has clear evidence of degeneration of the wings; and in our human records we have cases of albinism, imperfect sense-organs, and low intelligence. In accordance with this generalization qualities tend to run downhill unless lifted by union with a quality of higher grade—here we see the advantage of outcrossing in strengthening the stream of germ-plasm.

DETAILED REPORTS ON SCIENTIFIC WORK.

HEREDITY.

Poultry.—In this work 59 pens were maintained. About 12,000 eggs were incubated and 3,546 chicks hatched. As a matter of some physiological interest may be given the weekly record of egg-laying, in 4-weekly periods, of the 350 to 320 hens that constituted our flock.

For 4-week period beginning—

Sept. 1	546	Jan. 19	863	June 7	650
" 29	309	Feb. 16	2,556	July 5	253
Oct. 27	190	Mar. 15	3,736	Aug. 2	223
Nov. 24	299	Apr. 12	4,261		
Dec. 22	284	May 10	3,082	Total	17,252

Noteworthy are the grand period of maximum egg-laying from the middle of March to the middle of May and the period of depression from July 1 to January 15. The fluctuations in the latter period are due chiefly to feeding, as a diet of meat after prolonged abstinence will quickly double, at almost any time, the egg-yield; but on the withdrawal of such stimulating food the egg-yield rapidly diminishes. Another factor contributing to the irregularity of the egg-yield is the removal for market during June and July of about half the laying hens, and the increase in the number of laying birds during January and February by the maturing of the young stock.

The entire laying plant was removed during December and January a distance of about a mile, to a farm on the plateau, where the conditions are much better for the health of the hens. Artificial incubation and brooding were carried on at the laboratory and its immediate vicinity. In addition to poultry some guinea-fowl were bred.

Finches.—Sixty pairs of breeding canaries were mated and 5 of other finches. A total of 329 birds hatched, but owing, probably, to inadequate heating facilities only about 100 birds were reared. This number includes 3 hybrids between gray and white Java sparrows, which show gray dominant. During the year our stock of canaries was increased by the importation of some of the more novel and at the same time expensive varieties. Owing, perhaps, to incomplete acclimatization these have bred poorly this season.

Sheep and Goats.—Eight sheep and 9 goats were born during the year; in both species white fleece is dominant over black, but not over red. As a pure white Angora goat was used as sire during the present season only white or white-and-red kids were born. The neck "wattles" are dominant over their absence. During the year we received from Dr. A. G. Bell, a black ram with 6 nipples, which will be used in place of our former ram to prevent too close inbreeding. No increase in the number of nipples beyond 6 has yet occurred.

Cats.—The limitations of room have caused this experiment to come to a partial standstill. It is planned to provide improved and enlarged quarters for it. Some 20 cats were born during the year.

Drosophila.—The study by Dr. F. E. Lutz of the inheritance of the abnormal venation of the fruit-fly has been continued through more than 40 generations. The results will be ready for publication shortly. The inheritance of the scalloped wing was also tested and the inheritance of dwarfness. If time permits this latter work will be continued and the effect of environment will be considered. However, special stress will be laid during the coming year upon the work with *Gryllus.*

Gryllus.—The inheritance work with this genus has been continued along the lines laid down four years ago. While Dr. Lutz has been chiefly concerned with the wing dimorphism, data have been secured concerning all of the important organs. About 2,000 pedigreed offspring have been obtained this season. In May Dr. Lutz made a short trip to Cuba and Mexico with a view to arranging transplantation experiments. About 500 offspring are now being reared from the living material brought back, and some material was also collected for the purpose of studying geographic variation. It is hoped that the living material secured on this trip will breed in the greenhouse here during the winter, when the native crickets are hibernating. Dr. Lutz plans next summer to pay especial attention to the effect of humidity upon the wing dimorphism.

EVOLUTION IN THE COCCINELLIDÆ.

This work, which has been continued by Mr. Roswell Hill Johnson, is now drawing to a close, owing to his impending departure from the Station. Reports on the results attained are being prepared. His major paper deals with determinate evolution in the color-pattern of lady-beetles. He has also written several papers of more general import, the outcome of reflections and observations on these insects.

BREEDING STRAINS OF PLANTS.

Dr. George H. Shull, although occupied during much of the year (from February 15 to May 30) with his study of Mr. Burbank's horticultural methods and results, has been able to continue most of the strains listed in last year's report. He concluded his work on *Bursa pastoris* and has presented an important paper on the subject for publication. This species shows its composite nature in a fashion as to make it hardly less interesting than the evening-primrose. On August 14 he started on a tour of the principal plant-breeding establishments of Europe.

In hybrid beans it has been demonstrated that a mottled seed-coat, which appears as a novelty in several crosses, becomes evident only when in the heterozygous state. Individuals which possess the mottling factor in the homozygous condition are indistinguishable from those which lack this factor altogether. The mottled character which appears as a novelty in these crosses can not be segregated as a permanent characteristic of a pure strain, but plants possessing this character, when self-fertilized, continue to give only 50 per cent of mottled offspring. They form in respect to mottling a mid-race. The peculiar behavior of the mottling in these beans has given rise to the ratio 18 : 18 : 6 : 6 : 16, which has not been reported hitherto. The fact that the pure-bred dominants with respect to mottling are not mottled, even when pigment is present, makes it impossible to determine at this time whether the mottled pattern was derived from the pigmented bean or the white one, though it was assumed at first that it came from the latter. Means are now at hand for the solution of this problem, but the necessity of leaving the cultures on August 14, before the beans had begun to bloom, has made it necessary to postpone this matter until another season. Two other cases of latency have also been demonstrated in these beans. Both the White Flageolet and the

Prolific Black Wax have allelomorphs for a dark yellowish-brown color, which can be demonstrated by appropriate breeding-tests, and Ne Plus Ultra, which is dark orange, carries light yellow as a latent character. The crosses of the latter variety lend support to the "presence and absence" hypothesis. In discussing these results, four different types of latency have been recognized, namely, (*a*) Latency due to separation, as when two allelomorphs which are jointly necessary to the production of a visible character do not occur together in the same soma. This condition is very frequent in the case of albinos. (*b*) Latency due to combination, in which the cooperation of two allelomorphs in some way destroys or prevents their characteristic manifestations, thus rendering the individual possessing both of the allelomorphs in question quite indistinguishable from individuals which possess neither of them. (*c*) Latency due to hypostasis, the very common case of complete invisibility of one characteristic in the presence of another, the latter characteristic not being perceptibly modified by the presence of the former. (*d*) Latency due to fluctuation, when characters which are normally present are temporarily suppressed through malnutrition or other similar causes. The first three of these types of latency is exemplified by the hybrid beans, and each results in the production of definite ratios which differ from the typical Mendelian ratios without in the least affecting the fundamental principle of segregation of "pure" gametes and their union according to the laws of chance.

Studies on the effects of cross- and self-fertilization in maize have given further evidence that an ordinary field of Indian corn consists of a series of more or less complex hybrids among numerous elementary species or biotypes, and that the apparently injurious effects of self-fertilization are due simply to the unfavorable comparison of pure strains with their hybrids, and of less complex hybrids with more complex ones. Self-fertilization sooner or later reduces any pedigree to the condition of a pure strain by eliminating its hybrid elements. According to this hypothesis, when the strain is once reduced to a pure state, no further deterioration should result from continued self-fertilization. All the evidences available at this time appear to support this proposition.

In the common large-flowered garden sunflower, or Russian sunflower, there are two elementary forms, one of which is practically unbranched, the other having several to many lateral branches, particularly on the upper portion of the central axis. When the unbranched type possesses a few branches, as it does occasionally, these are near the base of the central axis. In crosses between these two forms, the branched type is dominant over the unbranched, the heterozygotes being quite indistinguishable from their branched parent. Segregation is perfect, regardless of the fact that the branching habit is rather easily modified by environment. In crosses between the Russian sunflower and the semi-wild *Helianthus annuus* of the prairies, the behavior with respect to branching is quite anomalous, and it is expected that this may throw some light upon the phylogenetic relations of these two forms.

In *Lychnis alba* purple and white flowered individuals give typical Mendelian crosses, and several abnormalities or atypic conditions are found to be rather strongly though imperfectly inherited. A large number of crosses have been made this year in *Lychnis,* particularly for the purpose of attacking certain problems relative to the inheritance of sex.

In crosses between yellow and pale flowered forms of *Verbascum blattaria,* the yellow is dominant. In nearly every F_2 family the number of pale-flowered individuals has been in excess of expectation, and considerably so in one or two families. Further crosses have been made to determine whether this is merely a matter of random sampling or whether it is a normal condition, and if the latter, what may be its cause.

Many pedigreed families of the Shirley poppy have been studied, and the general hereditary relations of the various tints and color-patterns are more or less clearly discerned. While the range of color is great, the variation within this range is not continuous. There are relatively few color-types, and within each of these there is but slight variation. There are also some obvious irregularities involving latency and perhaps also coupling.

The scope and extent of Dr. Shull's pedigree work during the past season is concisely shown in the following table, arranged as in his previous reports:

Species.	No. of pedigreed families.	No. of individuals.	Species.	No. of pedigreed families.	No. of individuals.
Chrysanthemum leucanthemum	1	6	Oenothera lata	4	181
Digitalis sp.	2	261	Oenothera nanella	1	75
Gaillardia sp.	2	231	Oenothera rubrinervis	3	150
Helianthus annuus	39	1,988	Papaver rhœas	83	2,060
Lychnis alba	19	1,374	Pentstemon sp.	1	1
Lycopersicon lycopersicon	2	40	Phaseolus vulgaris	546	10,000(?)
Lycopersicon sosonopsis	3	60	Trifolium hybridum	4	200
Oenothera cruciata	4	82	Verbascum blattaria	12	1,200
Oenothera gigas	2	65	Verbena stricta	1	50
Oenothera lamarckiana	11	479	Viola arvensis	2	40
			Zea mays	38	6,500(?)
				780	25,043

Dr. J. Arthur Harris has had general oversight of the preceding cultures during Dr. Shull's absence, and he is in addition making a detailed study of variation, correlation, and heredity of quantitative characters in several varieties of beans. Some 20,000 individually labeled seeds were planted in selected habitats at the Station for Experimental Evolution, in southeastern Ohio, in western Kansas, and at the Missouri Botanical Garden. Also, smaller plantings were made of a number of species to determine their fitness for serious experimental work.

VARIATION AND CORRELATION IN FERAL PLANTS.

Dr. Harris has been making comparative biometric studies on species of *Cercis, Staphylea, Sanguinaria, Hibiscus, Agave,* and *Cassia.* Extensive collections are being made from several habitats and seasons, in order to test the influence of environmental and seasonal differences on variation and correlation constants, and it is hoped that some of the results will be ready for publication shortly. During the year about 200 tables of data and calculated constants have been prepared. Probably these habitat investigations will form the basis of transplantation investigations to be undertaken later.

CELL STUDIES IN HEREDITY.

These were continued by Miss Lutz, who reports as follows: The work upon the chromosomes of the somatic cells of the oenotheras in 1907, reported upon in Year Book No. 6, has been continued throughout the present year on a much more extensive scale.

The investigations of the preceding year having revealed the number of somatic chromosomes for *Oenothera gigas* to be approximately double that of any other form so far studied, the opportunity was at once suggested of securing valuable data upon the question of the behavior of chromosomes in inheritance by crossing *gigas* with a form having the smaller number. Only 3 offspring of *O. lata* female $\times$ *O. gigas* male were available for study the first summer, but these showed such remarkable combinations of chromosomal and vegetative characters that it was decided to repeat the cross upon a larger scale the following season. Accordingly seeds were sown and 77 seedlings obtained, all of which were transplanted to the experimental gardens in May. Representative types were photographed in early rosette and late rosette and flowering stages—107 exposures in all—about one-fourth of which were of plants connected with work upon other problems.

Fixations were made of root-tips of 50 of the 77 hybrids in the early rosette stages, and 35 of these have been carefully studied and chromosomes counted. In connection with the microscopical investigations, the vegetative characters of the hybrids were closely observed daily from time of germation to close of flowering season, and continuously observed from 5 a. m. until $7^h\ 30^m$ p. m. daily from July 1 to September 1. The results of these investigations will be published shortly.

Owing to the scarcity of pollen produced by these hybrids, seeds were obtained only after the most persistent efforts at artificial self-pollination for six weeks following the opening of the first flower. Although the seeds have not been harvested, it is believed that by this means guarded self-pollinations were secured of the representative types of hybrids, and in a number of cases reciprocal crosses with *gigas.* These second-generation offspring will form the chief subject of study for 1909.

In addition to the above, 50 individuals of pure-bred *gigas* grown directly from de Vries seed have been described, types photographed, and root-tip fixations made for the study of chromosome variation. All forms (41) found among the following of Dr. Shull's cultures differing from the parental type were similarly treated.

Oenothera lamarckiana.	Oenothera rubrinervis.
gigas.	cruciata.
nanella.	lata ♀ × O. lamarckiana ♂.

CONSTRUCTION.

A shed of brick and concrete connecting with the stable and having an outside length of 50 meters was completed. This gives much-needed space for cows, for storing wagons, brooders, pipe, and other bulky material, and also a room for agricultural implements. A concrete pit for manure was also constructed.

The poultry plant was moved to a situation on the hill. Some two months were employed in this work and clearing the land and setting up the necessary fences. A small portable house was purchased and set in the midst of the plant for the temporary use of the poultryman. It is proposed to use this, henceforth, for experimental work.

A 5-inch well was driven at a desirable point on the land of the Biological Laboratory by permission of the Brooklyn Institute, in consideration of supplying its laboratory with part of the water during two months of the year. A flow of 90 gallons per minute was obtained at a depth of 76 feet, at a cost of $305. This supplies a ram which pumps water over the entire plant, the pipe line being about 1,300 feet. Thus at a total cost for well, pipe, and ram of $500, about $75 per year for electric power is saved and better service given. The cost of repairs of the electric pump had become burdensome, and it is believed with the ram a further saving will be made in repairs.

Three weeks of the time of the constructor was spent in replacing the decaying basement floor of the residence with concrete. The construction of a shelter for the launch has been begun.

EQUIPMENT.

Among the larger items of equipment were additional cabinets for storing microscopical slides and for insects, breeding-cages for canary birds, and shelves for the library.

MAINTENANCE.

The greenhouse, poultry houses and some outside woodwork of the main building were painted. One of the cesspools was connected with an underground sewerage-disposal system of the Waring type. To take care of the occasional violent rains that were eroding the soil of our garden and destroying the roads, a system of catch-basins and distributing-pipes was laid, so that now this water is largely carried to the sea underground.