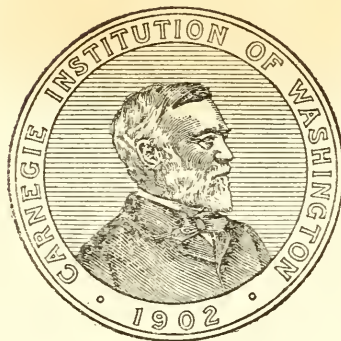


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DEPARTMENT OF EXPERIMENTAL EVOLUTION.*

C. B. DAVENPORT, DIRECTOR.

The work of the Station for Experimental Evolution has during 1919 emerged from its war status of comparative quiescence in its strict work to one of renewed activity. Many of the staff who have returned from army service are doing so with keener zest for the work that they regretfully laid aside and a resolution to bring to fruition many matters that had been long developing. On the other hand, the expense and waste of war still have their effect, and will for years to come, upon the cost of carrying on scientific work.

Among the principal advances of the year have been:

(1) The completion of the evidence that the offspring of alcoholized rats, to the second generation, are less capable of learning than the controls. This suggests an alteration of the germ-plasm by alcohol.

(2) The evidence of a certain amount of testicular degeneration in consequence of the use of alcohol.

(3) Further evidence, by the method of correlation, of the inefficiency of "selection" after the gametic factorial composition has been simplified in the earliest generations.

(4) Evidence that "staleness" of sperm does not influence the sex-ratio in pigeons.

(5) Statistical demonstration of the great increase in the proportion of males born from "hybrid" as opposed to "pure" matings in man.

(6) Statistical evidence that more still-births occur in "pure" than in "hybrid" matings; and that in "pure" matings there are relatively more males in first-born children than in later births.

(7) The discovery that species of *Portulaca*, like some other plant species, break up into numerous biotypes, including a dwarf form, and that they show abundant bud mutations.

(8) The dwarf *Portulaca* is a Mendelian recessive; so too is the weeping character of a mulberry tree as opposed to the erect form.

(9) The demonstration of four factors for color in dogs, one occurring in a triple allelomorph series.

(10) A demonstration of the chemical lack of differentiation in the brains of ataxic pigeons.

(11) Demonstration of the law of osmotic concentration of phanero-gamic epiphytes as compared with their hosts.

(12) The determination of correlations between age, weight, and pulse-rate and body surfaces, on the one hand, with each other, and, on the other hand, with heat production and gaseous exchange, for men, women, and children.

(13) Statistical demonstration of the non-validity or insufficiency of the body-surface law of human basal metabolism.

* Situated at Cold Spring Harbor, Long Island, New York

REPORTS ON INVESTIGATIONS IN PROGRESS.

THE GERM-PLASM AND ITS MODIFICATION.

COMPARATIVE STUDY OF THE CHROMOSOME GROUPS IN DIPTERA.

Dr. Metz has resumed his studies on spermatogenesis in *Drosophila* and other Diptera. Studies on *D. virilis* and on two species of Asilidæ were almost completed by September.

COMPARATIVE GENETICAL STUDIES OF DROSOPHILA.

During the past year, Dr. Weinstein, while caring for the mutant stocks, analyzed the relationship between certain of the mutant characters in *Drosophila virilis* that had not previously been fully analyzed. Since Dr. Metz has taken up the work, considerable progress has been made in obtaining new mutant characters in *Drosophila virilis*, *D. obscura*, and *D. willistoni* and in analyzing their mode of inheritance in accordance with the plan outlined previously for ascertaining the chromosomal and genetical relationships between different species of *Drosophila*. He states that 23 new mutant characters were found in the five months, March to July inclusive.

MODIFIABILITY OF THE GERM-PLASM BY ALCOHOL.

The effect of alcohol on the capacity for forming habits (as a test of intelligence) and the recurrence of the effects in later generations of the alcoholized ancestors have been the subjects of Dr. E. C. MacDowell's research for several years. This year there is no new experimental work to report. Dr. MacDowell reports as follows:

"During four years data were continuously being collected; very little time for their summarization, or even primary tabulation, was available. It has seemed important to complete the tabulation and the analysis of these extensive masses of data and publish the results before again becoming too deeply involved in the carrying on of new experiments. Besides their significance for the primary question as to the modifiability of the germ-plasm, these data will provide evidence upon such problems as growth, the relative significance of different criteria for judging animal behavior, and the immediate effects of alcohol upon mental and physical traits. In view of the large amount of time and money that has been spent upon the collection of these data, the greatest possible use should be made of them. The hazards of deciding mental problems in terms of numbers are great enough in themselves, without leaving any suspicion that the conclusions may depend upon the special statistical treatment employed. To guard against this danger, it will be necessary to treat the data in various ways, using different combinations and methods of averaging. The intensive study of the individual record-sheets showing the track followed in each trail of every rat will serve as an important check upon the statistical results. The conclusions reached from the study of the relative value of the various criteria employed will have a close bearing upon the general conclusion. Three different experimental methods have been employed, and the degree of success in each one is measurable in various ways. When Miss Vicari left this laboratory to enter the University of Minnesota under Professor J. B. Johnston, she took with

her a set of these rats in order to preserve the lines and to obtain later generations. Various adverse conditions defeated this purpose. She reports upon this attempt as follows:

“An attempt was made during the year of 1918-19 to continue the alcoholization of Dr. MacDowell's strain of rats into the third generation for further study to be taken up after the war. The first and second alcoholized generations and their offspring having been studied, the aim was to breed for the third alcoholized generation, from which it was hoped to obtain material for further study of the effect of alcohol on the germ-plasm. With this point in view, a few of his rats were transferred August 18, 1918, to the Institute of Anatomy of the University of Minnesota, where I could see to the experimental part of the work during my stay at that institution. This was made possible through the kindness of Dr. C. M. Jackson, who granted all the housing necessary for the animals and the help of the service-boy.

“Three pairs of alcoholized rats of alcoholized parents with their respective controls made the material for obtaining the third generation of this strain. In addition to these a group of 5 test rats (non-alcoholic, but of alcoholized parents and alcoholized grandparents) was transferred for the study of fertility. This group had been trained in the circular maze and in the multiple choice or trial-and-error problem. Still another group was added. This consisted of a litter of 5 rats (F_1) which were the result of a cross of white with pink-tipped hair. This character I had noticed in Dr. MacDowell's stock during the year 1918. In seeing the material while on a visit to this Station, Dr. Castle suggested that this trait could be a possible allelomorph of albinism, or that such coloration of albino hair might be a skin secretion and not a true hair-pigment. The aim was to carry the cross into F_2 to see if the trait of pink-tipped hairs is inherited and in what manner.

“At Minnesota the rats did not fare well. After a strenuous journey they had to readjust themselves to new environmental conditions, such as temperature, cage conveniences, and a change of diet. They had been accustomed to receive a daily ration of wheat bread soaked in fresh milk and all the dog bread they wanted. This dog bread was a special make, which, according to the chemist, Mr. Hallway, is a well-balanced food for animals or men, and hence had the necessary vitamins. The change was from this diet to bran bread soaked in fresh milk and dry corn. After a month of this diet the rats had lost from 10 to 22 per cent in gross body-weight. The mortality was high, and in order to save the stock their former diet was restored in November. From the three pairs of alcoholized rats offspring were obtained and four matings made. These were alcoholized from the time of weaning (28 days), but no offspring were had from them, though they lived to maturity. During the winter an epidemic of a digestive disorder took a few of the rats away. Of the second and third group of rats, breeding was continued and the results of fertility and color inheritance recorded.

“The hope of saving the alcoholized strain was not realized, principally on account of the lack of reproduction, the mortality, and the environmental conditions.’

“This summer all the time of Miss Vicari has been devoted to the rat data. To obtain a preliminary survey of the results bearing most critically upon the question of the inheritance of the changes caused by the administration of alcohol, the work has been focused upon the rats whose grandparents only had been given the alcohol treatment, and upon the controls, rats whose grandparents were normal, the brothers and sisters of the alcoholized grandparents of the rats under consideration. A year ago (Year Book, 1918, pp. 109-114) Miss Vicari gave the preliminary summaries for a group of 5 such

rats with their normal controls. In this case there appeared clearly a difference between the two sets of rats. The test animals (from alcoholized grandparents) were inferior to the controls by various criteria. We are able to present, at this time, similar preliminary summaries of 36 more rats from like experiments—18 test rats from alcoholized grandparents and normal parents, 18 controls from normal grandparents and normal parents.

“Two tables, giving the results from the training on the maze and the multiple-choice apparatus respectively are given. It must be noted that these figures are subject to correction upon subsequent checking. The numbers in the body of the tables are the averages of all the individuals in one family. In each case the number of rats included in the average is shown. By an experiment is meant a litter of test rats and the corresponding control litter. The averages of ‘all experiments’ are the primary averages of the individuals’ averages in all experiments.

“Table 1, the results of the training on the multiple-choice apparatus, gives the comparative averages of the test and control litters under five different experimental situations as indicated in the first column. The averages for

TABLE 1.—Comparison of rats from alcoholized grandparents with normal controls. Summary of results of training on multiple-choice apparatus.

Nature of training.	Exp. No.	Based on correct first choices.					Based on wrong choices.				
		Tests.		Controls.		Controls better.	Tests.		Controls.		Controls better.
		Av.	No.	Av.	No.		Av.	No.	Av.	No.	
Right-hand training proper.	19	3.62	5	2.42	5	-1.20	12.68	5	16.84	5	-4.16
	20	3.88	5	6.25	5	+2.37	12.44	5	7.42	5	+5.02
	21	4.70	2	6.10	2	+1.40	11.05	2	6.60	2	+4.45
	22	4.40	3	4.07	3	-.33	10.60	3	10.16	3	+.44
	23	3.47	8	4.03	8	+.56	13.31	8	11.24	8	+2.07
All exps. . . . .	....	3.82	23	4.35	23	+ .53±0.26	12.39	23	11.08	23	+1.31±0.69
Test set-ups.	19	4.90	5	2.70	5	-2.20	10.50	5	15.50	5	-5.00
	20	4.96	5	6.18	5	+1.22	7.00	5	5.90	5	+1.10
	22	4.33	3	4.33	3	.00	11.86	3	9.33	3	+2.53
	23	6.00	8	6.07	8	+.07	6.87	8	7.40	8	-.53
	All exps.	5.24	21	5.04	21	-.20±.35	8.47	21	9.40	21	-.93±.88
Left-hand training proper.	19	3.00	5	5.72	5	+2.72	14.59	5	9.20	5	+5.39
	20	3.92	5	3.66	5	-.26	14.60	5	13.40	5	+1.20
	22	4.90	3	4.96	3	+.06	11.30	3	13.20	3	-1.90
	23	3.76	8	4.90	8	+1.14	13.40	8	9.92	8	+3.48
	All exps.	3.78	21	4.80	21	+1.02±.30	13.66	21	11.04	21	+2.62±.73
Test set-ups.	19	2.80	5	5.90	5	+3.10	13.30	5	7.90	5	+5.40
	20	3.10	5	3.60	5	+.50	14.30	5	14.00	5	+.30
	22	3.50	3	4.00	3	+.50	11.60	3	12.30	3	-.70
	23	4.81	8	5.12	8	+.31	10.50	8	7.93	8	+2.57
	All exps.	3.74	21	4.78	21	+1.04±.32	12.23	21	10.00	21	+2.23±.84
Memory.	19	3.50	5	4.38	5	+.88	12.70	5	10.65	5	+2.05
	20	3.10	5	4.65	5	+1.55	16.05	5	10.15	5	+5.90
	22	2.83	3	4.33	3	+1.50	16.00	3	11.33	3	+4.67
	23	3.57	8	3.45	8	-.12	15.76	8	12.21	8	+3.55
	All exps.	3.33	21	4.09	21	+.76±.29	15.48	21	11.22	21	+4.26±.59

'training proper' (learning to enter the first door to the right or left of a variable series of opened doors) are based upon 100 trials per rat; 'test set-ups' (a different variable series of opened doors requiring the same solution) are based upon 20 trials per rat; the averages for 'memory' are based upon 40 trials per rat. Each series of trials may be judged in two ways—upon the number of times a rat chooses the correct door first and the number of wrong choices he makes on the average before choosing the correct door. Accordingly, the table is divided into two parts, the two sides being different methods of describing the same reactions of the same rats. In the columns headed 'Controls better' the difference between the test and the control averages is shown with a plus sign when the controls have more correct first choices and fewer wrong choices.

"In table 2, the results of the training on the maze, the right and left halves represent the two different experimental situations, and the first column gives three different methods of judging the same reactions. The meanings of these headings is fairly obvious.

TABLE 2.—*Comparison of test rats from alcoholized grandparents with normal controls. Summary of results of training on the maze.*

Criteria of comparison.	Exp. No.	Training proper.					Memory, based on last 12 trials.				
		Tests.		Controls.		Controls better.	Tests.		Controls.		Controls better.
		Av.	No.	Av.	No.		Av.	No.	Av.	No.	
Time (av. per day in secs.).	19	31.25	5	23.01	5	8.24	21.05	5	22.35	5	- 1.30
	20	18.89	5	10.14	5	8.75	14.15	5	15.69	4	- 1.54
	21	9.25	1	14.64	2	-5.39	.....	.....	.....	.....	.....
	22	42.14	3	17.09	3	25.05	23.47	3	20.87	3	2.60
	23	20.64	8	25.14	8	-4.50	26.16	8	14.88	8	11.88
	24	34.03	2	33.38	2	.65	28.97	2	59.23	2	-30.26
All exps. . . . .	.....	25.81	24	20.75	25	+5.06±2.05	22.33	23	17.03	22	+ 5.30±2.50
Number of perfect trials, av. per rat.	19	.40	5	.60	5	.20	1.22	5	2.00	5	.78
	20	.40	5	5.20	5	4.80	2.20	5	5.40	5	3.20
	22	.33	3	2.00	3	1.67	2.66	3	4.00	3	1.34
	23	2.50	8	1.62	8	-.88	3.25	8	4.75	8	1.50
	24	1.50	2	.50	2	-1.00	4.00	2	2.50	2	- 1.50
All exps. . . . .	.....	1.21	23	2.13	23	+ .92± .43	2.56	23	4.00	23	+1.44± .367
Errors (av. No. per rat per day).	19	4.67	5	3.49	5	1.18	3.01	5	3.10	5	-.09
	20	3.26	5	.76	5	2.50	1.78	5	1.37	5	.41
	22	3.93	3	1.91	3	2.02	2.57	3	1.30	3	1.27
	23	2.06	8	2.68	8	-.62	2.10	8	1.46	8	.64
	24	2.41	2	3.50	2	-1.09	1.70	2	2.41	2	-.71
All exps. . . . .	.....	3.16	23	2.32	23	+ .84± .26	2.25	23	1.86	23	+ .39± .22

"An 'error' is a wrong turn in the maze; its definitions have been carefully worked out and different types of error are recognized. These will form a special study later on. A perfect trial is run when no error is made. The same method of averaging has been used in the averages for all experiments as used for the multiple-choice results.

"In observing these figures it must be clearly realized that there are many factors influencing the results that are entirely blotted out by this sort of lumping together. No final conclusion should be drawn from such averages until all the influences back of them have been thoroughly analyzed. At the

same time, it is possible to obtain a fair opinion as to the general nature of the final conclusion from these figures. The basis of the interpretation of these tables must be the comparison of the test and control litters within one experiment. In averaging different experiments together, the differing numbers of individuals from different lines introduces a source of error that may seriously modify the figures obtained. Such averages are only given to help obtain a rough general impression of the nature of the results, but only by following one set of rats through the 10 criteria of comparison for the results of the multiple-choice problem and the 6 criteria for the maze results can a correct impression of the meaning of these numbers be obtained. It is obvious that all these criteria do not bear equal weight; 'training proper,' for instance, bears much more weight than either 'test set-ups' or 'memory,' on account of the larger numbers of trials involved. In the maze all criteria are based on the same numbers of trials, but it is a question whether speed or the number of perfect trials should have more or less weight, etc.

TABLE 3.—Summary of the comparisons given in tables 1 and 2 of the four main experiments. [The capital letter signifies the superior litter. T = tests superior; C = controls superior.]

Litter.	Experiment No. 19.		Experiment No. 20.		Experiment No. 22.		Experiment No. 23.		Experiment No. 24.	
	Tests.	Controls.	Tests.	Controls.	Tests.	Controls.	Tests.	Controls.	Tests.	Controls.
Maze:										
Training proper:										
1. Time.....		C		C		C		T		C
2. Perfect trials.....		C		C		C		T		T
3. Errors.....		C		C		C		T		T
Memory:										
1. Time.....	T		T			C		C	T	
2. Perfect trials.....		C		C		C		C	T	
3. Errors.....	T			C		C		C	T	
Multiple choice:										
Right-hand problem:										
2. Correct choices....	T			C	T			C	Not trained.	
2. Wrong choices....	T			C		C		C		
Right-hand test set-ups:										
1. Correct choices....	T			C	Same.			C		
2. Wrong choices....	T			C		C	T			
Left-hand problem:										
1. Correct choices....		C	T			C		C		
2. Wrong choices....		C		C	T			C		
Left-hand set-ups:										
1. Correct choices....		C		C		C		C		
2. Wrong choices....		C		C	T			C		
Memory:										
1. Correct choices....		C		C		C	T			
2. Wrong choices....		C		C		C		C		

"Table 3 has been made to assist in deciphering the confusing mass of comparisons in the other tables; it shows which litter in each of the 5 experiments was found to be superior for each of the 16 criteria. This takes no account of the numbers of individuals included, nor of the amount of difference, but merely indicates the directions of the differences found. In the case of experiment 20 there are only two exceptions to the superiority of the controls; it would seem safe to conclude that there was a difference between the two litters in this experiment. But in experiment 19 the case is by no means so clear. Does the superiority of the tests in the 'time' and 'errors' criteria of

the memory-maze and in the first half of the multiple-choice training indicate more than chance? If so, does the possession of alcoholic ancestors in general tend to favor the success of rats judged on these criteria? This last question is answered by the comparisons in experiments 23 and 24, in which the *tests* are better in the *maze*. In all but two of the 16 criteria, some cases have been found where the *tests* are better; the two in which they have not been found are in the left-hand problem with the test set-ups in the multiple-choice apparatus when judged by correct choices and in the multiple-choice, memory, when judged by wrong choices.

“When the averages for individual rats in all experiments are averaged for each criterion, the sign of the difference is plus in every case, that is, favoring the controls. Many of these differences are not large, and when the test of the probable error is applied, it appears that only in 6 cases may they be claimed to be statistically significant, that is, probably due to other causes than chance. In only 1 case are the different criteria for the same actual performances significant; this is in the left-hand training proper on the multiple-choice apparatus. There are 2 other cases of differences that are significant on the multiple-choice apparatus, namely, left-hand test set-ups, when judged by the number of correct first choices (when judged by the number of wrong choices the difference is so small that it falls within the range of chance variations), and the memory trials when judged by the number of wrong choices. The two significant differences found in the maze criteria occur in the training proper when judged by the number of errors per day (these same reactions of the rats when judged by the time and the number of perfect trials do not show significant differences) and in the memory trials, when judged by the number of perfect trials.

“At first glance the result seems clear and the conclusion to be drawn fairly obvious—that the alcoholized ‘test’ strains are mentally inferior; but, as has been indicated, the correct interpretation can not be finally made directly from these averages. Much detailed study will be required before any generalization can be drawn.”

CYTOLOGICAL STUDIES OF ALCOHOLIZED RATS.

The study of the cytological condition of the testes of the male alcoholized and the control rats produced in the course of these experiments was made by Dr. Ezra Allen, of the Wistar Institute of Anatomy and Biology, and results of the study were published in the *Anatomical Record* for April 1919. Very briefly, his findings are:

“There is testicular degeneration in both alcoholized and normal rats, but this is much greater in the alcoholics.”

In addition to the alcoholized rats, Allen used, for the sake of comparison, rats that had been raised on a diet deficient in water-soluble vitamins, but found the same sort of degeneration as in the alcoholized rats. Other investigators have found the same type of degeneration as a result of subsection of the gland to the X-ray. It appears then that similar states of degeneration may arise in the testes of rats through subsection to the X-ray, through deficiency in vitamins and through alcoholization. Allen concludes that the immediate cause affecting growth and cell-division of the germ-cells is identical in all three cases.

NEUROLOGICAL STUDIES OF ALCOHOLIZED RATS.

In order to see if there was any structural difference in the brains of alcoholized rats or their descendants that were slow in learning and the brains of the controlled series, Miss Vicari has undertaken histological studies of the brains of the two sets. The comparison of the histological studies of alcoholized and normal rats bears the same relation to their capacity for learning as a comparison of the structure of the testes in the two groups bears to the subject of growth and fertility. Miss Vicari makes the following statement concerning her work:

“Brains from about 20 of Dr. MacDowell’s rats, including tests and controls, were collected before leaving this institution. They were fixed for the study of degeneration. In Dr. J. B. Johnston’s laboratory at the University of Minnesota this material was dehydrated, cleared, and blocked. I wish to express my appreciation of the suggestions of Dr. Johnson and of his advice as to the treatment and possible method for the histological study of this material; also of his courtesy in offering the use of his laboratory for the preparation of this material.”

The preliminary results of the studies of MacDowell upon alcoholized rats thus confirm, in a general way, the conclusions of Stockard, namely, that alcohol affects not only the soma but also the germ-cells carried by the individual alcoholized, and that these germ-cells are so altered that the individuals developing from them show striking limitations in their capacity for full mental development, and this incapacity shows itself even in two generations removed from the alcoholized individuals. It looks very much as though alcohol was able sometimes to affect germinal material, probably specifically the chromosomes, so that it can no longer determine normal nervous development. The conclusion is so important, as almost the only successful means of modifying the germinal material at will, that the experiment deserves repetition. Further investigation of other methods of modification of the germ-plasm is also desirable.

ALTERATION OF THE QUALITY OF A POPULATION BY SOMATIC SELECTION.

Experiments with Drosophila.—One of the noteworthy discussions among geneticists in recent years has been that of the possibility of the contamination of genes in consequence of hybridization. This had been tied up with the question of the possibility of modifying a race in a desired direction purely by a process of selecting somatically. There has, indeed, been no dispute that a mixed race, or one in which a given trait depended upon a number of separate genes or germinal determiners, might be secured in a simpler condition through hybridization and selection for breeding of individuals whose somatic condition indicated a simple condition of their gametic makeup. The dispute was rather whether genes were, through a process of contamination or other, definitely variable so as to offer an unending stream of condi-

tions by which the experimenter might carry his strains definitely in any desired direction. It was the opinion of the great majority of experimentalists that the capacity of improvement by selection was definitely limited, owing to the fact that the number of kinds of genes available in the formation of a given organism is limited. On the other hand, Castle, to refer only to the most striking investigator in this field, accepts the view of unlimited capacity for modification through individual selection. This controversy is now to a large extent settled, chiefly through certain experiments of Castle himself, which have led him to reject his doctrine of contamination of genes, and apparently also of indefinite variability in them.

Castle's decision is, however, a matter of the last few months only, and meanwhile Dr. MacDowell has carried through an elaborate series of breedings upon *Drosophila* to determine whether the number of certain bristles on the back might be increased or diminished by selection of parents with an increased or diminished number of such bristles. As set forth in the Year Book for 1917, Dr. MacDowell reached the conclusion by the ordinary methods of genetical analysis that an indefinitely large change in the number of these bristles could not, as a matter of fact, be produced through the ordinary processes of selection.

Dr. MacDowell has now made a further statistical analysis of the data by means of the methods of correlation. Many calculations were required, and revised tables and charts and the text have been completed under the title, "Bristle Inheritance in *Drosophila* III. Correlation." The same conclusions are reached as by the ordinary method of genetic analysis. In brief, the correlations indicate that there was a tendency in the first five generations for the bristle grades of the offspring from high-grade parents to be higher than the bristle grades of the offspring from low-grade parents; that in no other period of the 54 generations did such a clear difference exist between the offspring of high and low grade parents; and that, when the environment was rendered as uniform as possible, no sign of any such relationship was found. In the generations where a difference was found between the offspring of high and low grade parents, it is obvious that the breeding of high-grade parents exclusively would raise the means of the race. The means actually obtained in the different generations of selection experiments show a close connection with the amount of correlation found. The means rise in the generations where the closest correlation is found. Selection has been dealing with hereditary units that were present in the original flies; it has not caused the origin of new units; its action has been to reduce the amount of genetic differences between individuals, whereas the primary requirement for evolution is that it should act so as to increase the amount of such differences. Natural selection acts as a stabilizer of evolving races; it has no part in the evolving itself.

Experiments with Daphnia.—Dr. A. M. Banta has completed the work of compiling a large number of statistics gained from his experiments on the possibility of modifying the reactions of Entomostraca to light by ordinary selection. One of the most extensive of his breeding-lines is known as line 757. In it, following selection, strains that reacted very dissimilarly appeared. In this line there is little, if any, relation between vigor and reactivity to light, so that the effect of selection secured in this line was not due to changes in the relative vigor of the plus or minus strains, that is, of the strains selected for quicker and those selected for slower phototactic response. Dr. Banta says that the divergence of the two strains can not readily be explained as due to mutation, for there is no point in the curve where mutation may be said to have occurred. The other lines, however, generally show no effective selection, and, therefore, some special explanation has to be sought for to account for the divergence of the reaction-time in the plus and minus strains of line 757. It is now proposed to start a test series to see if the effect of selection within line 757 has persisted. So far as results are secured, they seem to show that the effect does indeed persist, although $2\frac{1}{4}$ years have elapsed since selection within these strains ceased.

The principal result of our attempts to accentuate differences by breeding plus and minus strains in flies and *Daphnia* is to indicate that improvement is effected this way only until such time as a hybrid or complex condition of the genes of the trait in question is reduced to the simplest degree.

THE SIGNIFICANCE AND CONTROL OF SEX.

SEX IN PIGEONS.

During the absence of Dr. Riddle from Cold Spring Harbor, his assistant, Dr. Ellinor H. Behre, has completed a test of the hypothesis that the relative staleness of sperm might be responsible for abnormal sex-ratios. This experiment was suggested by the findings of other investigators, especially among amphibia. It has been found that the length of time during which pigeon sperm-cells retain their capacity to fertilize may vary somewhat, but probably in any case does not exceed 8 days. It is clear, however, from the evidence, that stale sperm does not affect the sex-ratio. This is of some importance, since it shows that the very abnormal sex-ratios obtained in Dr. Riddle's work with the pigeons is neither complicated nor explained by this fact.

SEX INTERGRADES IN DAPHNIA.

As pointed out in earlier reports, Dr. Banta has had the good fortune to find interesting and significant variations from the normal condition of the sexes in the water-fleas, Cladocera, and especially *Daphnia*

and related genera. During the year in review, the work with those individuals which show an intergrading or intermediate sex has been developed in two directions: (1) a detailed analysis of various degrees of intergrading as affecting a secondary sex character of *Daphnia longispina*; (2) the continuation of the selection experiment of the sex-intergrade strains of *Daphnia longispina*.

Analysis of degrees of sex intergradedness.—As has been said in previous reports, Dr. Banta finds that the sex-intergrades are not gynandromorphs in that they are not sexual mosaics, but that in the intergrades the male and female influences are blended to various degrees in the different parts of the body, as revealed by the several secondary sex-characters. A careful study of a secondary sex-character, the first leg, has shown clearly that this interpretation is correct and that there is an almost endless variety of conditions of sexual significance in this complicated appendage, which may exist in any condition between that of the fully developed male and that of the fully developed female. This first leg in the normal female has the following simpler salient features: (1) only a single flagellum-like terminal filament to the No. 2 element, which element does not possess a hook nor have a swollen hairy base; (2) further, this appendage in the normal female has its third element terminated by three filaments. In the male, on the other hand, (1) the second element has two terminal filaments and has a large, swollen base coarsely hairy on one side, from which is developed a relatively large stout hook almost as long as the remainder of the element, and moreover (2) the third element is terminated by four filaments. Between these two conditions, that typical for the normal female and that typical for the normal male, there is every conceivable intermediate condition of development. These intermediate conditions of development may be thought of as the results of the various degrees of female and male influences operative in different individual cases and in different parts of the same intergrade individual; *e.g.*, it is of interest to note that the two legs of the same pair in the same individual daphnid may differ slightly or largely in the degree of femaleness and maleness revealed in their morphological structure. One appendage may be normally female, while its mate is slightly or largely male in character.

Further, the degree of femaleness and maleness of one or both of the first legs may be quite unlike the degree of maleness and femaleness of the other secondary sex-characters of the same individual. However, it is true that if a certain secondary character is highly male (or female), the other secondary sex-characters are likely to be male (or female) to a somewhat similar degree. But, on the whole, the correlation in degree of maleness (or femaleness) between the different secondary sex-characters in an individual is not very large and in many cases not even apparent.

The following tabular statement suggests something of a typical series of sex conditions among the sex-intergrade stock. It is merely a stereotyped outline, however, and it should be remembered that in the vast majority of individuals no such regular and coincidental gradation of secondary sex-characters occurs, *i.e.*, in this tabular outline approximately the same intermediate condition of maleness and femaleness is assumed for every character of each individual of the series, while as a matter of fact the correlation in the degree of maleness and femaleness of the different secondary sex-characters of the same individual is frequently very low or even negligible.

TABLE 4.—*Typical series of sex-intergrades. Characters of first leg of sex-intergrades and of normal individuals of Daphnia longispina.*

	Second element.				Third element. No. of filaments.
	No. of filaments.	Base.	Hairs.	Hook.	
I. Normal ♀.	1	Unswollen.....	None.....	None.....	3
II. Intergrade.	1 or 2	Slightly enlarged.	Few or none.	No trace.....	3
III. Intergrade.	2	Swollen.....	Few.....	Do.....	3
IV. Intergrade.	2	More swollen....	Many.....	No trace or slight trace.	3 or 4
V. Intergrade.	2	.....Do.....	.....Do.....	Slight disturbance of contour, indicating position of hook.	3 or 4
VI. Intergrade.	2	.....Do.....	.....Do.....	Larger rudiment of hook.	4
VII. Intergrade.	2	.....Do.....	.....Do.....	A swollen, curved, irregular protuberance representing hook.	4
VIII. Intergrade.	2	.....Do.....	.....Do.....	Imperfect, usually 2-jointed, hook.	4
IX. Intergrade.	2	.....Do.....	.....Do.....	Imperfect but stout, fairly regular hook.	4
X. Normal ♂.	2	.....Do.....	.....Do.....	Perfect unjointed hook.	4

Selection in intergrade stock.—It was noticed that the sex intergrades of *Simocephalus vetulus* and *Daphnia longispina* showed a certain amount of relationship between the degree of maleness of a mother and the degree of maleness among her young. This suggested the possibility of obtaining an effect of selection by using as a basis for selection the degree of intergradeness among sibs in the same strain. Selection was begun with 6 strains of the same line of *Daphnia longispina*. These 6 strains had originated from 6 of the 8 young of a single brood of one of the original sex-intergrade mothers of this species. Three of these strains were selected toward normal femaleness and three toward intergradeness, the purpose being to make these as divergent as possible.

Selection was begun early in December 1917, and has been continued without interruption since, covering from 34 to 40 generations in the different strains. The data for only the last 16 generations of this

selection have been summarized. The summaries of the data indicate that there is an effect of selection. The strains (1, 4, and 6) selected to become more intergrade probably have not become more intergrade, but of the three strains (3, 5, and 8) selected to become more nearly normal-female-producing, two have become markedly less intergrade than they formerly were (in fact, almost exclusively normal-female-producing) and markedly less intergrade than the three strains selected for increasing the intergrade characters. One of the strains (8) selected to become less intergrade has not made progress in the desired direction during the past 16 generations (the only period for which the data have been summarized), though it had apparently done so during the 21 earlier generations of selection. A return selection is rendered extremely desirable and is to be undertaken as soon as the lines now being utilized are disposed of.

SEX-RATIO IN MAN.

Some years ago, Professor Raymond Pearl tested a view that has had some scientific currency, that hybrid matings tend to produce an excess of male offspring. He utilized for the purpose a record of the sex of offspring of matings in Argentina between native-born stock and those between immigrants from different countries. Dr. Little has tried to secure more extensive material and has been making use of the records of lying-in hospitals in the city of New York. A detailed study has been made, with the assistance of Miss Beatrice W. Johnson, of the records of the Sloane Maternity Hospital of New York City. The purpose was to compare the sex-ratio in the progeny of various types of racial matings. Matings in which both parents were from European (Caucasian) races were chosen. For the purpose of this study the term *race* is used in the sense of a biological center of more or less inbreeding. Thus, generally speaking, a mating of two Irish parents is a type of closer inbreeding than a mating in which one parent is Irish and the other Italian. Then a comparison between two such types of matings has been made. The races used were as follows: English, Irish, Scotch, German, Austrian, Russian, Italian, and Greek. These were tabulated in two main groups: (a) those matings in which both parents came from the same race, and (b) those in which the parents were from different races. While much information still remains to be gathered from the data, that part which concerns the ratio of the sexes among the offspring (including stillbirths) has been tabulated, with the results shown in table 5.

Several facts stand out as of general interest. Three of them resemble each other so closely as to suggest that a single explanation may properly include them all. These are: (1) the excess of male progeny found in the normal "pure" racial matings; (2) the significantly greater excess of males found in offspring of the "hybrid"

matings; and finally, (3) the great excess in pure matings of males among children of the first birth as compared with the later births, contrasted with the steady excess of males in hybrid matings.

TABLE 5.—*Sex ratio (male ÷ female) and proportion of stillbirths in pure and hybrid human matings.*

	"Pure" matings.	"Hybrid" matings.	Remarks.
Sex ratio (M ÷ F).			
Total births.....	5,753	1,305	Difference, 15.29 ± 2.26 (6.76 times its probable error).
Males.....	2,964	716	
Females.....	2,789	589	
Ratio.....	106.27 ± 0.95	121.56 ± 2.06	
Percentage of still-births occurring in the two types of matings.			
Total births.....	5,753	1,305	Difference, 2.21 ± 0.42 (5.26 times its probable error).
Born dead.....	355	52	
Percentage born dead.....	6.19 ± 0.19	3.98 ± 0.37	
First births:			
Total individuals.....	2,547	572	Difference, 117.85 ± 2.79
Sex ratio.....	117.88 ± 1.45	111.85 ± 2.79	
All other births:			
Total individuals.....	3,206	733	Difference, 129.75 ± 2.86
Sex ratio.....	97.90 ± 1.18	129.75 ± 2.86	
Difference between first and all other births.	19.98 ± 1.97 (10.68 × P.E.)	17.90 ± 3.99 (4.5 × P.E.)	

These facts are all explicable on the hypothesis that the male-forming sperm are less likely to be eliminated, because they are less able to carry genetic factors which might produce physiological incompatibility either during their intra-uterine journey or after fertilization, than are the female-producing sperm with their larger amount of foreign chromatin. Within "pure" races, the uterine secretions might at first eliminate sperm more easily and more specifically than they could later on; but the hybrids, in which there was a greater degree of difference between male and female gametes, might retain their eliminatory ability either for a longer time or even permanently. This would result in a great excess of male offspring from first matings within the "pure" races, and the continued excess of males among the racial hybrids.

The relatively smaller number of stillbirths in hybrids as compared with "pure" races is an interesting fact. At first it appears that because of the large number of cases of venereal disease involved, stillbirths are poor material for genetic analysis. But inasmuch as the result of the infection and not its occurrence is the matter of biological interest, it is entirely probable that truly genetic and biological factors underlie and determine whether a fetus infected with venereal disease shall or shall not die. The biological and genetic basis of factors con-

trolling the size of fetal head, width of pelvis, etc., is easier to admit. At all events, the genetic factors involved must be hypostatic in nature, and in this way the likelihood of the lethal RR combination being formed is greater in matings within the race than it is in matings outside of the race, where possibly an entirely different complex would exist. The work is being continued.

SEX IN MUCORS.

The work on sexuality of the mucors has been resumed by Dr. Blakeslee and zygospores hitherto unreported have been discovered, as well as a number of new forms. The investigations, however, have not been carried far enough to warrant an extended report. Attention has been called in earlier volumes, especially in Year Book No. 12, to the relative simplicity of vegetative structure in the mucors, their ease of cultivation, and the fact that the two sexes apparently contribute equal masses of protoplasm to the developing offspring. These investigations are especially adapted to biochemical investigation in the problems of sex, and these can properly be made only with the aid of a biochemist.

THE INHERITANCE OF GERMINAL PECULIARITIES.

FLOWERING PLANTS.

The genetical work on flowering plants has been seriously interrupted by the war. Our gardener, Mr. Billings T. Avery, jr., who had been identified with Dr. Blakeslee's work for many years, both in the Connecticut Agricultural College and here, died in service in France, and there has been no one else with the detailed knowledge of the strains who has been able to carry them forward with the same success based on knowledge. Since the war, a satisfactory personnel has been built up, and the prospect is good for a large development of this branch of the work.

The report of this department in Year Book No. 17, for 1918, told on page 114 of Dr. Blakeslee's plans for developing the adzuki bean as a war measure, undertaken at the request of the National Research Council. He secured the cooperation of some other breeding-stations for the development of this species. From our plots over 4 tons of adzuki beans were raised as a by-product of the experiments, and these were sold at a nominal rate to a nearby State hospital. The reports from other experiment stations on the productivity of this species were not especially favorable, due apparently to the relatively new though destructive "mosaic" disease of shelled beans. We have therefore cut down our work with the adzukis for the present and are testing out the different lines to discover, if possible, immune races before attempting further breeding with them.

Of the yellow daisies (*Rudbeckia*) we have plants growing from crosses made by Mr. Avery before he entered the service. The in-

vestigation of the inheritance of green cones and of doubling is being continued by Dr. Blakeslee. In view of the technical difficulties of hybridization, the decrease of vigor, and the increase of intersterility due to inbreeding, and on account of the loss of the special knowledge and technical skill for this work which followed the death of Mr. Avery, it seems desirable to discontinue for the most part further work with these forms.

In the portulacas, Dr. Blakeslee is carrying out further experiments with the dwarf mutation, which has been shown to be a Mendelian recessive, and with the reverting normal branches which they occasionally produce, which have been shown to be heterozygous dominants. An attempt is being made to alter the proportion of reverting branches by external stimuli. A number of vegetative mutations have also been found in flower colors, recessives mutating to dominants. The portulacas show a wide range of color in their flowers and give an opportunity to study color inheritance in this species, which is being availed of. Thus the portulacas reveal again that extraordinary richness in biotypes of plant species which Dr. George H. Shull years ago demonstrated at this station in the case of the wild shepherd's purse, a species which was commonly regarded by botanists as a unique representative of the genus in America.

Research on the variability in the jimson weed (*Datura*) is being resumed. The following mutants have been studied and named: Globe, Round-leaf Globe, Cocklebur, Poinsettia, Buckling, Sugarloaf, Polycarpic, Microcarpic, Ilex, Glossy, Rolled, and New Species. In addition, a number of new mutants as yet unnamed have been discovered and are being investigated. In one of the mutants an aberrant color ratio has occurred.

Of the cross between a weeping and an erect mulberry, the F_2 generation in the field is ready to be recorded. The weeping character appears to be a simple Mendelian recessive. Some of the F_1 plants which were last season recorded as male, this season produced both male and female flowers. Not all the F_1 plants were in flower, but in another season it should be possible to obtain sex-ratios in the F_1 generation.

In poplars we obtained last spring flowers from F_1 plants of a cross between an erect and a weeping aspen and have a few F_2 seedlings now in the nursery.

This summer, flowers were produced in F_1 plants of a cross between the purple-leaved variety of the common barberry and the form extensively used for low hedges (*Berberis thunbergii*). The former is a spreader of the wheat rust and is legislated against in many States, but the latter is immune. It is possible that a tall immune race eventually may be produced from the cross between these two species.

TETRACOTYLEDONOUS BEANS.

Dr. J. Arthur Harris has continued his investigation on variation, correlation, and selective death-rate of garden beans, especially those which have three or four cotyledons. A detailed study of the vascular anatomy of such seedlings, which has been carried on in the last three years with the collaboration of Dr. E. W. Sinnott and Dr. John Y. Pennypacker, will shortly be ready for publication.

HEREDITY OF COLOR IN DOGS.

A study has been made of data derived from the studbooks of the American Kennel Club to get at the inheritance of color in three breeds of dogs—Great Danes, Dachshunds, and Pomeranians; and a paper based on the data on Great Danes, written by Miss E. Elizabeth Jones, who has collaborated with Dr. C. C. Little in this work, is now in press. The following color-factors, apparently Mendelian in nature, have been demonstrated:

(1) *H*, a factor for "harlequin" (white) spotting, epistatic to its allelomorph *h*, the factor for solid-colored coat.

(2) *D*, a factor for intensity of pigmentation allelomorphous to *d*, producing dilute coat pigmentation.

(3) A triple allelomorph series of which the members are in order of dominance: *E*, a factor for extension of black pigment to the whole coat; *E'*, a factor for partial restriction of black pigment, producing "brindle" or "tigered" pattern, and *e'*, a factor producing the "fawn" coat-pattern, in which black is confined to the muzzle, face, and feet.

(4) *S*, a factor for self or white coat, allelomorphous to *s*, a factor producing a white chest or foot spot.

CROSSING OVER AND NON-DISJUNCTION IN SEX-LINKED TRAITS IN CATS, DOVES, AND CANARIES.

Dr. Little has reviewed the available literature to determine how completely the facts of inheritance in cats, doves, and canaries agree with the hypotheses of crossing over and non-disjunction advanced by various investigators to explain the occurrence of exceptional color classes in these animals.

In cats it was found that the exceptional color varieties were of two distinct sorts: (1) those which involved merely the appearance of an entirely normal and common color variety in a cross in which it was not expected, and (2) tortoise-shell males, which are an extremely rare variety, usually sterile, appearing irregularly, and, when they are fertile, breeding as yellows.

The exceptions in doves and canaries fall in the first of the two categories. To explain this first category, "crossing over" and "non-disjunction" meet serious difficulties, in that they predicate the appearance of color classes not yet observed, or interchange of genes

between the *X* and *Y* chromosomes in the heterozygous sex and, in the case of non-disjunction, sterility, which is also, as yet, unobserved.

To explain these cases, therefore, it is suggested that in certain rare individuals factorial changes from one allelomorph to another take place as follows:

In cats, from sex-linked factor *Y*, for the restriction of black pigment, to factor *y*, for the extension of black pigment to these regions.

In doves, from sex-linked factor *w*, for white plumage, to factor *W*, for colored plumage.

In canaries, from sex-linked factor *p*, for pink eye-color, to factor *P*, for dark eye-color.

To explain the second category, it is suggested that non-disjunction of the *X* chromosome, resulting in certain "males" which are *X* instead of *XY* in formula, is involved. Sterile tortoise-shell male cats are supposed to be animals of the constitution *X*, showing a peculiar mosaic distribution of black and yellow color. Similarly, the still rare fertile tortoise-shell males are considered as the result of secondary non-disjunction. These hypotheses are tentative and have been advanced by Dr. Little for consideration and experimental test.

HEREDITY IN SHEEP, MICE, AND POULTRY.

The experiments on heredity of twinning and multinippling in sheep were continued at the station. There were 30 lambs born from 17 mothers, being a proportion of 1.8 lambs per mother, as contrasted with 1.6 for 1917 and 2.2 for 1916. The cooperative sheep experiment with the New Hampshire Sheep Experiment Station is being continued.

Progress is being made with the poultry strains. During the year 109 chicks were hatched, mostly of the New Buff and Silky strains.

Dr. C. C. Little, who has been in part assisted by Mr. L. C. Strong, a graduate of Columbia University, has worked on an operative technique for ovarian transplantation in 1-day and 2-day old mice, in a series of over 300 operations. From this material it is hoped that evidence relating to the effect of the foster-mother on heredity of susceptibility to tumors, spotting, size, etc., will be secured. Mr. Strong's work was chiefly making operations upon older mice, with the view of continuing his work at Columbia University.

Mr. Reginald G. Harris, cooperating with Dr. Little, has measured skull and size inheritance of crosses in mice. Results of this will be included in the paper on the characteristics of mice which is now being prepared for publication. Dr. Little has also collected a series of over 500 mice in order to study the effect of age of transplantation to susceptibility to tumor. These animals are now under observation. Dr. Little proposes to continue this work as a control to the ovarian

transplantation work and to gain information as to the nature and effects of tumor growth.

During the summer, Dr. George B. Jenkins, of the Department of Embryology, Carnegie Institution of Washington, made preliminary studies of rumplessness, polydactylism, and abnormal plumage of Rumpless and Silky strains of poultry at this Station.

EXPERIMENTAL PRODUCTION OF VARIATIONS.

EFFECT OF CAVE CONDITIONS.

The experiment of comparing the effect of cave forms reared in the light and epigeal forms reared in caves, with the corresponding variations of these in their original habitat, is being continued by Dr. A. M. Banta. During the year he made successful collections in caves in the middle West, and we have now more cave material than at any previous time. The amount of material of most of the more readily breeding species is satisfactorily large.

PHYSIOLOGY OF REPRODUCTION.

BIOMETRIC STUDIES OF EGG PRODUCTION.

Dr. Harris has continued his statistical investigations into the physiology of egg production, with special reference to the prediction of egg production from short periods of observation. These are made in cooperation with three of the agricultural experiment stations.

OTHER INVESTIGATIONS.

CONTROL OF PROTEIN PRODUCTION IN EGG-WHITE BY QUININE.

Riddle and Anderson had already shown that the amount of the nitrogen-containing substance (protein) in egg-white was reduced under quinine. It remained to determine whether the reduction in weight implied also an actual and absolute reduction in nitrogen, or whether the reduction occurred in non-nitrogenous associates of the protein. This work was chiefly carried on during the past year by Dr. Ellinor H. Behre. An actual reduction of the nitrogen element has been found. This work has now been brought to a termination by Drs. Riddle and Behre. Their conclusions are as follows:

“Fresh-laid dove eggs contain about 12 per cent nitrogen per gram of solids.

“The data of Riddle and Anderson on the reduction of egg size and yolk size under quinine treatment are further corroborated by the records of 6 of 7 birds retested—egg size and yolk size are decreased during dosage and increased after dosage is discontinued.

“The normal quantity of (a more dilute) albumen is restored quickly after discontinuance of dosage.

“Less albumen is produced during dosage than before. Relatively more (of a more dilute) albumen is produced after dosage is discontinued than during dosage.

"The loss of weight or amount of albumen under quinine consists in (a) a loss of total substance, and (b) a disproportionate loss of solids.

"The loss of solids is accompanied by a loss of nitrogen. When the amount of albumen is later increased, in the after-dosage periods, the nitrogen does not increase in full proportion. The percentage of water remains high in albumen produced in these after-dosage periods.

"It seems clear that dosage of ring-doves with quinine sulphate causes less than the normal amount of nitrogen to be released by the albumen-secreting gland of the oviduct during the secretion of egg albumen."

CHEMISTRY OF BRAINS OF ATAXIC PIGEONS.

Dr. Oscar Riddle, in collaboration with Miss Mathilde L. Koch, of the Psychiatric Institute of the New York State Hospitals, has concluded a second study of the chemical constitution of the brains (cerebrums), analyzed separately from the cerebellums and medullas, of the strain of ataxic pigeons which has been developed in our collection. The conclusions drawn from the study are as follows:

"(1) The brains of birds which have lost a very large amount of the normal control of the voluntary movements (ataxia) show deviations from the normal brain in size and in chemical composition. These deviations are more pronounced in the cerebellum.

"(2) The brains of the ataxics are smaller. The cerebrums are either not reduced or are reduced in very small amount. The cerebellums and medullas (weighed together) are certainly reduced in size.

"(3) Eight analyses were made of anterior and posterior parts of the brain. Four of these were from ataxic and four from normal birds. The chemical changes found are more definite and pronounced in the cerebellums and medullas than in the cerebrums. The results support our previous conclusion that the differences 'suggest a chemical under-differentiation or immaturity of the ataxic brains.'

"(4) The pigeon cerebrum and cerebellum strongly contrast with the human cerebrum and cerebellum in the distribution of the several chemical constituents.

"(5) Entire brains of very young and of very old birds were analyzed. Data for the chemical changes in the brain which accompany age have been obtained for a series of ages in the pigeon. Examination of this more extensive 'age series' of pigeon brains has enabled us to evaluate much better than in our previous work the relation borne by the various chemical fractions to age.

"(6) The significance of the results obtained in the present and former series of analyses has been reviewed. The evidence warrants the conclusion that chemical differentiation does not proceed as rapidly in the brain, and more particularly in the cerebellum, of ataxic birds as in the brain of normal birds.

"More than a year ago several of these ataxic birds were sent to the Neurological Laboratory of the University of Chicago, where Dr. T. Hoshino has made a very extensive neurological study of the ataxic brains. His study is now complete and will be published simultaneously with our second paper on the chemistry of the brains."

VEGETABLE SAPS; OSMOTIC CONCENTRATION.

These studies, conducted primarily by Dr. Harris, have been outlined in considerable detail in preceding Year Books. The time available for these studies during the current year has been chiefly devoted to field work, but a discussion of the osmotic concentration of phanerogamic epiphytes, based on studies in Jamaica and in subtropical Florida, has been published. In this it has been shown that the concentration of the tissue fluids of epiphytic Bromeliaceæ, Piperaceæ, and Gesneraceæ is far lower than that of terrestrial vegetation. Furthermore, in the Bromeliaceæ, Orchidaceæ, and Piperaceæ the concentration of the species of the Jamaican rain-forest is lower than that of those found in the hammocks of subtropical Florida.

Two periods have been devoted to work in the field. The first covered the months of January, February, and March, which were spent in the mainland swamps and on the Gulf Keys of the west coast of Florida. The second covered the months of July and August, which were devoted to work along the Atlantic seaboard from the mouth of the Chesapeake to Biscayne Bay. These operations were carried out, in cooperation with the Department of Botanical Research, on a small yacht kindly placed at Dr. Harris's disposal by a friend. Mr. John V. Lawrence and Mr. M. C. E. Hauke, of the University of Chicago, took part in the operations along the Atlantic coast. Over 1,000 determinations of osmotic concentration were made by the cryoscopic method in these two field operations, but the data are not yet organized for discussion.

COOPERATIVE WORK ON HUMAN NUTRITION.

During the year Dr. Harris has published jointly with Dr. Francis G. Benedict, Director of the Nutrition Laboratory of the Institution, a "Biometric Study of Basal Metabolism in Man." This book is a compendium of statistical information, not only for the student of nutrition, but also for the anthropologist. With the assistance of his biometric assistants, Mr. Harris has worked out numerous correlations between age and stature, age and weight, weight and body-surface, weight and pulse-rate, weight and heat production, and many other elements involved in modern calorimetry. These correlations are worked out for athletes, for men in general, for women, for infants, and comparisons are made for diverse races. Some of the results of the study are to demonstrate practically no relationship between basal or normal pulse-rate and body-weight in adults, or between pulse-rate and stature. The larger gaseous exchange is associated with a more rapid pulse-rate, and the same is true of more rapid heat production. There is a close relation between gaseous exchange and body-weight and between total heat production and body-weight. It appears that throughout the whole range of adult life the heat production of in-

dividuals decreases with age. The statistical analysis shows that the body-surface law, according to which the heat production of an organism is proportional to its superficial area, is not strictly valid, but the basal metabolism in men is, on the average, higher than in women, and the actual heat production in men is higher than in women, even when the difference in physical make-up is taken into account; but no special difference is obtained in infants of the two sexes.

BIOMETRIC MISCELLANY.

Dr. Harris has undertaken, with the aid of his computing force, to make certain statistical studies on variation, correlation, and probable error on plot tests in cooperation with the Office of Western Irrigation Agriculture and the Office of Dry Land Farming of the United States Department of Agriculture.

EUGENICS RECORD OFFICE.*

C. B. DAVENPORT, DIRECTOR.

STAFF.

During the year ending September 1, 1919, the work of the Eugenics Record Office was seriously interrupted by the war. The extensive investigations of Captain A. H. Estabrook into the great family of Ishmaelites of Indiana and adjacent States have not been continued, owing to the fact that Dr. Estabrook remained, up to the time of report, in the United States Army in the psychological, and later in the reconstruction, service. Dr. Wilhelmine E. Key left March 1 to undertake the organization of a State girls' industrial school near East Lyme, Connecticut. Despite these limitations, progress has been made in several matters.

HEREDITY IN ARISTOGENIC FAMILIES.

First may be mentioned the work of Professor Howard J. Banker, who has for some years been engaged in a study as far removed as feasible from that of the defective stocks in which most of our studies have been made. No excuse or apology is necessary for having, hitherto, devoted the energies of the Office so largely to the cacogenic side. First of all, social needs seemed more pressing in this line than any other. Secondly, this aspect of eugenics brought us into close relations with superintendents of institutions and we thus secured the entrée into many homes and the cooperation of the State in the expense of the investigation.

It is an unfortunate result, however, of laying too much emphasis on this aspect of eugenics, that the term has come to have so largely a cacogenic connotation. To this situation the investigations of Dr. Banker will, it is believed, serve as a corrective. The characters that are popularly called "normal" are as clearly hereditary as any others; indeed, the very fact that they are so common in the race that they are taken for granted is the best evidence that they form the basal heritage of the race. As Doctor Banker says:

"The study of human heredity can never be complete, or even satisfactory, until these 'normal' traits are compiled and classified and their distribution through families and races are accurately described. But there are few accumulations of data on this phase of the general subject. The physician does not record the 'normal' reactions of his patient; they are assumed. 'Normal' individuals have not been segregated in institutions and had their behavior and reactions keenly observed, accurately recorded, and scientifically classified. Here, then, is an important and extensive field for observation which must be explored in order to lay a real foundation for all studies in heredity. The fact that the progress of civilization has developed no natural

*Situating at Cold Spring Harbor, Long Island, New York.

facilities for the accumulation of such data renders it all the more important that the work should be inaugurated and prosecuted persistently, to this specific end, through generations of time, by some suitably organized institution or institutions.

"There is one part of our social organization in which the normal individual might be studied and accurate records accumulated with the fullness and value shown in many of our institutions for defectives. That is the public-school system, from the kindergarten to the college. As yet, no attempt to utilize these institutions, in any comprehensive way, for the accumulation of complete and systematic records has been made.

"The present and past records of the schools, while often employed to draw fine quantitative distinctions in the awarding of prizes and determining rank in scholarship, are, nevertheless, very imperfect, unstandardized, and as a rule of much less value than they should be. College records should be better. Harvard University probably possesses the most complete and continuous records extending over the longest period of time of any institution in the country. Advantage was taken of this fact to utilize these records, as far as possible, and supplement them by a study of the family histories of the individuals represented. As was to be expected, these families are prevalently normal and efficient, with a tendency, apparently, to produce superior, rather than inferior, individuals. A remarkable, though not wholly unexpected, result that has developed is the fact that a large proportion of these selected old Harvard families are so intermarried that, as the study is extended, most of them tend to form part of a continuous family network."

During the past year and a half Dr. Banker has been almost wholly engaged in compiling biographical data of the individuals of one section of this network. This has now included incomplete studies of over 3,000 individuals, of whom nearly 500 are college graduates. It should be remembered that probably half of the total number of individuals are females, for whom, except in the case of a few of the latest generation, there are no college records. Approximately 1,000 letter-size pages of notes and citations from more than 400 works have been made, while probably more than four or five times that number of works have been consulted. As near as can be judged, the network has been only about two-thirds covered. No attempt has yet been made to analyze these data, to which additions are still being made. "A surprisingly large amount of biographical data, more or less satisfactory, concerning the individuals of these families is to be found in various publications. If they did not all get into the colleges," says Dr. Banker, "they did get into the books and papers. Many of the most valuable items are buried in 'Reminiscences' and 'Autobiographies' of their friends, or enemies, and other works not ostensibly concerning the person sought and, hence, not discoverable through the usual library indexes."

Meantime, with the work of analyzing the inheritance of the traits of successful men must go hand-in-hand the analysis of personality and a consideration of the "springs of conduct." A little attention to this matter brings out strongly the fundamental result that it gives us

pleasure to do those things for the doing of which well we have special gifts. Attempts to do things for which we have no natural aptitude are distasteful; but we like to do the things that we can do well; and we can do well, after a little training, things for the doing of which we have natural aptitudes. So we like to do the things for which we have natural aptitudes.

These conclusions are supported by the work on "Naval Officers, their Heredity and Development," prepared by the Director, with the assistance of Miss Mary F. Scudder, and published by the Institution. This study shows that naval fighters are chiefly hyperkinetics (over-active). In their youth they were nomadic, thalassophilic, adventurous. Other naval officers were such because they were great strategists (like St. Vincent), administrators (like Stockton), explorers (like Sir John Franklin), and adventurers (like William B. Cushing). Each type has its prevailing temperamental and intellectual equipment. Each officer, as a boy, gave promise of his adult performance. One of the most widespread traits among naval officers is love of the sea (thalassophilia). This is an inherited racial trait, a fundamental instinct. In inheritance it acts like a recessive that is also sex-limited, so that it shows itself almost exclusively in males. Another trait of fighting naval officers is, as just stated, hyperkinesis, a dominant trait. Still a third is nomadism, a sex-linked trait. Thus, the total inheritance of great naval fighters and explorers is complex.

INBRED COMMUNITIES.

Another investigation that is under way is that of certain isolated island communities, to learn the results of inbreeding in those communities. Some years ago, Miss Mary M. Sturges spent 18 months, at intervals, in one such locality and 6 months in another for comparison with the first.

"In the first island a fairly complete genealogy was obtained of the descendants of twelve children from a marriage dating 1800, with ancestral and collateral lines so determined that relationships are quite accurately known. A rougher, although fair, genealogy was obtained in the second island, and an endeavor was made to furnish each with a good historic and descriptive setting.

"Since consanguineous marriages subsequent to 1825 have formed 48 per cent (first-cousin marriage 11 per cent) of all, so many ancestors were common that direct and collateral branches could be unusually well known. Thus, aside from a useful addition to our knowledge of the sociological elements of isolation and inbreeding, the material affords by comparison of branches and location of traits in inheritance a background for such intensive work as may seem desirable. By means of such comparison and one rough census of 6 of the 12 complete branches (2 parallel first-cousin marriages, 4 parallel marriages of a set of brothers with a set of sisters), certain traits have been roughly located and the two months this summer have been spent in tabulating them; the incidence of left-handedness; red hair; albinism, asthma, hayfever, eczema, and angioneurotic edema; twinning; congenital anomalies, single or

apparently linked in inheritance; nervous instability, best recognized as epilepsy in one strain, insanity in another, and feeble-mindedness in a third—such form a promising field if careful, intensive work be available for a sufficient time upon one well-known genealogy.”

DEFECTS IN DRAFTED MEN.

Most of the time of the Director was spent in the Surgeon General's Office, Washington, on work akin to that of the Eugenics Record Office, namely, the distribution of defects found in drafted men and the physical measurements of such men. Four reports were projected and, of these, one is published (June 1919); one is in the hands of the printer; a third is over half done, and material for the fourth, the proportions of soldiers of different races and sizes, is being collected.

The first of these reports, published in collaboration with Lieut. Col. A. G. Love, is entitled “Physical Examination of the First Million Draft Recruits: Methods and Results,” and shows clearly that the varying proportion of defects detected at camps in accepted recruits from various States depends upon sundry causes, in part social, in part biological. The vast number of weak feet found was one of the features of the report. About one-fifth of all recruits showed weak feet, and this defect was commoner in recruits from the cities than from rural districts. This result indicates that the human foot is poorly adapted to the demands made upon it by modern civilized life. Even recognizing that much of the foot defect is due to wearing fashionable foot-gear (so that it is commoner in the Northern than the Southern States), yet the fact that it is common in rural districts, and especially where the population is of tall stature and heavy, indicates that the relatively recent adjustment to plantigrade locomotion of a foot that in the ancestors served for arboreal locomotion is far from meeting satisfactorily the requirements of our social organization. Again, hernia, more or less developed, was found in 3.5 per cent of the recruits. Here, again, there is evidence of a widespread, imperfect adaptation of the muscles and fascia of the inguinal region to carry the load and resist the pressures that accompany man's operations in an erect posture. Again, varicose veins and varicocele were found in great numbers, especially among tall recruits, indicating that the walls of veins of the legs and lower trunk are not always perfectly adjusted to the new hydrostatic problems introduced by man's erect position. Probably an important part of the “mental deficiency” is a heritage from neolithic and paleolithic man.

It is probable that part of these disharmonies between posture and size, on the one hand, and ability of parts to meet demands made on them is due to the hybridization between short and tall races that has been going on in this country, by which developmental tendencies adapted to small races have come to be associated with tendency to development of great size of body.

On the social side, there were about 3.3 per cent of recruits with venereal disease; but much more among the colored recruits than the white. Absence of fingers, arms, and legs were most frequent in regions of saw-mills, of cotton-mills in the South, and in cities largely made up of workers in railroad shops and of other present or former railroad employees.

The problem of goiter was brought out vividly when two great goiter centers were revealed—one about the Great Lakes and the other in the extreme Northwest.

The excess of pulmonary tuberculosis from the desert sanatoria States of the West revealed the great extent of the migration thither of the tuberculous.

The result of the draft was not such as to justify pessimism as to the national physique. Defects were found in less than half of the drafted men; and it is fair to conclude that in less than 8 per cent of the men was the disability of such a nature as to handicap the man in an important way for civil duties.

Since the remainder of the statistical work on the physique of the men of military age is not yet published, it will not be discussed here. It is believed that the experience gained by your Director in studying this data will be of no little use in further developing the work of the Eugenics Record Office.

FIELD WORK.

The work of Dr. Elizabeth C. Muncey during the year has been of a varied sort. On the one hand, she has secured extensive genealogical data on military men. For this purpose she has utilized the Library of Congress. She has also done some field work on twin-producing families and on families showing other traits which occurred in the territory traversed by her. Reports on all of her researches have been deposited at the Office.

STERILIZATION LAWS.

Dr. H. H. Laughlin, superintendent of the Office, has prepared for publication a work on the legal and legislative aspects of eugenical sterilization in the United States.

STATISTICAL STUDY OF STATE INSTITUTIONS.

The Bureau of the Census reports that the statistical study of State institutions for the socially inadequate, prepared during the years 1915 to 1917, the publication of which was delayed on account of the war, is now in press. This work gives a short historical account and, in detail, a statistical analysis of the accommodations, the movement of the population, and the administrative and maintenance expenditures of each of the 634 State and National institutions for the several types of the socially inadequate. It will appear under the title "A Statistical Directory of State Institutions for the Care of Defective, Dependent, and Delinquent Classes."

ELIMINATION OF MONGREL BLOOD BY OUT-BREEDING.

Statistical studies on the relation between the number of chromosomes characteristic of the species and the rate of the elimination of mongrel blood by the pure-sire system of breeding (on the assumption of no "crossing-over") are being made by Dr. Laughlin. A preliminary report of this work was given before the Society for Experimental Biology and Medicine on May 24, 1919.

ARCHIVES.

A large and important part of the current activities of the Office is devoted to the securing, filing, and indexing of data to be available for special studies.

Schedules.—For the purpose of the collection and recording of data, schedules are prepared and are distributed to collaborators or held in the office, as the case may require. Three of these schedules were printed during the year:

(1) Schedule for the cooperative use of genealogists and biographers. This is a 4-page, 5 by 8 inch folder. This was issued in November 1918, and is designed for the use of genealogists and biographers (*a*) in listing the families and individuals being studied, and (*b*) describing the forms and methods used in securing, recording, and preserving biographical and family-history data. Also (*c*) it urges the desirability of recording in the usual family history and biographical studies more data descriptive of inborn physical, mental, and temperamental traits.

(2) Index of fragmentary data or abstract form. This is a single 5 by 8 inch sheet, issued March 1919. The purpose of this sheet is to facilitate the condensation and preparation for permanent filing and proper indexing of the fragmentary data which come to the attention of the office from time to time; also for abstracting from letters and other sources fragmentary data and references of eugenical import which, if preserved only in the original form, would probably ultimately be lost in the dead-files.

(3) Study of heredity of weight, a single 5 by 8 sheet, issued April 1919. This schedule is patterned after a similar form on stature, which latter proved very valuable in securing pedigree records.

Clippings.—The new system of filing newspaper clippings has been installed and is developing satisfactorily. For this work 5 by 8 inch manila pockets or envelopes without flaps are provided as containers. The clippings are pasted on manila sheets which fit into these envelopes, which are then duly indexed and added to the proper file, according to whether the clippings are biographies or descriptive of special traits. 4,000 envelopes have been opened, which at present contain 4,800 sheets of biographical material and 575 of special trait descriptions.

FILER'S HAND BOOK.

New instructions for classifying, filing, and indexing.—A new scheme for classifying, filing, and indexing all records, books, and correspond-

ence of the Eugenics Record Office has been worked out and described in detail in a mimeographed pamphlet of 23 pages. These instructions provide for the three types of eugenical records—the archives, the library, and the correspondence files. The new system is based upon the experience of the past decade in classifying and indexing eugenical material. The Dewey Decimal System is incorporated into the library scheme. The plan for classifying the archives is a new one in which the different types of records are distributed among 19 files, each designated by a distinctive letter. The material within each file is classified according to the trait-book (Bulletin No. 6 of the Eugenics Record Office). The system of classifying correspondence is one devised for the particular needs of the office and, like the Dewey Decimal System for classifying books and the subject decimal classification of the War Department correspondence file, is an indefinitely expandible decimal scheme. It provides also for ample cross-references.

Additions to archives.—The care of the archives has remained in the hands of Miss Louise A. Nelson. She furnishes this summary of material added to the archives during the year, September 1, 1918, to September 1, 1919:

Index cards..... 74,149 Persons-index..... 240 Manuscript material: Field reports: Pages of description... 3,648 Sheets of pedigrees.... 523 Individuals charted.... 17,310 Records of family traits.... 174	Family distribution of personal traits.. 3 Additional individual analysis cards... 64 Biographies..... 53 Genealogies..... 76 Genealogical pamphlets..... 3 Town histories..... 30 Lists of genealogies..... 2
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This report brings the total number of index cards reported up to 684,064. Since each card has space for 40 entries (though in most cases there are only 1 or 2 entries), it is certain that the entries must be much over 1,000,000 and probably nearly 2,000,000. Of special field workers' reports we have now 56,825 pages. Of the record of family traits there are on file approximately 3,000.

TRAINING COURSE.

The 1919 training course for field-workers in eugenics was in session from July 2 to August 12. There were 16 students in the course, thus bringing the total number who have been trained by this office for field-workers up to 192. The demand for competent field-investigators is greater than the supply.

JOINT-BASIS FIELD-WORKERS.

An important element of the work of the office is the introduction of eugenical field-studies as a part of the regular work of custodial institutions for the several types of the socially inadequate. This has been worked out on the joint-basis plan, whereby the Eugenics Record Office trains the worker and pays her salary and the collaborating institution provides the maintenance and traveling-expense money. Two new joint-basis field-workers have been assigned for

the year beginning October 1, 1919, as follows: (1) Virginia Rohde, 1919, to the State Hospital at Bangor, Maine; (2) Cornelia Augenstein, 1919, to the Girls' Training School at Gainesville, Texas. Owing to war conditions, the contract for a joint-basis worker made a year ago with the Central Islip State Hospital at Central Islip, New York, was discontinued in April 1919. The contract is being completed by assigning (3) Miss Dorothy Aldridge, of this year's training course, to 6 months' work at Central Islip, beginning September 1, 1919.

Custodial institutions which have introduced modern eugenical field-studies by the joint-basis plan now number 53.

VOLUNTEER COLLABORATORS.

Superintendents of institutions who have once introduced modern eugenical field-studies into their work continue to send for deposit at the Eugenics Record Office copies of family-history studies made independently by their own workers. This year special mention should be made of contributions from Dr. David F. Weeks, superintendent of the State Village for Epileptics at Skillman, New Jersey; of Dr. Fred C. Nelles, superintendent of the State School at Whittier, California; of Dr. Floyd C. Haviland, superintendent of the State Hospital at Middletown, Connecticut; of Dr. F. Kuhlman, of the Minnesota School for Feeble-Minded at Faribault, Minnesota; of Dr. Oscar E. Thompson, of the State Institution for Feeble-Minded of Eastern Pennsylvania, at Spring City, Pennsylvania; of Dr. C. A. Potter, of the Gowanda State Hospital at Collins, New York; of Dr. Chester L. Carlisle, director of the Bureau of Analysis, State Board of Charities, at Albany, New York; and of Dr. Charles S. Little, superintendent of the Letchworth Village for Epileptics at Thiells, New York. Besides these institutions, a number of eugenicists have, on their own account, been equally generous and attentive in their collaboration. During the past year eugenical records have been contributed to the archives of the Eugenics Record Office by Professor Will S. Monroe, Montclair, New Jersey, and many others.

EUGENICS RESEARCH ASSOCIATION.

On February 18, 1919, the executive committee of the Eugenics Research Association, acting in consequence of instructions given by the association at its previous annual meeting, passed a series of resolutions seeking the cooperation of the State and National governments and organized societies and State institutions in eugenical research, and the application of practical eugenical matters.

The seventh annual meeting of the association was held at Cold Spring Harbor on June 20, 1919, under the presidency of Mr. Madison Grant. A committee was appointed for the purpose of representing the Eugenics Research Association in connection with the organization of a forthcoming international eugenics congress. The president for the year 1919-20 is Dr. Stuart Paton, of Princeton, New Jersey.