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DEPARTMENT OF GENETICS.[1]

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GENERAL STATEMENT.

In its second year following reorganization the work of this Department has shown itself especially productive, justifying the hopes we have had that the combination of research in plants, animals, and man would be a fruitful one. Despite the large extent of subjects covered, all investigations fall under the one subject of inquiry: the gametic constitution, its mechanism, its combinations, and their somatic manifestations.

While all investigations have been unusually prolific, three are sufficiently outstanding to warrant special mention. These are, first, the experimental modification of the germinal constitution in mice; second, the rapid opening up of the phenomenon of aberrations in the chromosome-complex of *Datura* and the mutations that result therefrom; and third, new light on the control of sex and the sex-ratio.

As modern genetics has been bringing to light the dependence of somatic form and structure on the architecture and number of chromosomes, the urgency of the problem of the experimental control of the structure and number of chromosomes has become more pressing. Indeed, not until such control is secured may the era of experimental evolution strictly be said to have been entered upon. While attempts to modify the germ-plasm may have been more or less successfully made by Stockard and McDowell with alcohol, by Guyer with cytolysins, and by others, yet none of these have yielded a type of inheritance that lent itself to Mendelian analysis. In this respect the results obtained by Dr. Little, with the cooperation of Dr. H. J. Bagg, are much more clean cut. By subjecting mice to X-rays some grandchildren were obtained with abnormal eyes. These were then bred from and subjected to the ordinary genetical analysis. Apparently a single-gene mutation affecting the eye has been induced, and this reappears in subsequent untreated generations like a Mendelian recessive. Moreover, in one or more chromosomes other genes have apparently been set mutating so that abnormal heads, appendages, trunk, and epidermal organs are appearing. Inasmuch as the control of mutation is the experimental control of evolution, outside of and beyond the ordinary operations of hybridization, the possibilities of such experimental control (now in its infancy) can not be overestimated.

The second outstanding result is the further analysis of the variations of the chromosomal complexes and their corresponding somatic mutation. Variations in the number of chromosomes had, indeed, been seen by others; that "non-disjunction" was accompanied by somatic modifications had been shown by Bridges in *Drosophila*; but it has remained for *Datura* to reveal in the hands of Blakeslee and his associates, Belling, Farnham and others, an extensive system of inter-chromosomal mutation and corresponding somatic change the like of which had been entirely unknown.

The studies of Morgan, Sturtevant, Bridges, and Muller of gene mutation and of Blakeslee and his associates on holochromosomal mutation, as well as

[1]Situated at Cold Spring Harbor, Long Island, New York.

those of Metz on chromosomal homologies and chromosomal fragmentation, elevate *the chromosome* to the position of the principal mechanism of heredity and evolution. It illustrates the slowness with which new discoveries filter into popular knowledge that the very name of the chromosome—so fateful for mankind and civilization—should still be almost unknown outside of genetic circles and sometimes insufficiently regarded and recognized even by active biologists. To the geneticist, however, the chromosome with its genes affords another precious link between the complex phenomena of the development of the individual on the one hand and the constitution of matter on the other. There is certainly much in the phenomena of gene mutation with its prevailing recessive tendency, its measurable rate of occurrence, and its predictability, that shows at least many points of similarity to the gradual changes, by loss, of the salts of the uraniun-radium-lead series.

In earlier reports much emphasis has been laid on the fundamental biological phenomenon of sex, and regret has been expressed that we were able to enter so inadequately into that field, for whose investigation we have special facilities. Yet marked progress has been made during the current year in an understanding of the nature of sex. For some years Dr. Riddle has demonstrated that the pigeon's egg that is destined to produce a female has more stored food material than an egg that is destined to produce a male. He has been inclined to conclude that the special metabolic environment of the early embryo was the cause of its becoming a female. Other biologists have emphasized the rôle of the sex-chromosome in determining sex. But the two views are not irreconcilable, inasmuch as the chromosomes are, doubtless, regulators of the metabolism of the cell; but other conditions may control cell metabolism and in so far sex. Dr. Riddle, however, has forged a new link in the evidence of the influence of metabolism on sex. Pigeons forced to lay excessively lay an excess of large, female eggs. Ovulation is associated with a functional enlargement of the suprarenal glands; suprarenal hyperactivity causes an increase of sugar in the blood. This provides more food for the eggs at the time of maturation. This is probably why more large (or female) eggs are laid during the period of enforced, excessive ovulation.

In Cladocera, also, progress has been made in isolating the factor or factors that bring about the production of males. The evidence indicates that the determination of sex takes place at the time of maturation of the parthenogenetic egg and that something in the water of overstocked culture-vials influences the processes of maturation so that some of the eggs will develop into male individuals.

The opportunities for investigation in the field of genetics are limitless, and the field touches vast human interests in agriculture, physiology, and applied eugenics. In the past we have prospected rather widely, with the aim of finding the best lodes to work. With our limitation in resources and with fertile subjects of research in hand, it is clearly advantageous to concentrate upon a few of the most productive of them. Thus we are gaining in unity, and profit by the mutual criticism and cumulative ideas that come from cooperation.

DETAILED REPORTS ON INVESTIGATIONS IN PROGRESS

INTERCHROMOSOMAL MUTATION.

The work of the past year has extended the studies on mutations in the jimson weed (*Datura*) due to variations in chromosome number and probably due in turn to abnormalities in the process of formation of the gametes. This work has become so broad as to require the cooperative studies of a number of persons and we have been so fortunate as to secure the collaboration during the summer time of investigators who are connected primarily with other institutions. Besides Dr. A. F. Blakeslee, who has charge of these experiments, Dr. John Belling, who is making the principal cytological studies and Mr. M. E. Farnham, who has immediate charge of most of the work in the greenhouse and the field, we have had the cooperation of Professor E. W. Sinnott, of the Connecticut Agricultural College at Storrs, who has been studying the internal anatomy of the Daturas and as a result of that study finds he is able to recognize the majority of the mutants from an examination of their tissues; of Dr. John T. Buckholz, who has been studying, with the use of a newly perfected method, the growth of pollen-tubes and abortion of ovules as problems in developmental selection. Miss Dorothy Bergner and Miss Lois Lampe have helped respectively in making chromosome counts, in counting pollen, and assisting in hybridization. Mr. J. L. Cartledge has again acted as summer recorder.

In addition to the securing of further data upon the breeding behavior of types mentioned in the Year Book for 1921, pages 104 to 107, work has been done on certain new types which have been discovered. These may be treated collectively under the heads of balanced and unbalanced types.

Balanced Types of Datura Mutants.

One of the most fundamental doctrines of genetical biology is that the germ-cells before union contain half of the number of chromosomes of the fertilized egg or developing embryo (zygote). It has been assumed that, except in the case of parthenogenetic species, the soma must contain chromosomes in sets of two, one of paternal and one of maternal origin. One of the most notable discoveries of the year was the finding of five haploid or $1n$ plants, which appeared in the offspring of parents treated with cold in an attempt to induce mutations by external stimuli.

They were early recognized as new forms by external appearance, but more definitely by the condition of the pollen. The 12 chromosomes in their pollen mother-cells undergo a pseudo-reduction into $8+4$, $7+5$, etc., a process which suggests that a paired condition of the homologous chromosomes is not necessary for the reduction division in gametogenesis. Occasionally a pollen mother-cell fails to undergo reduction, and normal $1n$ grains are produced which apparently function like pollen from a normal diploid ($2n$). The few seeds we have obtained this season from selfing our haploids ($1n$) have given rise to diploids ($2n$) which are of considerable genetic interest, since they furnish a new method of rendering a stock homozygous without long inbreeding. Coming from plants with but a single chromosome in each chromosomal set, the paired chromosomes in each set of these diploids must be identical. Hence, barring new mutations, diploids derived from a given haploid must be completely homozygous, as alike as identical twins.

A paper on inheritance in tetraploid Daturas now ready for publication gives records of color in over 37,000 individuals and forms the basis for the conclusion that the ratios of purples to whites obtained from combining the various genetic types are brought about by a random assortment of chromosomes in the purple-white chromosome set.

Dr. Blakeslee has reported further as follows:

"Tetraploidy may have been of influence in evolution. An experimental proof of this belief would probably demand the transformation of a tetraploid with 12 sets of chromosomes each into a double diploid with 24 sets of 2 chromosomes each. A single plant last year appeared to be duplex for the purple and armed factors and to give 15:1 ratios for both these two factors in its offspring, a result to have been expected if the plant had been a double diploid. Plants in the next generation, however, gave normal ratios characteristic of typical tetraploids and showed that, if the plant were in fact a double diploid, the condition had not been transmitted to its offspring.

"The assumption seems reasonable that competing plants in nature are diploid, although few forms have been critically tested and proven to be diploid rather than tetraploid either by breeding or cytological evidence. In order to discover if tetraploids are capable of establishing themselves in nature, we planted out on Goose Island this spring a score of tetraploid plants of *Datura*, and plan to leave them to seed themselves in competition with other species.

"The most expeditious way to obtain the full range of different $(2n+1)$ mutants in a given stock is by crossing triploids $(3n)$ by diploids $(2n)$. Triploids we have never identified in the offspring when both parents were diploids, but they may be obtained by crossing tetraploids with diploids. We are interested, therefore, in having possibly discovered a method of identifying tetraploids in the seed stage. Seeds of tetraploid plants average distinctly larger than those of diploids and from the few large seeds out of many thousands examined from our chief main line one already has given rise to a tetraploid plant, the first that we have discovered in this line during the last 7 years in which it has been extensively planted. It is not impossible that by a similar method of selecting large seed from tetraploids $(4n)$ we may be able to discover an octaploid $(8n)$ individual.

"Our balanced series now stands $1n$, $2n$, $3n$, $4n$, and in general a corresponding increase in size from the $1n$ to the $4n$ condition can be observed in external parts such as leaf and flowers, as well as in their component cells. Such a quantitative change is to be expected from the increased number of chromosomes when the balance is not disturbed by an increase or decrease in individual chromosomal sets. Less expected is the qualitative change in shape from the $1n$ to the $4n$ condition. Considering the leaves of $2n$ plants to be normal, $1n$ leaves are distinctly narrower, and $4n$ leaves are broader. Further, the $2n$ capsules are ovate and $4n$ capsules are nearly spherical. Such qualitative differences between balanced types may be due to quantitative differences in the ease of division or of expansion of cells in the different directions or may be due to the factors in certain chromosomes passing critical points sooner than those in others when the balanced chromosomal number is increased or decreased.

"The condition of the pollen has been found to be a diagnostic feature of considerable value in distinguishing the different balanced types, before the formation of capsules. Thus diploids $(2n)$ have relatively good pollen; tetraploids $(4n)$ have pollen only slightly less perfect than diploids, but the

individual grains are distinctly larger; haploids have a high percentage of empty grains (around 75 per cent), and the few good grains present are mainly of the same size as those of diploids; triploids have not only a high percentage of empty grains, but the full grains are of various sizes. Modified diploids, triploids, and tetraploids have pollen characters resembling their balanced types, but generally with a higher percentage of empty grains. Pollen counts can not take the place of chromosomal counts, but they are useful in survey work in determining in which group individual plants probably belong."

Unbalanced Types of Datura Mutants.

"A paper is nearly ready for publication on trisomic inheritance of the color factor in the $(2n+1)$ mutant *Poinsettia*, which will embody color records on between 12,000 and 15,000 descendants of *Poinsettia* parents. The completed mass of data fully substantiates the idea of random assortment of chromosomes in the purple-white chromosomal set at the reduction division. This is true when the purple and the white factors come from closely similar lines (obtained from Washington, D.C.). When the white factor, however, is derived from a distinctly different line (obtained from Germany), an excess of whites regularly appears in the offspring from certain crosses. The matter is receiving further experimental investigation.

"The trisomic inheritance in the cocklebur mutant is similar to the more typical behavior in *Poinsettia*, except that recessive *inermis* plants appear where they would not be expected. A similar peculiarity in the inheritance of the same factors occurs in tetraploid races and indicates that there is some peculiar behavior of the armed-*inermis* set which is not evident in the purple-white set.

"It is obvious that if there are 12 sets of chromosomes there should be expected 12 mutants of the type $(2n+1)$. These we have called the twelve apostles. At the present time we have, however, at least 20 distinct mutants which, both from their breeding behavior and from counts of their chromosomes, are known to be of the $(2n+1)$ type. In certain cases we have been able to show that one of these mutants is a variety or "acolyte" of one of the apostles. The matter is under investigation, but a provisional hypothesis for which there is some evidence is that the difference between apostle and acolyte is due to a Mendelian factor which produces a visible effect only when certain of the chromosomes are in trisomes.

"Apparently a new type of mutation has occurred in this year's plantings, namely, a somatic mutation producing a sectorial chimera with one branch distinctly abnormal in appearance and the rest of the plant apparently normal. Pollen from the abnormal sector contains a high proportion of bad grains, and chromosomal counts in pollen mother-cells show the tissue to have the constitution $(2n-1)$. This fact suggests that some of the not infrequent bud mutations found elsewhere in plants, such as in the citrus group, may be due to somatic changes in chromosomal number.

"It has been established, that of the modified tetraploids, selfed $(4n+1)$ Globe plants produce over 50 per cent Globe offspring; that selfed $(4n+2)$ Globes produce around 90 per cent Globes; that pollen from a $(4n+1)$ Globe when used on a $4n$ female produces about 15 per cent Globe offspring, while pollen from a $(4n+2)$ Globe used on a $4n$ female produces about 70 per cent Globes.

"Non-disjunctional mutations occur much more frequently in tetraploids than in diploids, and in addition to simple $(4n+1)$ and $(4n+2)$ mutants, double, triple, and quadruple mutants have been discovered. Due to the comparatively slight unbalance produced by the change of a single chromosome in tetraploids, the types are not so readily identified by mere inspection.

In order to obtain an idea of the distribution of chromosomal types in the offspring of $4n$ and of $(4n+1)$ and $(4n+2)$ forms, a cytological study is being made of certain pedigrees from such parents by Dr. Belling, whose report is given on page 99 It may be said, however, that the type of disjunction for normal tetraploids with 48 chromosomes has been established and found to be distinctly different from that for certain 48 chromosome forms which, both from the somatic appearance, with ovate instead of spherical capsules, and from the breeding behavior, had been believed to be of the type $(4n+1-1)$ with a chromosome deficiency in one set numerically compensated by an excess in another. The study shows that of two plants, each with 48 chromosomes, one may be a true $4n$ tetraploid, while the other may be a modified tetraploid with two sets differently affected."

A summary may be given of the chromosomal types already identified. In most cases their chromosomal counts have been determined by Dr. Belling, though in a few instances they have been recognized by morphological appearance and breeding behavior. In the 4 balanced types ($1n$, $2n$, $3n$, $4n$) the 4 forms theoretically possible have been identified. In each of the unbalanced types with one set affected, 12 forms are theoretically possible, and we have identified the following: $(2n+1)$, $(2n-1)$, $(2n+2)$, $(3n+1)$, $(3n-1)$, $(4n+1)$, $(4n-1)$, $(4n+2)$, $(4n+3)$. Of each of the unbalanced types with 2 sets similarly affected, 66 forms are theoretically possible, and we have identified the following: $(2n+1+1)$, $(4n+1+1)$, $(4n-1-1)$. In each of the unbalanced types with 3 sets similarly affected, 220 forms are theoretically possible, but we have identified only one form of the type $(2n+1+1+1)$. In addition, we have identified a form of the type $(4n+1-1)$ of which there are 132 forms theoretically possible, and one form of the type $(4n+1+1-1-1)$ of which there are 2,970 forms theoretically possible. In the above summary only "apostles" are considered. If the "acolytes" were included, the number of possible forms would be greatly increased. It is obvious that an enormous number of forms are theoretically possible by aberrations in chromosome number. Only the even-balanced types can be expected to breed true, but the other types could be propagated vegetatively if they were of sufficient economic importance.

"An effort has been made to induce mutations in the jimson weeds by various external stimuli. Of the $(2n+1)$ mutants derived from capsules which had been subjected to radium rays by Dr. Gager, one (a microcarpic plant) produced when selfed an offspring with about one-fourth of the individuals albinos, which died as seedlings. The inheritance of this albino character is being investigated. Its origin is possibly due to the radium treatment. Cold is a stimulus which has a very marked effect upon the formation of at least the male gametophytes. By its use we have been able to induce non-reduction and disturbances in chromosome disjunction, as indicated by the production of a large number of giant pollen-grains, an increase in the percentage of bad grains, and a wide variation in the size of good grains, and finally the entire abortion of the pollen. The seeds obtained by selfing plants thus treated with cold have given rise, among other mutant types, to 5 haploid and 2 tetraploid seedlings, but, in the majority of the cases at least, apparently the rough and poorly controlled treatment did not happen to reach the female gametes at the critical stage, and it is the female rather than the male gametes which are effective in initiating mutations. We believe that with more accurately regulated cold-temperature rooms it would be possible to control the production of mutants by means of cold treatment."

Gametophytic Selection in Datura.

The investigations of Dr. John T. Buchholz, who has been associated with Dr. Blakeslee, have been carried on at Cold Spring Harbor during the summers of 1921 and 1922. In regard to the selection between male gametophytes, he reports as follows:

"In the Globe mutant the pollen-tubes with $(n+1)$ chromosomes are slower in their growth than the pollen-tubes with (n) chromosomes. This is shown by the fact that the pollen-tubes are grouped in a bimodal curve of distribution when Globe pollen is applied to the stigma, while normal pollen under comparable conditions forms essentially a unimodal curve of distribution. The fact that the pollen transmits the Globe character-complex to only a slight degree when pollen from Globe plants is placed on normal plants is therefore explained on the basis of differential pollen-tube growth."

Dr. Buchholz is also working on a selection of ovules within the ovary and seed capsule—"interovular selection."

The Cytology of Datura Mutants.

As his share of the joint cooperative work on Daturas under Dr. Blakeslee, Dr. John Belling has paid particular attention to the tetraploids. He reports as follows:

"*Normal tetraploids.*—In the late prophase and early first metaphase in the pollen mother-cells, the 48 chromosomes of a normal tetraploid *Datura* are usually connected in groups of four (quadrivalents). At the anaphase these separate 2 and 2, or 1 and 3 (non-disjunction). Examination of the distribution at the second metaphases shows that a division into 24 and 24 has occurred in from three-quarters to two-thirds of the pollen-mother-cells, while the others mostly show 23 and 25, and rarely 22 and 26, etc.

"Normal tetraploids with 12 sets of 4 homologous chromosomes each, should, if the chromosomes in the megaspores are distributed as in the pollen-mother-cells, and if any of the 23 or 25 chromosome pollen functions, give some progeny with 49 and some with 47 chromosomes (and more rarely plants with 46 or with 50 chromosomes). This is the case."

"*Abnormal tetraploids.*—The occurrence of double opposed non-disjunction would lead to the production of gametes with 24 chromosomes, having only 1 of one set and 3 of another. Crossed by a normal 24-chromosome gamete, the resulting plant would have 48 chromosomes, including 3 of one set and 5 of another. Such plants might show over 50 per cent of apparent non-disjunction, and might give up to a quarter of 47-chromosome or of 49-chromosome plants among their progeny, and up to one-sixteenth of 46-chromosome or 50-chromosome plants. Two plants with this large amount of non-disjunction have been specially studied.

"*Tetrads of normal tetraploids.*—Normal tetraploids have rarely shown cases of non-reduction (leading to the formation of 48-chromosome pollen-grains). Two pairs of giant cells have, however, been met with among nearly 3,000 tetrads. Such pollen-grains, if functional, would produce hexaploid $(6n)$ plants.

"*Progeny of tetraploid pollinated by normal.*—This difficult cross has resulted in 27 plants, of which 25 have had sufficient chromosome sets counted, and 2 are still somewhat uncertain. 14 were diploid and 2 had $13+12$ chromosomes. The origin of these is uncertain. Six plants of this cross were triploid; one had 35 and another 37 chromosomes. Judging from this evidence as to the

chromosomes in the egg-cells of the tetraploids, we have presumably 1 egg-cell with 23, 1 with 25, and 6 with 24 chromosomes. This is the same proportion as was found in the distribution in the pollen-mother cells, namely, three cells giving 24 and 24 to one cell giving 23 and 25.

"*Chromosomes of triploid Daturas.*—The results from crosses with tetraploid pollen add to the evidence as to the assortment in the megaspores. Combined with the previous results from triploid pollinated by diploid, we now have indirect proof as to the existence in triploid Daturas of egg-cells with 12, 13, 14, 15 . . . . . 22, 23, and 24 chromosomes.

"*Non-disjunction in diploid Daturas.*—A special examination of 500 second metaphases of normal diploid Daturas by Miss A. D. Bergner resulted in the finding of one (complex) case of non-disjunction (11 and 13). This rare non-disjunction is presumably the basis for the rare formation of $(2n+1)$ mutants.

"*Pollen-mother cells of haploid Daturas.*—The pollen mother-cells of the haploid being taken as 1 in volume (measured between the first and second metaphases inclusive), those of the diploids are nearly 2, the triploids nearly 3, and the tetraploids nearly 4.

"*Evolutionary significance of tetraploidy.*—If any natural species have lately sprung from tetraploids, they should, if their chromosomes differ in size, show 4 of each size instead of 2. They will then show 2 of each size in the haploid state. In studies of species for this purpose plants which show clear chromosomes may be classified as follows: (1) marked size differences; (2) size differences, no haploid pairs; (3) size differences, some haploid pairs; (4) size differences, all in haploid pairs."

COMPARATIVE STUDY OF THE CHROMOSOME GROUPS IN DIPTERA.

After it became clear through the work of Morgan, Sturtevant, Bridges, and Muller that characters of the adult *Drosophila melanogaster* are largely determined by genes which appear to have a definite locus in the chromosomes, it was a natural inquiry whether related species had a related construction of the germ-plasm. Since the problem of evolution of organisms has shifted from that of the soma of organisms to that of their chromosomes, inasmuch as mutations occur primarily in the chromosomes, it becomes important to know about the genetic constitution of the germ-plasm of related species.

This is the problem with which Dr. C. W. Metz is engaged, with the assistance of Miss Mildred S. Moses, Miss Ruth Ferry, and, temporarily, of Mr. S. K. Emerson. The work involves the genetic behavior of mutants. It is slow and laborious, but significant advances have been made.

Breeding Work.

In *Drosophila willistoni* the results of the study of 28 sex-linked mutant characters have been published during the year:

[These serve as a basis for] "beginning the detailed comparison of the genetic constitution of this species with that of the other species under observation. The recent discovery by Miss Ferry of additional mutant characters that appear to parallel those of other species provides the type of material needed for this comparison. The genetic relations of these characters have not yet been fully analyzed, but the available data suggested a more definite relation to conditions found in other species than was intimated in last year's report.

"In *Drosophila virilis*, whose study has likewise been continued during the present year, 44 mutant characters are now known, of which 11 are dominant characters. Present evidence indicates that 6 groups of linked characters have now been identified in this species, corresponding to its six pairs of chromosomes. The "chromosome map lengths" of these groups, based upon percentages of crossing over, range from approximately 110 units in the case of the X-chromosome to zero in the case of one group of three non-sex-linked characters. It is possible that the latter group represents the small, dot-like pair of chromosomes, although the evidence is not yet clear, partly because of the fact that the sixth group has not yet been tested for crossing over.

"Evidence from the sex-linked characters in *Drosophila virilis* tends more and more to indicate a genetic as well as morphological correspondence between the X-chromosomes of this species and those of *Drosophila melanogaster*. The non-sex-linked characters have not appeared in sufficient numbers to make possible a comparison of the non-sex-linked groups.

"With the accumulation of mutant types for comparison, both in these species and in species studied by other workers, significant results are obtained more and more rapidly. Furthermore, the element of speculation, which loomed large when the study of *Drosophila virilis* was first undertaken, has now been dispelled to a great extent by the appearance of parallel characters in this and other species. Such characters agree in different species to such an extent as to make the probability of homology very great; and this in turn allows a comparison of the genetic make-up of chromosomes in different species to be made with some assurance.

"If the present evidence is reliable, even in part, it indicates a considerable degree of stability in chromosomal organization over relatively long periods of time during the evolution of the species involved."

Work on *Leria pectinata*, on which a beginning was made by Dr. E. G. Anderson (Year Book, 1921, p. 112), has progressed in spite of various interruptions.

Dr. Anderson has also carried out the experimental study of crossing over in triploid flies, as a first step in which it has been necessary to make to order all of the flies to be used in the experiments. Each of the initial stocks to be used contains four or more mutant characters. The required compound stocks have been synthesized.

Cytological Work.

It is believed that progress will be most rapid when the cytological and the genetic methods of attack on the problem of chromosome organization and behavior are combined. The studies on spermatogenesis and oogenesis in various Diptera have been continued by Dr. Metz. Attention has been devoted especially to the exceptional conditions found in one of the robber flies, *Lasiopogon bivittatus* Lw., specimens of which were taken and prepared in Wyoming. In these specimens the spermatocyte nuclei at certain stages exhibit such peculiar relations between nuclear wall and chromosomes as to suggest that the latter are surrounded by thick, transparent envelopes of a gelatinous nature, which serve, among other things, to hold the chromosomes away from one another and from the nuclear wall.

The study of what appears to be incomplete synapsis of certain chromosomes during spermatogenesis in *Dasyllis*, reported previously, has been completed by Dr. Metz, together with a partial study of oogenesis in the same forms.

An examination of tetraploid somatic cells in *Sarcophaga* has indicated that in prophases of these cells all four homologous chromosomes of each sort come into intimate and equivalent association, just as do the two homologues in diploid cells.

In addition to the above, the comparative survey of chromosomal conditions in the Diptera has been continued, particularly by Miss M. S. Moses.

EXPERIMENTAL MODIFICATION OF THE GERM-PLASM.

Genetic Behavior of X-rayed Mice.

In the Year Book for 1921 reference was made to the experiments of Drs. C. C. Little and H. J. Bagg, in exposing mice to very small doses of X-rays. The dosage given was one-fifth of an erythemal dose for five successive days. The radiation was given over the whole body to both male and female parents. This part of the experiment was performed at the Memorial Hospital in New York City.

The further experiment involved the contrasting of the breeding behavior of these mice with that of untreated controls. Dr. Little reports:

"The first litters of young to be recorded from any of the treated animals did not appear until at least six weeks after radiation. As a general thing, these litters were slightly smaller than the normal litter size, although the young produced were apparently normal and healthy. These animals and their descendants have since been bred *inter se* with brother-to-sister matings. More then 4,500 mice have been recorded in these experiments. Approximately 1,000 of these are descendants of the untreated controls. Among these have appeared two grossly abnormal individuals, both in a single, unusually large litter. Experiments are now being conducted to determine whether or not this tendency to produce abnormals is hereditary, and if so, what the type of inheritance is. Information on this point should be obtainable within the next year. Among the descendants of the X-ray pairs, more than 275 grossly abnormal individuals have been obtained. It has been possible to group these abnormalities somewhat as follows:

"(1) *Eye lesions.*—These are usually hemorrhagic, involving a dry or crusted appearance of one or both eyes. This abnormality is clearly visible at birth and persists throughout the lifetime of the individual, usually producing blindness due to clouding atrophy, and in rare cases apparently complete absence of the eye. The inheritance of this abnormality has been carefully studied, and it has been found to be Mendelian in its behavior and recessive in nature. The recessives, when bred together, do occasionally give individuals somatically normal in appearnace, but these are merely somatic "overlaps" and breed as abnormals. Since the type of lesion appearing in this abnormality usually involves hemorrhagic areas, the symbol h has been given to this mutation, with H as its normal allelomorph.

"(2) *Abnormal head.*—This abnormality involves a series of different types. The commonest of these shows defects in, or absence of, the lower jaw. Correlated with these appears reduction or absence of the mouth opening and of the tongue. Occasionally, due to the reduction of the lower jaw, the tongue appears large and protruded from the mouth. Naturally these mice are either born dead or die soon after birth, since it is impossible for them to nurse, and in some cases to breathe. At other times the eyes are also involved, but in these cases there is no lesion to the outside, as in the types described under heading (1). The eyes are either merely reduced or perhaps more commonly

completely absent. This condition may or may not be accompanied by abnormalities of the mouth and jaw already referred to. When the mouth is normal and one or both eyes abnormal, the mice may live for 5 or 6 weeks. Such individuals are, however, always undersized, highly nervous, and weak. None of them has attained breeding age. The effect of this modification is, then, always lethal, although the lethal action may be in some cases delayed for a considerable period.

"(3) *Foot and leg abnormalities.*—These involve a reduction of digits, syndactylism, and other abnormalities of any or all of the feet and legs. This abnormality in all probability bears some relation to the eye-lesion abnormality, although the genetics have not been clearly worked out as yet.

"(4) *Hair abnormality.*—This involves a shortening of the hair on one or both flanks. In pigmented mice this produces a lighter degree of pigmentation in the regions where the hair is shorter, thus producing a "saddle" effect. This abnormality has not yet been worked out in relation to those already described, but it is clearly distinct and is extremely striking in appearance. Its identity as a structural character has been determined by its appearance on an albino.

"(5) *Lesions involving the entire cranium.*—These occurred in the same family as that giving the first described type of hemorrhagic eye abnormality in some 8 or 9 mice which were born dead with partial or total absence of the cranium. These acraniate forms are very striking and are unlike any other abnormalities hitherto described in mice.

"(6) *Minor abnormalities of the eye involving breaks in the ring of iris pigment to greater or lesser extent.* These have occurred in only a few cases and, as it happens, the mice have not survived.

"(7) *Spinal lesion.*—This has occurred in one animal, resulting in death a short time after birth. The lesion was in the sacral region, and superficially resembled spina bifida."

In order to determine whether or not there is a direct effect of X-rays upon the treated animals themselves, Miss Margaret Schneider and Mr. L. H. Snyder are sectioning a series of eyes and gonads of animals which received the same dose as did those used in the original X-ray experiment.

Modifiability of the Germ-Plasm by Alcohol.

This experiment, which has been continued for 6 or 7 years, may now be considered practically completed. Though with the use of rats no such striking results were obtained as reported by Stockard for guinea-pigs, nevertheless a clear effect of alcohol in reducing the capacity for learning in the treated generation was found; and this effect persisted to the next generation, even if that generation was not subjected to further alcohol.

It remained to learn if there were any slight morphological effects of the alcohols, and, if so, any persistence of those effects to the next generation. To this end the skull and the bones of the appendages were saved for measurement. By an accident many rat skulls of the parental and first filial generations were destroyed. However, 472 skulls altogether have been measured in four dimensions: total length, width, height, and length of nasal bones.

When this total is subdivided according to the generation and sex, the numbers are too small to afford a basis for any conclusion as to the relative size of tests and controls. The work was done under Dr. MacDowell's direction by the Misses Vicari and Hubbard.

THE SIGNIFICANCE AND CONTROL OF SEX.

Relation of Reproductive Overwork and Storage Metabolism of Ova to Sex.

During the year Dr. Oscar Riddle has obtained new light upon the mechanism of "reproductive overwork" (Whitman, Riddle) by the observation that the suprarenal glands of female pigeons undergo marked and prolonged hypertrophy in very exact coincidence with each ovulation period (dehiscence of two ova); and by the further observation that the carbohydrate metabolism of the bird undergoes a simultaneous change, as shown by an increased concentration of the sugar of the blood. The data for the latter point were obtained by Dr. Riddle with the cooperation of Dr. H. E. Honeywell, of the Department of Physiology, Columbia University. Both of these results are represented in curves, figure 1, which shows, in addition, that the oviduct begins a pronounced temporary enlargement, and one or two ova begin a period of extremely rapid growth, both coincident with the beginning of hypertrophy in the suprarenals.

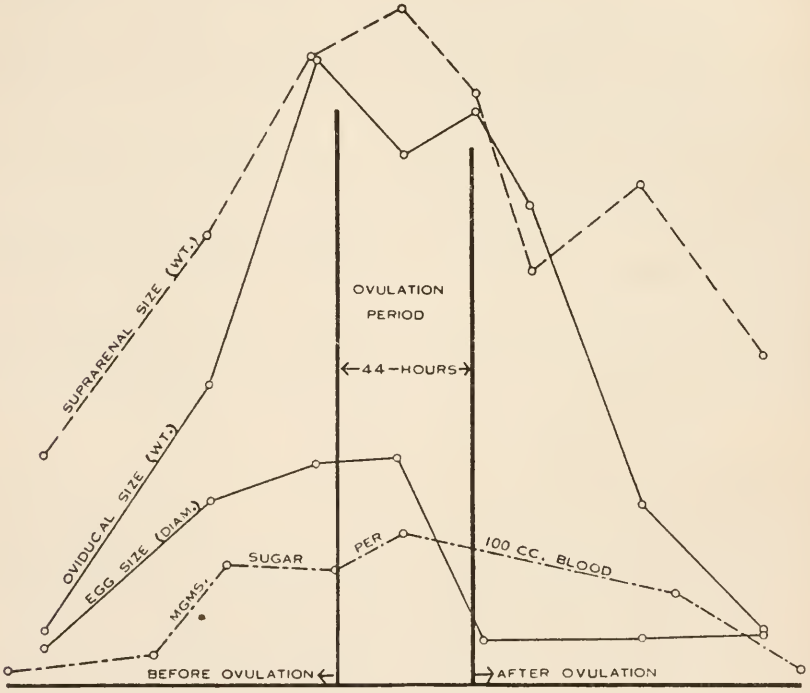

Fig. 1.—Variation of weight of suprarenal gland, weight of oviduct, diameter of egg, and proportion of sugar in the blood, before, during, and after ovulation.

The data of the curve represent their first series of determinations only; and, although later determinations have not given uniformly smooth results, it is believed that the situation expressed by the curve has been satisfactorily demonstrated. The curves for suprarenal size, oviducal weight, and diameter of ovum were constructed from data obtained from 22 common pigeons; the curve for blood sugar from repeated determinations on 5 healthy ring-

doves. Essentially similar curves have been obtained for two additional groups of birds. Though only one of the expected effects of suprarenal hypertrophy has been investigated, the result clearly indicates that "the enforcement in pigeons of frequent and continuous ovulations throughout the year, as this has been practiced and reported by Whitman and by Riddle, with important results on sex, viability, and longevity of offspring, is doubtless accompanied by an increased and nearly continuous mobilization of carbohydrate in the female parents."

A study of the effects of some of the products of the endocrine glands upon the storage metabolism of ova has yielded some definite results which clarify and confirm Dr. Riddle's earlier interpretation of this matter. Among these glandular products are some which are well known to have marked effects upon the basal metabolism of the organism. Of these glands the thyroid has the most pronounced effect in increasing the metabolism. Dr. Riddle has demonstrated that the oral administration of thyroid, in quantities so small as to be compatible with continued reproduction by normal healthy females, distinctly *diminishes* the storage metabolism of the ova being produced. It would seem necessary to conclude that this reduced storage (smaller yolk size) is a reflection of the *increased* oxidation which is known to characterize the action of this substance on the body as a whole. From

TABLE 1.—*Effects of desiccated thyroid (20 mg. daily) on the storage metabolism of the ova (yolk weight) of a single ring-dove during one year; 6 control eggs alternating with 6 treated eggs.*

Means for periods of dosage and control.	No. of eggs.	Average weight (grams).	
		Eggs.	Yolks.
Mean for control.....	30	9.508±0.043	1.940±0.021
Mean for thyroid dosage..	18	9.928±0.064	1.767±0.020

the beginning of Dr. Riddle's studies in 1911 he has been led by other kinds of evidence to interpret high storage values of the yolk to mean low oxidizing capacity. Still further confirmation of this interpretation has been obtained from similar studies with the products of other glands of internal secretion. The whole of these data will be summarized at an early date and form a chapter of a volume now in preparation. A summary of the data obtained during one year from a single thyroid-fed female is given in table 1.

Dr. Riddle earlier reported that one unique bit of evidence for the correlation of large yolk-size of the egg with femaleness in the embryo which arises from it has been obtained from measurements of twin-producing eggs. The important fact was that all of the few female single-yolk twins obtained in this research were associated with yolks demonstrably of extremely large size. On the basis of his illuminating experiments on twinning and double monsters in fish embryos, Stockard has recently suggested that twins in birds probably arise in those particular eggs which are laid prematurely. If such eggs are laid a few hours earlier than is normal, the process of gastrulation in the embryo would have to occur at the prevailing lower temperature of the air. On Stockard's view a lowering of the temperature during the sensitive period of gastrulation induces double gastrulation and resultant twins.

In making a test of the above hypothesis, Dr. Riddle obtained a relatively large series of eggs of varying stages of prematurity and subjected them to various temperatures during variable periods. His results strongly indicate that twins and double monsters are not thus produced in pigeons. From 200 adequate tests there resulted 192 normal embryos, 5 with some abnormality probable, 3 possibly though not probably of double nature, and none plainly twins or double monsters. When these data are reviewed in the light of other limiting circumstances previously reported, the result is, it is believed, a conclusive demonstration that the particular twins on which our studies are based were not the result of premature laying with consequent modification of the gastrulation process. The evidence which our cases of twins afford for the relation of high yolk storage to femaleness remains, therefore, quite unimpaired.

Control of the Sex-Ratio.

Attention has been called in earlier Year Books to the attempts made by Dr. A. M. Banta to control the sex-ratio in Cladocera. In certain lines in this group males have never been observed; in others, males occasionally appear. The conditions that determine their appearance have never been discovered. With the collaboration of Mr. L. A. Brown, of the University of Pittsburgh, important progress has been made during the past year, first, in determining the critical period during which the sex of the offspring of *Moina macrocopa* is subject to experimental control; second, in the elimination of a number of environmental factors as primary agents in sex control; third, in securing, by experiment, suggestions as to the specific environmental factors involved.

To find the stage in the developing egg at which sex is determined, 32 experiments were made (involving a record of 6,895 young) in which females were removed from the crowded bottles at various instars. No males appear among the young of mothers relieved from crowding prior to the late third instar. But if the transfer was delayed until the beginning of the fourth instar (when the eggs are in the brood pouch) the normal proportion of male offspring appeared. It is concluded, accordingly, that in this species sex is determined immediately before the eggs leave the ovary; and this is known, in some species of Cladocera, to be the time of maturation of the parthenogenetic egg.

As for the second and third points, it was known from our earlier experiments that in 95 per cent of the cases males were produced in bottles containing 10 or more mothers, if the bottles were left undisturbed, while bottles containing only 1 mother never yielded a first brood of male young.

Two groups of experiments were conducted. In the first group aeration of the culture water was accomplished (1) by bubbling air through the test bottles, (2) by bubbling oxygen through the bottles, (3) by shaking the bottles with air, and (4) by shaking the bottles with oxygen. Thirty experiments of this type gave 4,364 control young, of which 38.7 per cent were males, while in the tests there were 3,870 young, of which 24.9 per cent were males. Thus the aeration apparently reduced the percentage of males by one-third.

In the second group the mothers themselves were treated by aerating them on a slide in a thin film of water. Of 2,122 young of the controls, 55.9 per

cent were males, and of 2,706 young of the tests only 19.5 per cent were males. Thus the treatment of the mothers apparently reduced the number of their male young by nearly two-thirds.

Experiments were planned to test whether or not this result was due to the reduction of carbon dioxide. Uncrowded mothers were treated with carbon dioxide. If the crowding effect was due to carbon dioxide, this treatment should give males. Twenty-one experiments were attempted in which the amouut of carbon dioxide given ranged from 20 bubbles to a lethal dose. All of the 3,285 young produced were female. Hence it would seem that male prodnction is not determined by an excess of carbon dioxide in the culture water.

The next expedient tried was the removal of oxygen from the uncrowded bottles by streaming nitrogen through the culture water. The 3,969 young resulting, except for a few chance cases, were females.

Six experiments have been completed, in which nitrogen was bubbled into crowded bottles. These experiments included 206 mothers and 1,240 young. The crowded controls, as usual, gave many males (40.9 per cent), and the treated bottles gave 27.3 per cent males, a difference of one-third.

From the foregoing brief summaries of Dr. Banta's experiments it will be seen that, while aeration decreases the percentage of males in crowded bottles, an increase in carbon dioxide or a decrease in the amount of oxygen in uncrowded bottles fails to cause the production of males. It will also be noticed that nitrogen apparently produces somewhat the same result when bubbled through a crowded bottle as is accomplished by the aeration.

Control of Production of Sexual Eggs.

Associated with the problem of control of the sex ratio in *Daphnia* is that of the experimental control of the production of that peculiar type of egg which will not develop unless fertilized, called ephippial egg. This control has been secured, in Dr. Banta's experiments, with two of the laboratory forms and partial control has been secured for a third form.

"With one of the (?) *Daphnia pulex* types, the '984 type,' the simple expedient of crowding the young from birth until they are sexually mature determines the production (*not* of males as in all other forms similarly treated but) of 'ephippia' bearing the sexual eggs. With *Moina macrocopa* ephippial eggs are produced by females crowded in strained spring water from soon after birth until sexual maturity. This species may also usually be caused to produce ephippial eggs by crowding the young females in old, somewhat depleted food. It would seem that paucity of food and the accumulation of waste products may possibly both be involved in this control measure.

"*Daphnia longispina* is likewise somewhat amenable to the last-mentioned treatment as a means of ephippial production.

"The '984 type' has not been known to produce males, although it has a long laboratory history and has been designedly subjected to rather varied conditions at different times. It is believed that males do not occur in this form. Of further interest is the anomalous discovery that in this form *'sexual'* eggs develop *asexually*.

"To the previous evidence bearing on the non-occurrence of the supposed internal sexual cycle, (1) the long-continued parthenogenetic reproduction, (2) the undiminished vigor under continued parthenogenesis, and (3) the fact

that the sexual phenomena have been experimentally controlled, may now be added a new line of experimental evidence.

"Were there an internal sexual cycle one should expect Cladocera, because of the working of the internal factor, to become more and more prone to manifest sexuality as parthenogenesis continues. Experiments in control of male production, using females from stock long subjected to parthenogenesis in comparison with females just hatched from sexual eggs or having descended by parthenogenesis for only one to seven generations, showed that the stock which had recently gone through sexual reproduction produced males just as freely as stock which had been exclusively parthenogenetic for 300 generations."

Selection of Sex Intergrades in Daphnia.

Continuing the experiments reported last year, Dr. Banta has, with the assistance of Mr. George G. Snider, obtained from the selection of the sex-intergrade stock of *Daphnia longispina* a mass of data which indicate that the degree of sex-intergradeness is clearly inherited, that its inheritance is dependent upon a single mutable factor (or several factors), and that genetic change is rather frequent, though not equally frequent in all strains of this stock.

Sex in the Mucor Cunninghamella.

The study of the sexual condition in the mucor genus *Cunninghamella* has been brought to completion by Dr. Blakeslee. The results of making contrast tests between more than 200 races from 4 different species offer no evidence for an exception to the rule of a strict sexual dimorphism in this genus. Similar studies on the intraspecific sexual reactions in some 30 different species of other genera as well as study of the intraspecific reactions between the sexual races of these different species strongly indicate that there is a common fundamental something peculiar to each of the two sexes throughout the whole group of the mucors.

INHERITANCE OF SPECIAL TRAITS.

Flowering Plants.

The physico-chemical properties of the leaf-tissue fluids of Egyptian and Upland cotton and of their hybrids.—Genetic work has been largely confined in the past to the visible morphological characteristics of organisms, such as form and color. The possibility of studying the genetics of certain of the biophysical and biochemical peculiarities has been opened up by the demonstration that Egyptian and Upland cottons, which hybridize freely, differ in certain of these characteristics, such as osmotic concentration, specific electrical conductivity, and hydrogen-ion concentration in their leaf-tissue fluids.

This demonstration was made by Dr. J. A. Harris in studies carried out by courtesy of the U. S. Department of Agriculture at the Cooperative Testing Station on the Gila River Indian Reservation at Sacaton, Arizona, in 1920 and 1921. An investigation of the sap properties of the F_1 hybrid between Egyptian and Upland cotton, carried out simultaneously with the above investigations of the differentiation of the two forms, shows that the leaf-tissue fluids of the hybrids are characterized by a lower osmotic concentra-

tion and a lower specific electrical conductivity than are those of either of the parent forms. The ratios of specific electrical conductivity to freezing-point depression indicate that the hybrid absorbs relatively larger quantities of electrolytes than either of the parent forms. The tissue fluids of the hybrid are characterized by a lower acidity than are those of the Egyptian parent, but by a higher acidity than those of the Upland parent. With respect to this sap property, the heterozygous individual is, therefore, intermediate between the two parent forms.

A detailed discussion of the foregoing results is nearly ready for publication.

These investigations have been continued during the present year, by a more detailed comparison between the Egyptian and Upland types, involving several newly imported Egyptian varieties. The F_2 generation of hybrids has also been investigated. These studies occupied the attention of Dr. Harris, with the cooperation of Messrs. Arnold H. Johnson, Robert D. Evans, and A. T. Valentine, during several weeks of the summer.

Mirabilis.—Dr. John Belling has been working on the "multimutating" genes of the four o'clocks, testing the hypothesis that the genes in the chromosomes have a number of possible allelomorphs to any of which they may eventually mutate.

"In the homozygous tricolor *Mirabilis* two pairs of multimutating genes are found. The mutations are from yellow-striped to yellow, and from red-striped to red, but the red shows only in presence of the gene for yellow. The numbers of mutant progeny from tricolor parents were 6 per cent of the yellow and 4 per cent of the red in 458 offspring. Totaling all cases in which one of a pair of genes for yellow striping could mutate to a gene for yellow there were 4 per cent of mutants out of 820 progeny; and in the similar cases of red striping, 5 per cent of mutants in 1,063 progeny. In the parents of one sibship, the gene for yellow striping was heterozygous, and in its progeny there were 3 per cent of mutants out of 112 plants, where only about half as many are expected as from a homoygous parent. A distinct mutant (probably chromosomal) has been found in tricolor progeny, of which the homozygous condition seems lethal, and the heterozygotes occur in less than half the normal number, 109 seeds giving a quarter of normals and less than a quarter of heterozygotes, with only one recognizable mutant homogote."

Genetic Basis of Animal Behavior.

Heredity of behavior in dogs.—Considerable time was devoted during the year under review to getting a quantitative expression of the behavior of dogs as a preliminary to a study of the genetic elements in such behavior. The work met with wholly unanticipated difficulties. These are described by the experimenter (Dr. E. C. MacDowell) as follows:

"(*a*) *Discrimination apparatus.*—The difference in the adaptability of two litters of dachshunds in the preliminary training in the discrimination apparatus was noted in the Year Book of 1921, pages 129–130. The training of these two litters was continued for 6 months. For the first 3 months the buzzers were used as signals; for the last 3 months the lights were the signals. With the buzzers, there seemed to be a fair degree of learning shown by each set, so that on the last 7 days of the training with the sound signals, no dog made less than 8 correct trials out of the 10 per day. The difference between the two litters in the preliminary training did not appear in their ability to form sound associations. In the training with the light signals there are

more records in the last 7 days above 50 per cent correct per day than of 50 per cent and under; this indicates a somewhat stronger tendency to go towards than away from the light, but none of the dogs has approached formation of full association of the light with food. The two litters gave, in general, like results in the training with light signals.

"During the training with the light signals, certain positive habits were developed that very seriously interfered with the progress and analysis of the behavior. In spite of special training to eliminate these habits the subsequent behavior was complicated by the probable continued effect of these habits in varying degrees.

"Another litter of five 6-month dachshunds was started at the first of the year and trained in this apparatus for 3 months with the buzzer signals. At the end of this time there was no indication that any association had been formed; the number of correct trials per day fluctuated around 5 out of 10. In only one case a record of 9 correct was made; in another case (a different dog) a record of 10 correct. The subsequent behavior indicated clearly that these cases were due to other causes than the formation of an association between the buzzer and the food. The preliminary training was as similar as possible to that given to the three litters which learned the association with the buzzer; moreover, the failure of this litter to learn can not be ascribed to any family difference, since the parents of this litter were from the same strain as the successful litters.

"A group of 4 chow-chow bitches was given the preliminary training in this apparatus. In spite of great differences in their ages and experiences they all failed to master the necessary preliminary routine of the apparatus; even after three months of training.

"Since this apparatus was planned to test the relative ability of different breeds to form associations with a series of different types of signals, and since no indications have been found of any association with strong light signals, and, further, since three months is not a long enough time to form the sound associations in a litter from the stock that had previously given three litters that did learn them, and since the chow-chows tested were not amenable to the necessary preliminary training, it becomes clear that this apparatus provides an unsatisfactory method of testing native tendencies as the basis for genetic studies.

"*Jumping test.*—In searching for suitable tests for measuring family and racial characteristics in dogs, an apparatus was constructed to find the height from which a dog would jump. It was an elevator consisting of a closed box operated by block and pulley, running up and down on tracks that reached up to a height of 20 feet. The test was started with the height 2 feet; in practically all cases the dog jumped immediately when the door was raised; so no preliminary training was necessary. After jumping, the dog was returned to the house, and the next one in the litter was tested at the same height. In this manner all the dogs in a litter were put into the elevator at successive heights of 2, 3, 4, 5, etc., feet, until the limit was reached. No special reward was given to stimulate the jumping, since up to a certain height all the dachshunds were anxious to jump down. The test for a dog was concluded for the day when he sat for 20 minutes without jumping. The test was repeated every two months. The records gave the height jumped, the time between the opening of the door and the arrival in the straw bed, and the vocal behavior of the dog. Three litters of dachshunds and four chow-chow bitches were tested by this method.

"Certain general results were found. There is a strong tendency for a dog to take longer before jumping as the height increases; also, at increasing

heights the dog begins to whine before jumping, then to cry, then to chatter or bark, and finally to combine all these sounds in a violently excited behavior. As the limit of his jumping is reached the sounds reach a maximum; as the limit is passed the noises diminish in intensity and the dog may lie down at the back of the box. There are many variations from this general behavior and many individual idiosyncrasies in the character of the sounds made.

"Some dogs would jump from the elevator when raised to 12 feet; others would refuse to jump at 4 feet. There was no indication of correlation between such differences and the size of the dogs. The tests gave higher limits when repeated after two months, so, in spite of the brief duration of the test, an element of learning was obviously involved. One litter showed great uniformity in jumping from considerable height; another litter showed great irregularity, some making high jumps while others refused to jump much above the initial 2 feet. These seemed to be favorable indications for the success of the method. It had the great advantage of being brief, it gave direct numerical data, and it required no preliminary training. But when the chows were tried, difficulties were encountered; they preferred to sit in the box rather than use the energy to jump. One of them would jump whenever some extraneous sound or motion attracted her to the ground; the others sat contentedly in the elevator when it was raised above the first positions; two would jump when called or at the sight of a person. Although it is possible to show that the dachshunds jumped from greater heights than the chows under the same given conditions, such a comparison can have little significance, for it was obvious that the dachshunds were anxious to jump, and in most cases would jump till they bounced high on landing in the straw, while the chows would lie quietly till the proper incentive appeared and would then leap at once with the greatest ease.

"Whereas the method at first appeared to offer many advantages and to give a simple measure of temperamental differences, it soon became clear that behind its simple data there were many causes. The very same data could mean very different things. When a dog refused to jump from 4 feet it may have meant (1) that the dog was scared by the height, or (2) that he had no interest in the ground, and remained in the elevator because he was contented to do so. When a dog jumped from 10 feet it may have meant (1) that he had a great desire to run about on the ground, (2) that he was scared by the unusual elevation, or by the elevator itself, or (3) that he had a well-knit body, or a light body, that had not been hurt by the jolt in landing upon the straw in the previous jump. One could be led to believe that the height data measured courage, by observing many of the dachshunds and hearing their noises as the height increased; yet, for the chow, height certainly does not measure courage, and quantitatively it probably measures nothing at all. More likely in this case the data indicate that chows were not stimulated by a situation that did stimulate dachshunds, but such a difference between the breeds applies only roughly, for reversed conditions were found in both breeds. So by the same units we may be measuring one character in some cases while in others we may be measuring a different character or measuring nothing; and comparisons mean nothing if the data do not measure the same thing. Although considerable data have been gathered from these elevator tests, they are now believed to have little value for a comparative study of native temperament in different families or different breeds. The method is too simple for an analysis of a vastly complicated situation."

To the difficulties in obtaining measurements of behavior of the dogs was finally added an epidemic of distemper. In the face of such difficulties it has become clear that the problem of inheritance of the elements of behavior in dogs is too large and too expensive for this Department to undertake with its limited resources. There is required for the work the cooperation of a group of investigators including at least an animal behaviorist and a physiologist in addition to a geneticist.

Heredity of Learning Capacity in Mice.

Miss E. Vicari was a guest of the Department during the summer and continued her investigation into the rate of learning in mice, using for this purpose, in addition to the strains which she reported last year, the abnormal-eyed descendants of X-rayed mice and a closely inbred strain of dilute brown mice.

The Inheritance of Cross-Bill in Pigeons.

This character has appeared at various times in the past in connection with other breeding work. During the past two years several matings have been made by Dr. Riddle in order to test the mode of its inheritance. This has not been determined, but the fact of inheritance is clear. It has also been learned that the character is more properly described as "deformity of the beak region." This manifests itself in various ways—absence of little or much of upper beak or of lower beak, upturned beak, one or both nares unclosed, wide or unusual gape.

The Inheritance of Blood-Sugar Values in Generic Crosses.

Our ample collection of pedigreed birds, particularly of hybrids from crosses involving different genera, has made it possible to obtain a partial test of the behavior in hybridization of such a physiological or chemical character as the concentration of the sugar of the blood. This work was done by Dr. Riddle with the cooperation of Dr. H. E. Honeywell.

When it was learned that the Japanese turtle-dove (*Turtur orientalis*) has a relatively high concentration of blood sugar, while the ring-dove (*Streptopelia alba*) has the lowest amount of blood sugar of any of those measured by us, we naturally selected the F_1 hybrids of these two species for this test. A study of the F_2 hybrids is highly desirable, but this has not yet been made. The individuals used to determine the amount of blood sugar in the parent species were not the parents of the particular hybrids whose blood was examined. All of the hybrids in our collection having this type of origin were included in the study.

The result of this inquiry indicates that 68 of these hybrids have a blood-sugar value almost exactly intermediate to that found for the two parent species. In these F_1 hybrids the data for blood sugar indicate as truly an intermediate value as do the data for size. An additional group of F_1 hybrids has been examined. Other studies in progress should soon make it possible to estimate the significance and value of the results already obtained.

Coat Colors in Dogs.

In connection with the observations on coat color of the dachshunds and chow-chows at this Department, Miss Jane Hubbard, in collaboration with

Miss E. E. Jones, has made an analysis of the records in the Stud Books of the American Kennel Club. The necessary tabulations and calculations have been made and the material is now ready for publication.

Heredity of Blood Types in Mice; a Negative Result.

As is well known, human blood falls into a number of types which differ by the capacity of the serum to agglutinate the corpuscles. Obviously a person's own blood will not agglutinate his corpuscles and thus destroy the functioning of the blood. Also the blood-serum of A's own blood *type* will not agglutinate the corpuscles of A's type. But there are other types which probably will. Von Dungern and Hirschfield abroad and Ottenberg in this country have maintained that these types are inherited simply, and indeed in Mendelian fashion. Others dispute this conclusion. It was thought desirable to test the theory in a rapidly breeding animal whose breeding could be controlled. It was stated that blood groups similar to the human occurred in rabbits and cattle. It was decided to look for them in mice, especially since the numerous collaborators working on mice at this Department during the summer would bring together a great variety of strains. Accordingly, the necessary technique was worked up by Dr. MacDowell in preparation for the testing of the various stocks of mice for isoagglutinins that might appear in regular groups.

From 11 different races of mice contributed by Drs. Little, Dunn, and Strong, Professor Gates, and Miss Vicari, 48 sera were made and a total of 300 samples of cells were tested; the total number of different combinations of cells and sera was 1,180. Of these combinations, 2 showed agglutinations. Repeated tests with sera from the same stock and cells from the same mice failed to substantiate these positive findings.

Since one mouse yields such a small amount of serum, it was thought that some other serum, obtainable in larger quantities, would be far more satisfactory as a test for differences in the bloods of different strains. To this end 4 guinea-pig sera were used in making 180 tests; 4 sheep sera were used in making 136 tests; and 9 rat sera were used in making 275 tests. In every case the guinea-pig and the sheep sera showed unquestionable agglutination, and in no case did the rat serum show any signs of agglutination, although the whole range of stocks was represented in all three cases.

Our attempt to study the heredity of blood groups in mice has thus ended, since there apparently are no blood groups in mice. All we found was that mouse cells are agglutinated by the serum of guinea-pigs and sheep, but not of rats.

Susceptibility to Inoculate Tumors.

The work on inoculable tumors, which was reported on at some length in the Year Book for 1921, pages 122–127, has been continued by Doctors Little and L. C. Strong, and by the use of larger numbers of individuals the Mendelian behavior of the factors underlying susceptibility to the two adeno-carcinomas dbrA and dbrB has been more clearly established.

In the F_2 generation susceptibility to the dbrB tumor depends on the presence of at least two independent Mendelian units, since a typical 9:7 ratio is obtained in this generation. The susceptibility factors are called A^{st} and B^{st}. For the dbrA tumor, 3 Mendelian units are necessary. Of these,

2 are the same as the 2 permitting the growth of the dbrB tumor. The dbrA tumor will continue to grow, however, only when a third factor called C^{st} is also present. Thus, Dr. Strong has shown that the physiological differences between histologically identical tumors are genetic differences.

The work has now reached a point where it will be necessary to conduct a series of individual tests leading to the isolation of lines differing in single mendelizing factors for susceptibility and immunity.

Doctor Strong is continuing his work on these tumors with special reference to their rate of growth and their relation to other spontaneous tumors which have arisen in his stocks, while the experiments dealing with isolation of single-factor lines Doctor Little hopes to carry on at the University of Maine.

Cooperative Breeding of Mice.

The need of a central agency to maintain mutant strains of mice has been felt for some time. The preservation of such strains is a prerequisite to extensive linkage studies. Inasmuch as this Department has come to be the gathering-place of many mouse geneticists during the summer, it has been requested to perform this service. In view of its limited resources and in view of the danger from epidemics, the Department can not guarantee to take care of all mutant strains that may be offered in the future, but it is glad to be of such service as it can in this matter.

At present the following stocks are on hand:

(1) Lathrop Japanese waltzers, which will be bred by brother-to-sister matings.
(2) Inbred dilute browns of Little.
(3) Abnormal and control X-ray lines, including the gene for abnormal eye of line 85 from Little.
(4) Bagg albinos.
(5) Storrs albinos, carrying the pink-eye factor; two wild lines.
(6) Storrs-Little, a race parallel to the dilute browns, in which homozygotes of the different dilute and pink-eye combinations will be sorted out to provide known stocks for testing the genetic constitution of the very confusing pale combinations.
(7) Piebald and black-eyed whites from the inbred race of Strong.
(8) Dilute pink-eyed browns, which, with the introduction of the waltzing character, will become very nearly the ultimate recessive for the more familiar genes, and hence be very valuable for the analysis of individuals of unknown constitution.

GERMINAL AND SOMATIC VARIATIONS.

Mutations in Cladocera.

Cladocera are prevailingly parthenogenetic; hence all individuals of a clone are expected to be alike except as mutations occur. The species bred by us are 13 in number and comprise 71 lines, as follows: *Daphnia longispina*, 3 lines; *D. pulex*, 17 lines; *Simocephalus vetulus*, 5 lines; *S. exspinosus*, 10 lines; *S. serrulatus*, 21 lines; *Simocephalus* sp?, 2 lines; *Ceriodaphnia rigandi*, 1 line; *C. megalops*, 1 line; *C. quadrangula*, 1 line; *Moina rectirostris*, 2 lines; *M. affinis*, 2 lines; *M. macrocopa*, 4 lines; *Lathonura?* 2 lines.

In addition to these 13 clearly distinct species, there are five morphologically different types of *Daphnia pulex* and four different types of *Simocephalus serrulatus*. These types have constant differences and some of them are doubtless entitled to specific rank. The usefulness of this varied stock as observa-

tional material and to serve as checks upon various conclusions justifies the relatively small amount of labor involved in its maintenance. In these lines various mutations have arisen. The physiologically different strains of line 757, whose histories are set forth in Carnegie Institution of Washington Publication No. 305, and the sex-intergrade (physiologically and morphologically distinct) strains of *Simocephalus spinosus* and *Daphnia longispina*, have been previously mentioned in these reports.

Two new mutations have arisen during the past year, both involving the head form in *Daphnia longispina*. The first of these mutations is a marked indentation of the front of the head serving to lengthen the anterior margin of the beak and imparting to these "excavate head" animals a somewhat grotesque appearance. The second mutation is a shortening of the posterior beak margin, and while less striking in appearance than the other, nevertheless seems to be a good character. Work is being done on the inheritance of these new characters.

A point of interest with reference to excavated head is the undoubted recurrence of the mutation. Occurring first in September 1921, it reappeared in another strain in the following February, in a third strain in June, and in a fourth strain in August. It is worth noting that the occurrences of this mutation are in strains originating from three of our original intergrade strains, which, though having a common origin, had been separate for 104 generations covering a period of over four years.

Eyelessness in Cladocera.

To the three cases of eyelessness in Cladocera mentioned a year ago, Dr. Banta has been able to add 10 additional cases. As in the cases reported before, the optic ganglia were partially or completely aborted, and in some cases the stem-like structures, which possibly represented aborted primordia of the eye and adjacent structures, were present on the front of the head in the young eyeless individuals. The sporadic occurrence of these eyeless individuals (7 were in a single bottle), their occurrence in some cases in bottles in which other abnormal individuals arose, and the lack of inheritance of the character, indicate that these are merely somatic alterations due to environmental factors. However, since eyelessness is a chracteristic of many cave animals, it is believed that any occurrence of such a trait should be carefully followed up.

Studies on the Vascular Anatomy of Normal and Teratological Seedlings of Phaseolus vulgaris.

Further studies on the vascular anatomy of normal and teratological seedlings of *Phaseolus* have been carried out by J. A. Harris, E. W. Sinnott, J. Y. Pennypacker, and G. B. Durham. These data have heretofore been treated from the purely anatomical side, but are to be used in connection with studies on natural selection, for which the experimental records are already available.

STUDIES ON HUMAN GENETICS.

Heredity in Aristogenic Families.

Dr. H. J. Banker has spent much time in collecting scholarship records in coeducational schools, with the aim of studying inheritance of special scholarship. An attempt was then made to analyze this material statistically. The

data consisted of the records from two colleges and two secondary schools, and proved to be insufficient to furnish very definite conclusions by this method of treatment. The total population in the various tables that were constructed ranged from 87 to 354 and the number of children from 39 to 170, which in many cases were to be distributed in 6 categories. In specific subjects, as languages, mathematics, and history, as well as in general scholarship, there were indications of positive correlations between parents and children, but there appeared to be no evidence of Mendelizing factors, nor was there suggestion of significant variations of correlations with sex. Further data are sought for.

The work on a "eugenic" genealogy of a New England family was continued by Dr. Banker.

Heredity in Cacogenic Families.

Dr. A. H. Estabrook has completed the field work and writing up of his report on the Tribe of Ishmael. The year's work involved also the study of specific families, especially such as had removed into new environments farther west than Indiana, the main home of the tribe. One large group of this sort was found in Missouri and studied in detail.

In addition to his main investigation, Dr. Estabrook has made short studies (not cacogenic) of the Owen family of New Harmony and of the Merrill family of Vermont. Since in his studies at Indianapolis he has received every courtesy and assistance from the State and the head of the State Board of Charities, Dr. Amos W. Butler, and has been housed in the State Capitol, he has assisted the State in various ways outside of his main research. Thus he has met with the Indiana Committee on Mental Defectives at all its meetings during the year under review and advised with them. He has collaborated with their field investigators to the extent of advice and suggestions in their field work, and supervision of and responsibility for the scientific part of the report of the committee on its work in 1921 and 1922. He also gave a number of addresses and lectures before schools, churches, Rotary Clubs, social clubs, the State University, the Indiana Conference of Charities and Corrections, and others. Beginning December 1, 1922, Dr. Estabrook is undertaking a study of the "Highlanders" of the southern Appalachian Mountains.

Heredity of Body-Build.

During the past two years most of the Director's free time has been spent on a research into the heredity of body-build in man. This research has led to a study of the normal changes in body-build during development. A paper on this subject was published in Eugenical News for July. To secure data for the developmental curve of build, special measurements were made by Misses Louise A. Nelson and Margaret Babcock on 1,000 infants of known sex, age, and race at milk stations in New York City. In addition, Dr. Bret Ratner, of New York City, obtained for us daily measurements of weight, height, and chest-girth of 11 children at birth and each of the 10 days thereafter. For later life I made measurements on boys at Brooklyn Y. M. C. A.; Boy's Welcome Club; New York Society for Prevention of Cruelty to Children; Orphan Asylum, Brooklyn; Hebrew Orphan Asylum, Manhattan; New York Catholic Protectory; Children's Village; Hebrew Sheltering Guardian Society;

and Leake and Watts Orphan House. In many of these measurements I was assisted by Dr. Govaerts. About 1,500 boys were measured altogether. Acknowledgment is made of the cordial cooperation of the chief officers of these various institutions, who appreciated the need of developmental data for studies in inheritance of somatological characters. The analysis of the hereditary factors involved is nearly ready for publication.

Heredity of Multiple Sclerosis.

At the request of the Association for Research in Nervous and Mental Disease, I undertook to work up data on multiple sclerosis from the racial standpoint. With the aid of Miss Nelson, a number of families in New York City who show the disease were studied, and with the valuable assistance of Miss Mabel L. Earle a number of family histories referred to in the literature were discussed. Clear evidence was found of the presence of genetic factors.

The Heredity Factor in Human Tuberculosis.

During 7 months of the past year, Dr. Albert Govaerts, secretary of the Société Belge d'Eugenique, was a guest of the Eugenics Record Office. Dr. Govaerts brought to the office a special training in seriology which led him to undertake some experimental work on the effect of lens cytoloysins on the offspring of rats, with negative results. He paid special attention to a statistical study of tuberculosis as distributed in the families recorded at the Eugenics Record Office. A paper giving the results of this investigation is about to appear in the American Review of Tuberculosis. The main finding is clear evidence of the insufficiency of the contact theory to explain the high incidence of tuberculosis in certain families. The view of an inherited susceptibility to tuberculosis seems to be demonstrated by all of the facts of family history.

Assortative Mating in Man.

An analysis of the data on head-form, published by Frets, was carried out by Dr. Harris in cooperation with M. Albert Govaerts. It shows that for head-length, head-breadth, and cephalic index the coefficient of assortative mating is very low. The result is of importance in the general theory of assortative mating in that it shows that a character which has been regarded of considerable racial significance is not of importance in mate selection.

Variation, Correlation, and Racial Differentiation in the New-born Infant.

Dr. J. A. Harris and Dr. C. C. Little have under way an investigation of the characteristics of the new-born infant when the parents are of various nationalities. About 10,000 records from the Sloane Hospital, New York City, are being considered statistically.

GENETIC CONSTITUTION OF THE AMERICAN POPULATION.

Comparative Social Traits of Various Races.

On the hypothesis that racial traits are hereditary traits, an attempt was made by the Director to secure measurements of 10 such traits of different races represented in the New York City high schools. Two groups of data were obtained: one for 51 girls secured by the kind permission of Principal

Edward C. Zabriskie and the generous cooperation of Miss Rosemary F. Mullen, chairman of the biology department of the Washington Irving High School. The other group was of 148 boys obtained by Dr. R. S. Benedict, of the Stuyvesant High School. A study of the first group was published in School and Society, in October 1921. A second study of the entire collection has been made with the cooperation of Miss Laura Craytor.

Immigration and Deportation.

The Congress of the United States is seeking facts to guide it in its immigration policy. Mr. Albert Johnson, chairman of the Committee on Immigration and Naturalization of the House of Representatives, has asked the cooperation of the Eugenics Record Office, and Dr. H. H. Laughlin has been made a special agent of the committee for the purpose of an investigation into the "racial values" of the various immigrating peoples. To this end, facts concerning the racial (or more strictly national) origin of inmates of State and Federal institutions have been secured from 445 such institutions, which includes practically all of the larger and better organized. With the assistance of Miss Alice Hellmer, the results have been tabulated and will be duly reported to the committee of the House.

Provision is made in the immigration law for deportation of persons who become public charges within 5 years after arrival in the United States. Dr. Laughlin is securing, for the Congressional Committee on Immigration and Naturalization, facts concerning the practical working out of this law. In this cooperative study, returns have been received from 46 of the 48 State governments in reference to governmental laws and practices in the matter, and from 638 of the total 698 custodial institutions maintained by the State and Federal governments in the continental United States.

An analysis of the returns, as made by Dr. Laughlin, shows that a peculiar situation has developed in the United States in reference to the theory and practice of deportation. It is clear that the authority which deals with immigration and deportation is vested solely in the Federal Government, while the care of the socially inadequates of all types, in the United States, both native-born and alien, devolves primarily upon the several individual States. This situation of mixed authority and responsibility requires a system of more carefully adjusted coordination between the Federal and the several State governments, if an effective deportation practice is to be developed, with its expected relief to the congestion in State custodial institutions, and the prevention of contamination of future American stocks by the permanent introduction of excessive amount of defective alien germ-plasm. Largely on account of a marked failure of the States to secure the deportation of aliens who are deportable under the law, numerous aliens (over 200,000) are maintained by the several State governments. Dr. Laughlin has undertaken an estimate of the cost of maintaining such aliens, and this will be duly reported to Congress.

Eugenical Sterilization.

Dr. Laughlin has been engaged for about 10 years in collecting data on the operation of the "sterilization" laws which have been enacted by the various States. These laws not only constitute a remarkable episode in modern legis-

lation, but they may well have a considerable importance in exercising a certain degree of control over the genetic constitution of the population of the United States. The data thus collected make an extensive volume which is being published in book form by the psychopathic laboratory of the municipal court of Chicago. Though such novel and intimately personal legislation has aroused very different opinions and emotions in people, the desirability of a judicial review of legislation having such potentital eugenical bearing can not be denied.

THE PHYSIOLOGY OF REPRODUCTION AND DEVELOPMENT.

The Relation of Endocrines to Reproduction and Growth.

Dr. Riddle has felt obliged to undertake this study because of difficulties and exceptions encountered in his earlier (but still unpublished) work on sex, and also because of its bearing on all genetic work on birds. It has received much of his attention throughout the year. Miss Mary Holmes has given valuable help with records, pedigrees, and computations concerned in these studies. Summaries for parts of this work are still incomplete. The results thus far obtained may be stated as follows:

(1) Desiccated glandular products given by mouth are usually without effect on birds; thymus, thyroid, and parathyroid are the chief exceptions. The normal effects of most of these glands can be obtained only by injection of extracts or suspensions.

(2) Additional data suggest that the thymus gland of birds largely presides over the secretion of egg-albumen and the egg-envelopes, and thus retains the function which it probably had in the lower vertebrates. On this view the thymus of mammals lost its function in the change to the mammalian mode of reproduction.

(3) McCarrison's conclusion is confirmed that the thymus persists throughout life (perhaps it should be said during reproductive activity) in the pigeon, and that the male thymus is nearly twice the size of the female thymus. Further, in agreement both with this difference in size of thymus in the two sexes, and with the current view that the thymus antagonistically affects the growth of the gonads, it has been found that the testes of the male pigeon are retarded in their growth for a longer (juvenile) period than is the (single) ovary of the pigeon.

(4) Moderate doses of thyroid substance are often capable of producing reproductive abnormalities in healthy birds. Delayed and diminished egg production and clutches of single eggs are among the observed irregularities. Though there is reason to believe that such individuals exist, we have failed thus far to find birds whose abnormalities of reproduction could be corrected by the administration of thyroid.

Other work of similar nature done by Dr. Riddle in cooperation during the year is as follows:

(5) The effects of repeated transplantation of suprarenals on young doves (with Dr. Tadachika Minoura). The adrenals of the birds into which transplants were repeatedly made did not measurably differ from the control, and the time of sexual maturity was nearly the same in transplanted and control groups. A notable amount of infertility and reproductive abnormality has been obtained from the first-generation offspring of the transplanted birds. The study of this point is being continued.

(6) The relation of the pituitary and its parts to growth, time of maturity, and phenomena of reproduction and sex (with Mr. J. R. Spannuth). The oral administration of the various preparations of this gland have little or no measurable effect on the growth curve. Injections of the extracts of anterior and posterior parts of the pituitary body have been made and growth curves obtained. Data for maturity and reproduction are not yet complete. This is practically the only type of study of this important gland which can be easily made on the pigeon.

INFLUENCE OF INCRETIONS OF THE MOTHER UPON EMBRYONIC DEATHS OF THE OFFSPRING.

A knowledge of the complete genetic output of a pair of pigeons presupposes that all of the number of eggs laid shall be known and that these shall in nearly all cases be hatched and reared. But in certain parts of our recent work with pigeons very large numbers of young are lost, owing to infertility, early cessation of development, death of embryo, etc. These developmental failures constitute one of the greatest obstacles to progress. During the past year important progress has been made in determining their cause.

Thus, it appears that some pigeons retain for variable, but abnormally prolonged, periods a small proportion of their eggs in the shell gland of the lower oviduct after the shell material has been placed upon the egg. Such egg-shells usually have an abnormal thickness, and they develop abnormally. The delay may reach the extreme of 100 hours. When it exceeds 20 to 24 hours, the developing germ usually dies at the one-half day stage. From a delay of 24 to 50 hours an embryo occasionally survives.

As stated below, such delayed eggs are easily forced from the oviduct by the administration of pituitrin, and it is possible that the failure to expel the egg is due to disfunctioning of the bird's pituitary gland.

In a third series of cases evidence has been obtained which indicates that death of the embryo sometimes results from the very early break or rupture of an inefficient vitelline membrane. The eggs of only a few birds exhibit this characteristic, but it is usually exhibited by several or many of the eggs of a particular bird. The rupture and death occur most commonly at the one-day or two-day stage. After a real rupture of the yolk-membrane, and after significant outflow of yolk, continued life in the embryo is impossible.

In a fourth group of cases, series of embryos from the same parents are found dead at the three-day to four-day stage, and, though these embryos seem otherwise normal, the amnion has failed to complete its development and the incompletely inclosed embryo has become adhered to the shell. Dr. Riddle concludes that, though our evidence is not conclusive on the matter, the initial failure is that of the development of the amnion and that adhesion to the shell and resultant death are subsequent events. Data concerning the more remote basis of the improper development are being collected.

A fifth group of cases is formed by those ova which are not received into the oviduct, but pass into the body-cavity and there fail to develop. It has been shown that the injection of small amounts of pituitrin (the active principle of the pituitary gland) during the first few hours after the entrance of an ovum into the upper oviduct will usually cause this yolk to be returned to the body-cavity. These results suggest that a temporary hypersecretion of the pituitary gland by the mother bird may be the cause of these ovulations into the body-cavity.

These observations concerning the relation of endocrine glands to the various causes of early embryonic death indicate that many of the disorders of reproduction are traceable to abnormal incretions of the mother.

Another line of investigation of early embryonic death has been made in cooperation with Mr. Embree R. Rose. This is a study of various elements of nutrition as possible causes of reproductive abnormalities and embryonic death. This work was nearing completion when reported for last year. The final results confirm the statements made at that time—the notable reproductive abnormalities which appear in significant numbers in our birds can not be ascribed to deficiencies of the common and well-known factors of diet.

A Simple Method for Obtaining Premature Eggs from Birds.

A paper dealing with this subject has been published by Dr. Riddle. By means of hypodermic injections of small amounts of pituitrin, the eggs are laid in from 4 to 30 minutes after injection.

By this method eggs at various stages of immaturity, including successive eggs from the same parent, are made easily available for studies on the earlier stages of embryonic development, for experimental studies on these most modifiable stages, for chemical studies on various parts of the egg with less than the usual opportunities for change and admixture, and for isolating the functions of the various parts of the bird's oviduct. It is probable also that under certain conditions or limitations this reaction of the dove's oviduct, living and *in situ*, would be useful as a means of standardizing solutions of the active principle of the pituitary gland.

Decrease of Blood Sugar of Pigeons During Prolonged Inactivity and Close Confinement.

This study was made by Dr. Riddle in cooperation with Dr. H. E. Honeywell. It is well known that common pigeons kept confined in small cages usually do not produce eggs. The reason for this has been far from clear. It has, however, been shown by Lusk that dogs kept in the laboratory and in very confining quarters undergo a decrease in their basal metabolism. Since we had already learned that a high mobilization of sugar occurs at ovulation periods in pigeons, we considered it probable that the close confinement of these pigeons brought about a reduction in their metabolism similar to that found by Lusk for dogs, and that this lowered metabolism should express itself in a lowered blood sugar. Three series of tests made on 25 common pigeons show a fall of the blood-sugar value from 180 mg. per 100 c. c. of blood to 126 mg. as the result of three weeks of close confinement.

Variation and Correlation of Fecundity in the Domestic Fowl.

For the past several years this Department has had under way a detailed statistical investigation of the various phases of the problem of variation, correlation, and the inheritance of fecundity in the domestic fowl.

From the practical side, one of the most important results of these investigations has been the demonstration that the egg records of various periods of the year are so correlated that it is possible to predict the future egg record or the annual egg record of a bird from the records of short periods of time with a considerable degree of accuracy. This conclusion has been based primarily on studies of the White Leghorn, for which more data are available

than for any other breed. It has seemed very desirable to determine whether similar laws hold for the other breeds of poultry.

Studies of the White Wyandotte breed by Dr. Harris and of the Rhode Island Red breed by Dr. Harris and Professor Goodale, of the Massachusetts Agricultural Experiment Station, are now in press. While the numerical values of the statistical constants differ somewhat from those found for the White Leghorn, the results confirm in all essentials those already reported in earlier Year Books and presented in detail in *Genetics* and other journals. The possibilities of the prediction of the egg production of longer periods from the recorded egg record of shorter periods is, therefore, not limited to one peculiar breed, but is in all probability equally applicable to all the more important commercial breeds.

The foregoing studies have been limited to first-year production. Dr. Harris and Professor Harry R. Lewis, of the New Jersey Agricultural Experiment Station, have shown that similar correlations between the egg record of various periods of the year obtain in the second laying year of the White Leghorn fowl. Thus it should be possible to predict the second-year annual production from the records of the individual months of the second laying year, just as it has been shown to be possible to predict the annual production of the first laying year from the records of individual months.

A portion of the results of an investigation of the relationship between the records of the individual months of the first year and the records of the individual months of the second year are now in press, under the joint authorship of J. A. Harris and Harry R. Lewis. As pointed out in the last Year Book, the results of these studies tend to throw considerable doubt upon the importance of the so-called winter cycle as a distinct entity of importance in the inheritance of fecundity in the fowl. These investigations are now showing that there are definite laws underlying the distribution of the inter-mensual correlations of the first, of the second, and of the first and second years. These will be ready for publication in the near future.

In the course of the investigation of the relationship between the egg production of the first and second years, it became evident that there must be a fairly close correlation between the time of beginning and of cessation in the first and second egg-laying years of the bird's life. A special investigation was, therefore, made of this problem. The results of this study show that there is not merely a correlation between the time of beginning of laying and the time of cessation of laying in the first and second years respectively, but that there is a definite correlation between the time of cessation of laying in the first year and the beginning of laying in the second year. The results of this study are now in press in *Genetics*.

Differences in Rate of Growth of the Races of Mice.

During the summer, Professor W. H. Gates, of the State University, Baton Rouge, Louisiana, has been studying the rate of growth during the first three weeks of young mice of the Japanese waltzing variety, of descendants of the X-rayed non-waltzing and of control non-waltzing mice, with a view of determining whether or not a racial difference in the rate of growth exists. The data comprise observations made on about 1,000 animals.

Correlation Between Physical and Mental Development in Man.

As a member of the committee for the study of the problem of feeble-mindedness at Letchworth Village, the Director made measurements and other physical observations on 100 idiot boys at that institution. He was assisted by Dr. Govaerts and Miss L. A. Nelson. The superintendent, Dr. Charles S. Little, afforded the investigators every courtesy. The measurements thus obtained bear upon the problem of the specific action of endocrine disfunctioning upon development and the inheritance of such disfunctioning. An analysis of some of the data collected has been made by Dr. Bertha E. Martin and is now nearly ready for publication.

OTHER INVESTIGATIONS.

Studies on Physico-Chemical Properties of Vegetable Saps.

Physico-chemical properties of the tissue fluids of alpine and subalpine vegetation.—Work has been continued by Dr. Harris on the data secured by Professor and Mrs. Lawrence (through the courtesy of Professor Clements, who allowed Dr. Harris to utilize his Alpine Laboratory as a base of operations) in the Pike's Peak region. Further determinations have been secured from Mount Nebo, of the Wasatch Range, Utah.

Physico-chemical properties of the tissue fluids of coastal vegetation.—These studies have been continued by Dr. Harris as opportunity offered, along the lines laid down in the last Year Book of the Institution. Some field work has been done, but attention has been chiefly devoted to analytical work.

Studies on the physico-chemical properties of the tissue fluids of cereals as grown under dry-farm and irrigation agriculture.—These investigations have been continued by Dr. Harris at the Nephi substation and at the Utah Agricultural Experiment Station, Logan, Utah. The purposes of the investigations have been sufficiently outlined in the last Year Book. In 1922, Mr. W. F. Hoffman, Mr. A. H. Johnson, and Mr. R. D. Evans were largely responsible for this work under Dr. Harris's direction.

Studies on the evolution of the Loranthaceæ and other phanerogamic parasites.—These studies have been continued, as outlined in earlier reports, as occasion has offered.

Biometric Methods.

Dr. Harris, in cooperation with Messrs. Blakeslee and Belling, has completed for publication a set of tables showing the probability that a culture of a given size is capable of producing only individuals of the dominant type.

Formulæ for the determination of the correlation between a variable and the deviation of an associated but not dependent variable from its probable value have been determined and are now in press.

ADMINISTRATIVE RECORD.

Archives of the Eugenics Record Office.

The care of the archives has been in the hands of Dr. Elizabeth C. Muncey, who was assisted by the Misses Helen Bowen, Helen Brown, and Margaret Martin, as indexers. Owing to the fact that our accumulation of archives is

exceeding the capacity of our archive room, it became necessary to remove some of the filing cases to the basement. They are thus rendered relatively inaccessible and their distance from the main files adds to the expense of administration.

An estimate of the extent of the records and their index, made as of September 1, 1922, is as follows: 878,971 cards in the index: 1,496 books in archives. The field reports (F) number 53,998 sheets; the special traits file (A) 23,181 sheets; the records of family traits (R) and (M) files, 4,679 parts.

During the summer we had the assistance of a number of college students in preparation of material for the archives and in the analysis of records. Misses Laura Craytor, Esther Powell, and Katherine Belzer collated data on racial social traits, eye and hair color, and somatic proportions of idiot children.

Collection of Data.

Excellent progress has been made this year in securing the cooperation of college teachers in introducing into their courses of biology, sociology, and psychology the exercise of filling out family-history schedules. The Department offers to furnish the blank schedules in duplicate, with the understanding that one copy filled out will be deposited at the Eugenics Record Office. The number of collaborating teachers in this service during the year was 23, too large to acknowledge adequately individually. The number of records of family traits thus supplied totals 552. The teachers and students have found the exercise a valuable one; for the most part the students have evidently done the work with thoroughness and accuracy.

Especial mention must be made of the gift by Dr. Harold Bowditch of manuscript anthropometric records and a number of composite photographs made by his father, the late Dr. Henry P. Bowditch, Professor of Physiology at the Harvard Medical School and a pioneer in biometry in America. Dr. Bowditch also sent us a number of rare biometric books from his father's library and secured the gift from Mrs. Charles P. Bowditch of her husband's genealogy of the Pickering family. From Colonel D. Cornman, U. S. Army, were received 2,000 manuscript pages of Leighton genealogy and 11 printed genealogies and town histories. Professor W. M. Goldsmith, of Southwestern College, Kansas, secured for us 938 records and presented an exhibit, "The Catlin Mark." Dr. R. C. Benedict secured for us 153 eye and hair color schedules and many data for a further study of racial social traits. Mr. Albert Wiggam secured for the Office 250 twin schedules and numerous photographs. The largest collection of records of family traits was one of 268 sent by Professor W. M. Barrows, of the Ohio State University. The Whittier State School has continued to send carbons of all their extremely valuable case and family histories.

Training Corps.

Fifteen women and three men were trained for eugenical field work June 28 to August 8. Of these, 8 have secured or are considering appointments in eugenical field work or related positions. To date 233 persons have received this training, which consists chiefly of laboratory work and clinics in institutions. This body of trained workers has not only contributed greatly to the building up of our records, but in other respects has proved indispensable to eugenical research.

Second International Congress of Eugenics.

This Department was called upon to assist in organizing and carrying through this congress, which met September 22 to 28, 1921, at the American Museum of Natural History, New York, and for one day at Cold Spring Harbor. Dr. C. C. Little served as secretary-general and Dr. H. H. Laughlin as chairman of the Committee on Exhibits. The congress was supported by leading geneticists and by investigators in eugenics, as well as by numerous persons interested in the social applications of these subjects. The proceedings of the congress are being published. As there were 500 members of the congress and over 5,000 persons visited the exhibits, it is thought that the participation of the Department in this congress was justified by the increased popular interest awakened in genetical research.

Special Activities of and Changes in Staff.

A severe loss has been experienced by the Department in the resignation of Assistant Director Little on July 1, to become president of the University of Maine. During his three years at this Department he made some discoveries of fundamental importance and stimulated the spirit of cooperation not only inside the Department but also between the Department and geneticists generally. Fortunately, we may look forward to his continued association with this department in his genetical research.

The work of the Department is gradually crystallizing about a few main centers: First, the mammal work, of which the experimental work is now focused upon mice, both because of their rapid breeding, their relatively slight cost, and the large amount of work already done on them. Here Doctors Little and MacDowell are primarily in charge, with a number of assistants and summer collaborators. The experimental work on mammals fits in closely with the eugenics work, which is largely statistical, and in which Dr. Harris's biometric laboratory is of special assistance. Besides Dr. Harris, the principal investigators in this group are the Director, Doctors Laughlin, Banker, and Estabrook, Miss Louise A. Nelson, and assistants. Second, the chromosome work on *Datura* under the charge of Dr. A. F. Blakeslee, with Dr. John Belling cooperating in the cytological work and Mr. Farnham assisting in garden and field and a number of assistants and summer collaborators; and on Diptera by Doctors Metz and Anderson and assistants. In addition, there is the sex work on pigeons by Dr. Riddle and his assistants, and on Cladocera by Dr. Banta, with an assistant and the temporary collaboration of Mr. L. A. Brown.