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# BIOLOGY, EXPERIMENTAL.

## DEPARTMENT OF EXPERIMENTAL EVOLUTION, COLD SPRING HARBOR, NEW YORK.*

By Charles B. Davenport, Director.

Two years of work at the station have been accomplished and that for the immediate future has been planned. It may now be advantageous to consider in general fashion what are the present aims of work in experimental evolution.

Man is philosophic. He looks for general principles and on the whole he acts on general principles. So his general theory of the world is of importance. It makes a real difference in his conduct whether he regards the world events as cataclysmic or as ever continuous and lawful. Consequently the work of Lyell in establishing the law of continuity in geology and the work of Darwin in establishing that law in organisms have revolutionized not only human thought but human action. This law of continuity, moreover, is necessarily applicable to human evolution. Neither physically nor psychologically is there a sharp break in the animal series where it culminates in man. Consequently the discovery of the laws of organic evolution is, at the same time, a study of human evolution. Since when we know the law we may control the process, the principles of evolution will show the way to an improvement of the human race.

A knowledge of the principles of evolution is advantageous in still another way. It shows how organisms may be best modified to meet our requirements of beauty, food, materials, and power. The carnation can be made not only crimson, but white, yellow, and blue; it can be made as large as a chrysanthemum or dwarfed. So the bantam fowl may be made of a red color, or black, or white; with a ruff or without; with a long tail or with no tail. Likewise the yield of wheat per acre may be doubled and the northern limit of wheat cultivation pushed poleward many miles each year. The egg yield of the hen may be raised from 150 to over 200 per year. The strength of cotton fiber may be improved and its length increased. The hardiness of fruits may be changed so that subtropical plants bear in temperate climates. The strength of the horse may be increased as that of the Percheron exceeds that of the Norwegian pony. In fact, by using the already known principles of evolution great practical advances have been made in the past. We are consequently justified in expecting that an extension of evolutionary principles will result in further advances in the future.

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While there can be no doubt of the practical importance of applying the known laws of evolution it would seem to be unwise for this station to devote its time to such work. There is no lack of practical workers. There are 56 State agricultural experiment stations where they may be found. Also the Federal Department of Agriculture maintains many practical breeders in the bureaus of Animal Industry and Plant Industry. Congress appropriates about $25,000 a year for the experimental gardens of the Department of Agriculture and $20,000 for the Arlington Experimental Farm. Finally there are thousands of plant and animal breeders in this country who are applying with more or less intelligence the established principles of the improvement of races. But all of these experiment stations and the individual breeders are held closely to work yielding immediate practical results. They apply known laws; they have no time or facilities for investigating in a calm and extended way those subjects that shall best reveal new laws. The work even of our experiment stations stands at the plane where it has been put by the workers in pure science. Their work in plant hybridization depends on the discovery of the sexual nature of the floral organs made over a century ago by the botanist Kölreuter and on the method and principles of crossing investigated by the plant physiologist Knight. Mendel, working in his cloister garden, was not concerned with making plants more beautiful or useful. But he established a new principle which is of inestimable value to breeders. He discovered the principle forty years ago; but it was overlooked by the practical breeder, and through thirty-five years of practical work was never rediscovered by the thousands of breeders or the scores of experiment stations. Now that attention has been directed to it it is being constantly used by practical men to get useful results. Had Mendel spent his time in improving some plant he would doubtless have succeeded, but he would have failed to discover his law. Mendel failed to accomplish the commonplace, but succeeded in discovering the new guiding principle.

So in the case of this Department. We could easily produce new and valuable races. We could do all these things with certainty by the application of well-known and constantly employed principles. But we prefer to risk certain results for the uncertainty of attaining new principles. A new theory may well be of much greater value than any improved race of plants or animals. It may affect the whole live-stock business whose cash value in America is very great. This commercial aspect is, however, rarely to be thought of. We propose to leave the question of application to others, bending our whole energy to our main work—the discovery of general principles or laws.

Our first two summers were largely spent in preparation for our work. Methods, many of them new, had to be perfected. Results are now com-

ing, but they must be tested repeatedly and many of them followed up for several years before they are reported upon fully. It may be well to consider in a general way the subjects we are investigating.

*Inheritance of Characteristics.*—One kind of organism differs from another, and the newly evolved species differs from its progenitor, in one or more characteristics. We have not reached the point where new characteristics can be produced at will, but we can learn the laws of inheritance of characteristics, and such knowledge will enable us to predict how a new variation will behave when crossed with the parental species and to classify variations according to their origin and behavior in heredity.

We find that when two varieties that differ in some characteristic are crossed it frequently happens that one only of the two forms will reappear in the offspring (viz, the *dominant* characteristic, of Mendel), and it will be little modified by the presence, in that offspring, of the germ of the opposite characteristic. This is in accordance with the theory that most characteristics are, or may be resolved into, elementary units. Similarly, when a variety that has some new feature not possessed by the ancestor is crossed with that ancestor the offspring usually have the character fully developed (dominant). If these offspring are crossed together the character is absent in a small proportion only, on the average one-quarter, of their offspring. The consequence of this law is that a newly evolved characteristic is not at once swamped by intercrossing, as has often been assumed, but may even spread at the expense of the parental type. Thus the new species is nurtured in its infancy.

*Unit Characteristics.*—The fact that in crossing varieties their dissimilar characters do not blend is important, since it supports the theory that such characters first appear as they now are, fully formed. It indicates that since evolution has advanced by the addition of new characteristics it had advanced by steps or jumps. A new species has not *gradually* arisen from an old one, but suddenly, by *mutation*. Our breeding experience, consequently, supports, in part, the mutation theory of de Vries. The practical consequence of this theory is that it is more important to look for sports or new combinations of characteristics than to work by selection.

On the other hand, it is becoming clear that unit characters are not immutable; for, in hybridizing, the dominant form often shows traces of its antagonist; and if the dominant form is repeatedly infected by continued hybridization it may become much changed.

*Rôle of Selection.*—Breeders attribute their success in improving races chiefly to the selection, for breeding stock, of the best-appearing individuals. Recently, a school has arisen which maintains that, within narrow limits, selection is impotent. Our results are giving us an exact insight into the truth of the matter and justify to a certain extent the breeder's operations while offering a new explanation for them.

*Origin of New Characteristics.*—This is the most important work in hand. If by any means new, inheritable characteristics can be brought out, then new races can be created. If characteristics can be induced of a desired sort, then evolution can be directed at will. Some of the new characteristics that we get are of the order of mutations and can not, at present, be predicted nor controlled. Others result from hybridization. Others still are induced by subjecting the parent to new conditions. As is well known, in the abnormal environment new characteristics arise; we are studying the method of inheritance of such new characteristics. There is reason for thinking that various agents may permanently modify the germ plasm; at least we are testing the matter.

*Identity of Evolutionary Processes in Plants and Animals.*—From its inception we have studied equally plants and animals in the conviction that evolutionary processes are similar in all organisms. Our experience so far has justified our conviction. It has been stimulating, in our weekly conferences, to note the parallelism of the results reported by those working with plants, insects, birds, and mammals.

## WORK OF DEPARTMENTS.

The work with plants has hitherto been conducted solely by Dr. George H. Shull. Owing to his temporary assignment to study the work of Mr. Luther Burbank, Dr. E. N. Transeau, formerly of Alma College, Michigan, and earlier of the University of Michigan and of the University of Chicago, has been appointed to the resident staff. Dr. Transeau will continue many of the experiments started by Dr. Shull and will undertake in addition the study of adaptation in plants. For this work a set of instruments capable of analyzing the environmental factors will be required. The expansion of the botanical work has made it necessary to rent a parcel of land situated about a mile distant from the Station.

The investigations upon insects have made more rapid progress as the technical difficulties of breeding them have been overcome. They have proved excellent material for experiments on the influence of changed conditions of life. Valuable results have been gained on the inheritance of different types of variations. As the experiments have far outgrown the space available in the laboratory, a new vivarium is being built for them. Since the addition of an inexpensive helper has increased by several fold the scientific output of other departments, it is proposed to employ, next season, a vivarium boy to assist in the mechanical part of the insect work.

The work with domesticated races was five times as extensive this year as last, owing to the employment of a poultryman and the construction of fifty new breeding pens. Sixty distinct sets of experiments were made with poultry. Approximately 10,000 eggs were recorded, with few exceptions from exactly known mother and father. The number of chicks

hatched was 2,985; and more or less complete records were obtained also from about 3,000 chicks that developed but did not hatch. All of these have been described and the records tabulated to be used for immediate publication of results or to be held awaiting further information. The canary birds and finches have done well, 92 offspring having been reared. The births of the year include 6 goats, 6 sheep, and 20 cats. An additional step has been made toward the attainment of the particular combination in one cat of the characteristics named in my last report. Work with pigeons has been continued.

The cytological investigations have continued under the charge of Miss Lutz. Early in the year she was relieved of the work of secretary, which threatened to absorb her entire time, so that now she devotes herself wholly to investigation. She has gained results bearing on the infertility in buckwheat when like flowers are bred together.

## COOPERATION WITH OTHER INVESTIGATORS.

The number of investigators working experimentally on topics in evolution continues to grow. We have been visited by workers from different parts of the country who have wished to inspect our work or consult on particular points and we have profited by visits to consult with and examine the work of others.

Our facilities have been extended to the following investigators who are not on the staff of the Station:

Dr. N. M. Stevens, of Bryn Mawr College, worked during the summer upon the germ-cells of Coleoptera and continued her experimental work on breeding plant-lice aphids. She was accompanied by Miss Alice M. Boring, of Bryn Mawr College, who worked on the germ-cells of hemipterous insects belonging to the family Membracidæ.

Prof. W. J. Moenkhaus, of Indiana University, continued his work on the breeding of flies to determine if the sex ratio can be modified by selective breeding and if there is a reduction in fertility and vigor in successive generations as a result of close in-breeding.

Prof. H. E. Crampton, of Columbia University, continued at the Biological Laboratory and the Station his work on selective breeding of the large Saturnid moths.

During the summer several of the investigators at the Biological Laboratory made use of the library and other facilities of the Station.

The following have been added to our correspondents:

Dr. Francis Galton, F. R. S., the well-known student of human heredity, to whom is due the introduction into biology of statistical methods.

Dr. Alfred Giard, professor at the University of Paris and director of the Laboratoire d'évolution des êtres organisées. To Professor Giard is due the conception in recent times of the establishment of an "Institut

PLATE 4

VIEW ACROSS COLD SPRING VALLEY LOOKING SOUTHEASTWARD, SHOWING PART OF THE GROUNDS OF THE STATION FOR EXPERIMENTAL EVOLUTION.

Main building at the extreme right, potting house and propagating house in front, and vivarium, under construction, in front of and to left of latter. To the left (north) of the main building is seen part of the east experimental garden. Near the extreme left is the brooder house, from which radiate eight poultry runs, seen in the middle foreground.

transformiste," an idea taken up in turn by the late George J. Romanes in England, and which has fruited in the present Station for Experimental Evolution.

Geheimrath Dr. August Weismann, professor of zoology at Freiburg. His well-known theories of evolution are guiding experimental investigations not only in his own laboratory but wherever such work is done.

Dr. Vernon L. Kellogg, professor of entomology at Stanford University, who has made extensive studies on variability in insects and has instigated a number of important investigations on inheritance in this group.

## WORK OF SUBSIDIARY DEPARTMENTS.

The library remains an important adjunct of our work. The current journals are reviewed frequently and many of the ideas gleaned from them have been the starting points of new investigations or improved methods. The total number of bound volumes and pamphlets is 981, an increase during the year of 406. The library has been kept in fair shape by the attention during a few minutes of each day of one of the staff, supplemented by certain assistance paid for by the hour.

## CARE AND DEVELOPMENT OF THE PLANT.

The main building proves to be highly satisfactory for our work. A smart blaze in the basement, due to the carelessness of a workman, occurred in the middle of the night, but was confined to the room in which it started by the fire-resisting nature of the construction. The small size of the building necessitates that it be used in the future almost exclusively for making, storing, and working over the records (including photographs) for the library and for the cytological and administration departments. The carpenter shop will be removed to a commodious building which we obtained at the cost of removal to its present site on our grounds. The plant cultures were transferred during the early winter to the new propagating house, which has proved of the greatest assistance in enabling us to hasten the succession of plant generations. The insect experiments at present occupy two large rooms in the main building. These experiments will be transferred to the vivarium, which is now being roofed in and will be ready for use in the spring. One of the rooms thus set free will be partitioned off into investigators' rooms. As soon as the bird house can be built the canaries now in the main building will be moved from it. Additional greenhouse room is demanded and will be provided as soon as feasible. The brooder-house was equipped in the spring with a heating plant and has been of the greatest assistance in rearing the young chicks. Forty colony houses for laying stock were erected on a lot near the Station grounds. They were made portable, so

as to be removable to another field if eventually acquired. An accessory water supply was equipped and has been used during the season for irrigation of the greenhouse and gardens.

As the work develops it becomes clearer that additional land will be needed in the near future.

The Station has this year as hitherto been the recipient of many gifts of interesting living plants and animals to be used for breeding and of use of land and materials to facilitate our investigations.

## REPORT OF DR. GEORGE H. SHULL.

The studies on variation and heredity in plants have been continued along the lines indicated in my report for last year. The addition to our garden equipment of a greenhouse and an efficient gardener, both of which were available December 1, 1905, have increased by several fold the amount and value of the work accomplished during the year.

As compared with last year, there have been few failures in getting seeds to germinate, and the number of pedigrees which have come to fruition since October 1, 1905, is 291, belonging to the following 46 species. The number preceding each specific name in this list is the number of distinct pedigreed families studied in that species and the number following the name is the total number of individuals considered.

| No. of families. | | Individuals. |
|---|---|---|
| 3. | Commelina nudiflora L. | 563 |
| 5. | Lychnis alba Mill. | 1,521 |
| 2. | Ranunculus sp. | 97 |
| 2. | Chelidonium majus L. | 354 |
| 2. | Eschscholtzia maritima Hort. | 25 |
| 3. | Eschscholtzia rosea Hort. | 81 |
| 163. | Bursa bursa-pastoris (L.) Britton | 17,532 |
| 1. | Bursa heegeri (Solms) | 23 |
| 2. | Fragaria sp. | 50 |
| 1. | Lathyrus maritimus (L.) Bigel. | 13 |
| 1. | Polygala polygama Walt. | 3 |
| 3. | Viola arvensis L. | 47 |
| 1. | Viola papilionacea Pursh. | 12 |
| 4. | Viola spp. | 29 |
| 1. | Oenothera biennis L. | 83 |
| 6. | Oenothera cruciata Nutt. | 87 |
| 3. | Oenothera gigas De Vries. | 439 |
| 16. | Oenothera lamarckiana Ser. | 2,172 |
| 2. | Oenothera lata De Vries. | 355 |
| 2. | Oenothera nanella De Vries. | 244 |
| 4. | Oenothera rubrinervis De Vries | 1,038 |
| 1. | Oenothera sp. | 11 |
| 1. | Clarkia pulchella Pursh. | 81 |
| 1. | Gentiana crinita Froel. | 2 |
| 1. | Solanum aff. lanceolatum. | 6 |
| 3. | Solanum aff. nigrum L. | 162 |
| 1. | Lycopersicon lycopersicon (L.) Karst | 25 |
| 1. | Lycopersicon solanopsis White | 25 |
| 1. | Lycopersicon sp. | 25 |
| 1. | Verbascum thapsus L. | 37 |
| 1. | Mimulus ringens L. | 367 |
| 1. | Digitalis sp. | 161 |
| 4. | Plantago lanceolata L. | 266 |
| 2. | Plantago major L. | 180 |
| 1. | Dipsacus sylvestris Huds. | 114 |
| 15. | Ambrosia artemisiæfolia L. | 902 |
| 1. | Chrysopsis argentea Small. | 9 |
| 1. | Chrysopsis graminifolia | 52 |
| 2. | Erigeron ramosus (Walt) B. S. P. | 180 |
| 7. | Rudbeckia hirta L. | 382 |
| 13. | Helianthus annuus L. | 929 |
| 1. | Helianthus debilis | 93 |
| 1. | Helianthus petiolaris | 5 |
| 1. | Gaillardia pulchella pieta Gray. | 115 |
| 2. | Erechtites hieracifolia (L.) Raf. | 180 |

In the continuation of my investigations into the fluctuations of *Oenothera lamarckiana* and those of its mutants, about 18,000 measurements have been made on the buds from fifteen different pedigreed families of Oenothera, representing particularly different treatment as regards

cross- and self-fertilization. In the cross-fertilized series care is being taken to introduce newly arisen mutants wherever possible.

The second generation of hybrid beans is being harvested, and enough have been examined to show that the latency of a mottled color pattern and a pigment darkener in the white variety used in these crosses was correctly assumed. This allowed the prediction that in the second generation between white and yellow beans, for instance, there would be found some individuals which would produce only plain black beans, and some only yellow mottled ones, though neither form probably occurred in the recent ancestry on either side of the pedigree. The prediction has been realized, but whether the proportions will approximate those expected can be seen only when the investigation of the several thousand hybrid individuals has been completed. In addition to these expected results there are a few individuals which belong to none of the predicted classes, and these may indicate the presence of other latent characters not detected in the first generation because they were recessive. Owing to the lack of facilities for guarding against cross-fertilization, this point can not be satisfactorily determined.

Besides these hybrid beans, the following hybrids have been under observation during the year: *Lychnis alba* Mill. (purple × white and reciprocal), *Eschscholtzia rosea* × *maritima* Hort., *Bursa bursa-pastoris* (L.) Britton (several elementary species), *Bursa bursa-pastoris* × *heegeri* and reciprocal, *Verbascum blattaria* L. (white × yellow), *Verbascum thapsus* × *blattaria*, *Helianthus annuus* L. ("Russian" × Western native). With exception of the last, the results of these hybridizations generally agree with what might be expected upon the basis of certain theoretical considerations. Arrangements have been made to continue these hybrid combinations and in addition an apparently successful attempt has been made to secure hybrid seeds of *Lycopersicon lycopersicon* (L.) Karst and *L. solanopsis* White.

From May 15 until July 15 I was absent from the Station for the purpose of studying the valuable horticultural work of Mr. Luther Burbank. Notwithstanding the devotion of those left in charge of the cultures during this time, several of them suffered irreparable injury. The most unfortunate of these involved the "pure line" beans, and as I am likely to be absent for considerable intervals during the next several years, it seems best to abandon this experiment until such time as satisfactory conditions for control may be attainable.

Most of the specimens collected during 1905 for the herbarium have been mounted. These are distributed as follows: The flora of Cold Spring Harbor, Long Island, 480 specimens; pedigreed plants, 452 specimens; seedling and juvenile forms, 12 specimens; abnormalities, 22 specimens; total, 966 specimens.

## REPORT OF MR. F. E. LUTZ.

The work outlined in the last report has been conducted on as large a scale as circumstances permitted. The principal insects used have been *Hyphantria cunea* (fall webworm), *Gryllus* sp. (cricket), and *Crioceria asparagii* (asparagus beetles). As in former years, trials have been made of other species to determine their fitness for the work in hand, especially their adaptability to laboratory conditions. In arranging these conditions the aim has been to devise schemes which will, as nearly as possible, make the pedigree insects take care of themselves.

The chief point in the work with *Hyphantria cunea* was originally to test the inheritance of the dichromism of the larvæ which is so generally figured. The two forms, however, were not found distinct. The facts of the case seem to be that the larvæ reach their full pigmentation very slowly after each molt, and the presence of a large number of newly molted, partly pigmented larvæ in a nest containing also fully pigmented individuals has given rise to the notion of light and dark forms. Only one individual, out of several hundred that were watched, pupated before the full pigmentation after the last larval molt was reached. This was probably a pathological case. It died as a pupa. Individuals may be found, however, which are normally light throughout larval life. This phase of the experiment has not been abandoned. Meanwhile attention is being paid to the color variations of the adult which are considered by some to constitute differences of specific rank.

The biometric studies of Gryllus have been continued. It is hoped that they may be valuable in themselves, but more so as a basis for experimental work on the inheritance of fluctuating variants, provided the technique of breeding Gryllus can be mastered. The pedigree strain was all but lost this season through ignorance of the fact that the overwintering eggs almost require freezing for their proper development. No time was gained by "forcing" the hatching and much material was lost. Those individuals which did mature, of the lot hatched in January, matured only several days earlier than their cousins which had passed the egg state out of doors and hatched in June. Selection and different methods of forcing will, nevertheless, be tried, both for their theoretical interest and the practical importance of getting a rapidly breeding strain; but the majority of the eggs will be kept this winter under perfectly normal conditions lest the strain developed during the past several summers be entirely lost. The above remarks apply to the native Gryllus. *Gryllus domesticus* has also been experimented with and has multiplied very satisfactorily under severe laboratory conditions. Pedigree cultures have been started. Crosses between *Gryllus domesticus* and our native crickets proved sterile, as expected.

The main work of the summer months has been with *Crioceris asparagii*. They hibernate as adults and become active at Cold Spring Harbor

NEAR VIEW OF PART OF THE WEST EXPERIMENTAL GARDEN, WITH PROPAGATING HOUSE IN THE BACKGROUND.

VIEW OF "NORTH LOT" WITH ITS 62 POULTRY RUNS AND TWO SHEEP AND GOAT PASTURES.

about the middle of May. The grandchildren of these hibernating adults mature in late August and early September and then hibernate, although a few lay eggs which give rise to a weak additional generation. Without much doubt, then, a three-generation-a-year strain can be developed. The beetles are fairly easy to rear. The chief difficulty has been the danger of introducing wild eggs or larvæ with the food. It is planned to grow the food next summer under glass and also inside of a large netting tent in the garden. A study of the inheritance of the 3-brooded *vs.* the 2-brooded condition may prove interesting; also the inheritance of various physiological characters. The main objects of the experiment, however, are to test the inheritance of the color pattern and to attempt to find out the cause of the variation which ranges from light spots on a dark ground to dark spots on light ground. The range already worked with is shown in the accompanying figures.


Pattern *a* acts as a Mendelian dominant to patterns *c*, *d*, and *e*. A special study of the variable recessive group and an analysis of pattern *b* will be attempted next season. The lighter forms are southern. This fact would point to a relation between temperature and color pattern. A little work was done along this line this summer and more will probably be done next. The possibility of changing at will definitely inherited color patterns by slightly altering temperature conditions is worth investigating.

During the winter certain biometric work will be carried on; also a study of the color pattern of *Crioceris asparagii* from morphological and phylogenetic viewpoints. Material for these investigations is being procured.

## REPORT OF MISS ANNE M. LUTZ.

In order to repeat under more favorable conditions the experiments undertaken last year with the buckwheat (*Fagopyrum fagopyrum*), a new lot of 52 plants was grown in the greenhouse, blossoming in April and May. It was possible here to guard securely against pollination by insects and to be certain of results. This first lot produced such an excess of abnormal blossoms that it was considered unreliable material for preservation and was abandoned; the second potting of 110 plants came to bloom in June. The primary object was to fix material for histological study which would throw light upon the sterility of long-

styled plants to pollen from long-styled, and of short-styled to short-styled. Before proceeding, however, it was thought advisable to ascertain whether this sterility was an infallible rule. Previous to the opening of the first blossom, all plants were securely bagged against stray insects or flying pollen, and in every case possible blossoms were castrated before anthers opened, with the exception of such as were to be used for pollinating purposes.

In this manner 22 long-styled plants were operated upon, pollinated in each case with its own or, in a few cases, with pollen from another long-styled plant. Of this number (ranging from 1 to 30 blossoms each), 12 plants set seed, varying in number from 1 to 5 each and in degrees of maturity to which the seed attained. In all 218 long-styled blossoms were self-pollinated, and 21 of these produced seed; 17 short-styled plants were similarly operated upon, and 7 of these set seed in numbers ranging from 1 to 13. Of the 73 short-styled blossoms self-pollinated, 12 came to seed. All seeds so produced were planted in sterilized soil, and, with the exception of a small percentage which sprouted before planting, all grew. The experiment will be repeated on a much larger scale this autumn in order to have larger numbers from which to obtain percentages of successful self-pollinations; to obtain seed of self-pollinated material to plant for study of inheritance; to experiment with possible parthenogenetic development, and, primarily, to obtain material for the study of the histological problems in connection with these experiments.

The attempt to hybridize the two species of *Gastroidea cyanea* and *polygoni* reported upon last year was repeated this spring. No offspring were produced, although hundreds of supposed hybrid eggs were obtained which developed quite normally for about three-fourths of the incubation period. Upon examination of eggs of virgin females, however, they were found to have developed parthenogenetically in the same manner, a number showing eyes, body segments, and appendages quite distinctly. Material has been fixed for the cytological problems in connection with this experiment.

A study of the cytological phenomena to be observed in connection with the sterility of certain selected insects has not yet progressed sufficiently to report upon.

## REPORT OF MR. ROSWELL H. JOHNSON.

The past year has shown that it is possible to provide lady-beetles with their food (plant-lice) and to breed them the year around. The necessary experience has been acquired concerning the best species of plant-lice to raise indoors and in the garden, and the hosts, seasons, and availability of those found wild. The death rate of the lady-beetles in confinement has been rather high, the progeny were sometimes sterile, and egg-laying has been interrupted at times. These adverse conditions will be some-

what mitigated in the future by the experience which has been gained and the more favorable temperature and arrangement in the new vivarium. Although the difficulties are such that it is generally necessary to start several pairs to rear progeny to maturity from one, the especial advantages of this material as shown in the last report have led to satisfactory results.

In addition to lady-beetles, I have undertaken similar work in another section of the Coccinellidæ, viz, the squash-beetles. Although less favorable from the fact that there are but three species in the United States, the ease with which large series are raised and the variation of its color pattern make it desirable for some lines of work.

In order to ascertain if the laboratory conditions would in themselves produce modifications, pedigrees were started from normal specimens of our local species of lady-beetles. With one exception, to be pursued further, there has been no change.

Normal specimens of other species from distant localities have been bred, in one case for several generations. No modification has resulted. *Adalia frigida* var. *ophthalmica,* from Springfield, Mass., produced some progeny of the varieties *disjuncta, ornatella,* and *annectans,* but these were probably predetermined.

Attempts have been made to modify most of the species available by increased dryness, moisture, heat, and cold. In contrast to the usual negative results is the effect of cold applied intermittently to *Hippodamia convergens.* The effect is an increase of the black markings along definite lines, particular spots being prolonged in definite directions in a definite order. Heat was effective only in the case of the squash-beetle, in which the pattern of the wing-cover remains normal; but the black markings of the thorax are all reduced, producing the conditions found in specimens from Texas.

Hybrid pedigrees have been started in the following cases: *Hippodamia convergens* × *H. c.* var. *ambigua;** *Hippodamia convergens* × *H. c.* var. *extensa;** *Hippodamia convergens* × *H. c.* var. *juncta;** *Adalia frigida* var. *ophthalmica** × *A. f.* var. *disjuncta;** *Coccinella novemnotata* × *C. n.* var. *confluens;* and between various unnamed forms of *Epilachna borealis* and *Hippodamia convergens.* In general it may be said that the inheritance is alternative in some cases, and in other cases *some* of the progeny are intermediate. A Mendelian segregation is found in subsequent generations in some cases, but so far these have shown some individuals with the parental characteristics modified.

The following closely allied species and others less allied were intersterile: *Hippodamia convergens* × *H. glacialis; Coccinella californica* × *C. monticola.*

* Considered species by Casey.

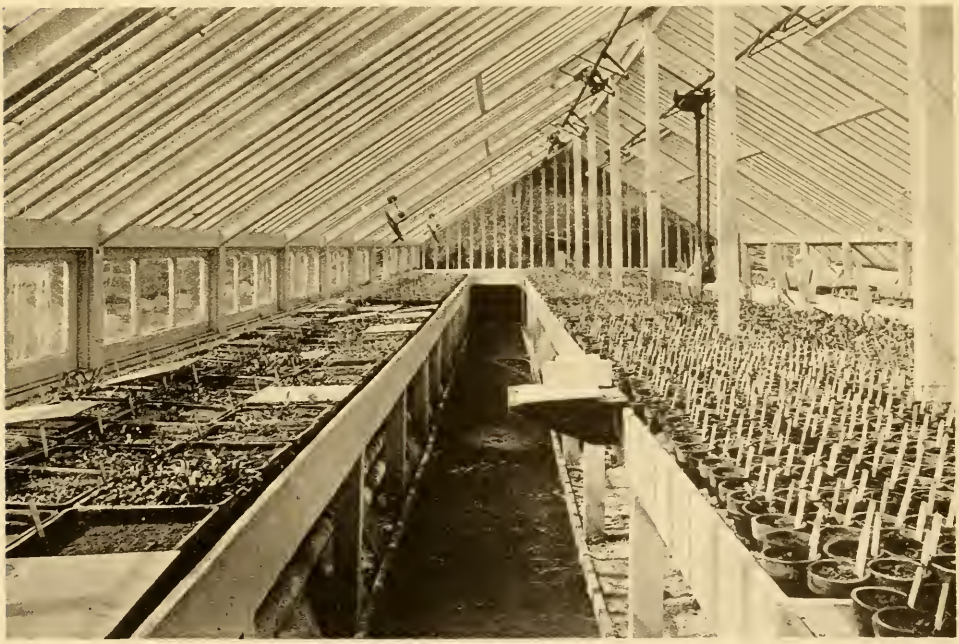
When time was available from the breeding work, the variation and geographical distribution of the genera used were investigated and my own collection much enlarged. The collections in New York, Philadelphia, and Washington were studied. A lot of 15,415 Hippodamiæ from the top of Kamiack Butte, Washington, was classified into categories and the intermediates arranged. The distances between spots, the thickness of the connections between spots when joined, and correlations of a lot of 334 Hippodamiæ from Fairfield, Washington, were studied statistically. These results, which were to have been published this past spring, I have decided to publish later with the experimental work. The lady-beetles when disturbed exude from some joints of the legs a fluid tasting like aloes. That this is really distasteful to birds I have found by experiment. The spots upon the lady-beetles have been supposed to be association marks by which the birds may avoid lady-beetles and the beetles thus profit. But if this were true, variations from the pattern in the directions of loss or fusion would be eliminated. Yet in most parts of the United States the spotted *Hippodamia convergens* occurs along with some of its forms or closely related species which show fusion of spots, and in parts of California and Oregon with a form that is spotless. In California, where the spotted and spotless forms are together, a number of mated pairs which I collected showed no evidence of preferential or assortative mating. It would seem, therefore, that the evolution of the color-pattern in these beetles is not the result of selection, but that here we deal with evolution resulting from progressive variation or from mutation associated with dominance and imperfect segregation. The fact that *Coccinella transverso-guttata, C. trifasciata,* and *Hippodamia convergens* all have their spotless forms in the same locality would make it appear that the origin of the new forms is the result of direct alteration of the germ-plasm by the environment in these cases. These beetles therefore seem to be in the very condition which most needs investigation.

An incidental result of my hunt for aphids has been the discovery of some on plants which do not seem to be recorded as hosts. This with information as to the preferences shown by some lady-beetles for some aphids and distaste for others and as to the parasites of lady-beetles may be of use to economic entomologists and will be published separately where accessible to them.

The following statistics give some idea of the extent of work done:

| | |
|---|---|
| Controlled matings | 205 |
| Of these, fertile eggs obtained from | 22 |
| Number of females isolated (from the field) | 74 |
| Fertile eggs obtained from | 49 |
| Progeny reared successfully | 498 |
| Pupæ brought in from field for modification experiments and emerged. | 74 |
| Pupæ collected in field for observation, emerged | 117 |
| Larvæ now developing | 73 |

INTERIOR VIEW IN MAIN BUILDING, SHOWING ROOM DEVOTED TO BREEDING CANARIES AND OTHER CAGE BIRDS. THERE ARE ABOUT 175 BIRDS IN THE ROOM.



INTERIOR OF PROPAGATING HOUSE, SHOWING PEDIGREED CULTURES OF PLANTS.

## REPORT OF DR. E. N. TRANSEAU.

Since coming to the Station in July most of my time has been spent in the study of the local plant societies. Especial attention has been given to those species which occur in more than one habitat, as they will probably furnish the material for future experimentation. Herbarium and alcoholic specimens of these plants have been collected for a further study of their structural variations. It is hoped that this work will point the way to field experiments on habitat modifications and selection.

On the other hand, several species are being cultivated in order to determine the range of their variability in a single habitat. When the habitat experiments are begun, it is hoped that they may be conducted with pedigreed seeds of plants whose variation in a single habitat is known.

In order to differentiate the effects of the various soil and meteorological factors, measurements by means of recording instruments should be made throughout the growing season. When the habitat characteristics and their united effects on plants are known, control experiments in the plant-house will aid in the separation of the individual factors.

## REPORT OF DR. W. J. MOENKHAUS.

During the past two years my work has been principally on the sex ratio in Drosophila, with especial reference to its control by selection. Data on over 10,000 individuals have been obtained; most of this is pedigreed. I consider the results sufficiently definite to warrant publication and they are about ready for the press.

## REPORT OF DR. N. M. STEVENS.

My work at Cold Spring Harbor was a study of the germ-cells of Coleoptera, with reference to the problem of sex determination; also some observations on aphids with reference to correlation of color with sex. I also began studying the banana-fly in connection with the same problem—sex determination.

Miss Boring, who was with me for six weeks, was making a comparative study of the germ-cells of several families of the Hemiptera-Homoptera, especially the Membracidæ, Fulgoridæ, and Jassidæ.