

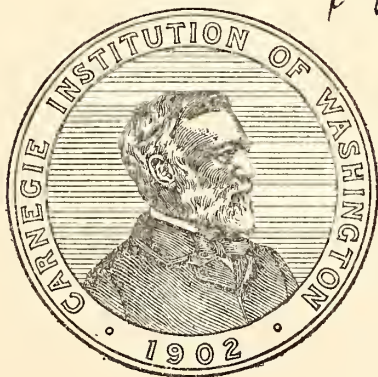
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DEPARTMENT OF GENETICS.

C. B. DAVENPORT, DIRECTOR.

GENERAL STATEMENT.

Owing to the fact that the report for this year closes two months earlier than previous years, this report covers only ten months and takes no account at all of the results of our busiest season, namely, July 1 to September 1. There will naturally be less to tell than in preceding years.

As outstanding results of the year may be cited the further confirmation of the interpretation of the secondary trisomic mutants of *Datura* as due to "fracture" of a chromosome, and the accumulation of evidence that in the secondary the extra chromosome may be a doubled half. Also, the discovery that, at the metaphase, chromosomes lie so that homologous poles are next to each other, or in intimate contact. In the sex problem, "plus" strains of mucors are found to be, in general, relatively stronger reducers of tellurium salts than "minus" strains. Also, evidence is gained for the conclusion that there are other conditions regulating metabolism that determine sex besides the sex chromosome; indeed, apparently a body, which has already gained mature primary glands of one sex, may under extreme conditions have them replaced by glands of the opposite sex. Additional evidence of the germinal complexity of certain traits is adduced in the demonstration that at least 10 genetically different factors determine albinism in maize. Grave doubt is thrown on some evidence recently adduced in favor of the inheritance of the effects of training. Important evidence has been gained of the inheritance of the chemical constitution of tissue fluids in plants. The feasibility of getting family (genetical) history of human applicants for admission to the United States has been demonstrated in 3 European countries. Additions to endocrinology—the science of the organs that play a great part in control of development—have been made, in securing conclusive evidence that the thymus in birds regulates eggshell production and that the reduction of blood-sugar by insulin in doves is followed by increase in thickness of the suprarenal cortex resulting in increased sugar in the blood.

The friendly criticism has sometimes been directed toward this Department that its investigations are somewhat diffuse and not concentrated sufficiently upon a single point. That a certain diffuseness results from a union of the purely theoretical and the applied work must be admitted. Even on the purely theoretical side our work does, indeed, range from chromosomes to endocrines; and this may be regarded as a diffuse program. It is doubtful, however, if a more concentrated attack would take us as far as we want to go. The extraordinary relation that has been worked out between chromosomes and heredity leads to the conclusion that "we are what our chromosomes make us." But we must not forget that endocrinology reveals the fact that persons with very dissimilar chromosomes may become as like as two brothers, in consequence of similar disfunctioning of the endocrine glands. Struck by these remarkable facts, endocrinologists may well insist that "we are what our endocrine glands make us." Between these two views there is, doubtless, no real conflict. If we are what our endocrines make us, our endocrines are what our chromosomes make them. Heredity is the control of the development of the individual. Apparently, in the earlier stages of

development the chromosomes play their rôle rather directly, and among other things determine the quality of cell-tissue or organs which have the special function of determining local metabolism and hence differentiation. Of such organs the endocrine glands are the largest and most striking and stand out most clearly as the great regulators of development. However, we can not neglect the probability that, from very early stages, less obvious and more diffuse cell-groups and tissues are performing a like function. The control of development is a chain with several links; and we shall not understand the mechanism of heredity by confining our attention to any one of the links. Chromosomes, cell-physiology, hormones, and the physical-chemical processes of development are all necessary to an understanding of genetics.

DETAILED REPORT ON CURRENT INVESTIGATIONS.

THE GERM-PLASM.

Since the importance of the chromosomes (Weismann's germ-plasm) in development and heredity becomes constantly more apparent with progress in genetics, it is natural that the investigation of these bodies should have a primary place in our work. Studies are being continued both on the jimson weed, *Datura*, and the banana fly, *Drosophila*, and in both genera the somatic findings in breeding experiments have been correlated with the chromosomal conditions. Cases that do not conform to theory are naturally constantly arising, and the attempt to solve the difficulties they offer leads to important discoveries.

DATURA.

Work on the mutations of the chromosomes of the jimson weed, by Dr. Blakeslee and Dr. Belling, with the assistance of Mr. Gordon Morrison and Miss Betty P. Watt, is leading to new general points of view that can be utilized by all students of genetics and cell-research.

TRISOMIC TYPES; PRIMARY AND SECONDARY.

It has been previously reported that among *Daturas* of the $2n+1$ series there have been found not only primary mutants (of which 12 are expected) but also certain other types with an extra chromosome. The latter are called secondaries. The secondaries now appear to be divisible into at least 3 subclasses. And, first of all, it may be pointed out that studies in pollen abortion carried out by Mr. Cartledge in 1923 had shown that, in all cases investigated, the pollen of secondaries has a higher average percentage of shriveled grains than their respective primaries. This observation, together with the facts presented in our last report, suggested that the difference might be due to some modification of the extra chromosome in the case of the secondaries. It is this suggestion that the past year's studies have confirmed and elaborated.

"In last year's report," states Dr. Blakeslee, "it was pointed out that although the primary mutant Cocklebur appeared to have its extra chromosome in the set carrying the genes for armed and *inermis* capsules, since it threw trisomic ratios when heterozygous for them, nevertheless its secondary Wedge gave only disomic ratios so far as investigated. Thus the Wedge plants tested should have had the formula A_2a if they were like their primary and should have thrown the trisomic ratios $8A : 1a$ among the normal and $9A : 0a$ among the mutant offspring. Actually, they threw instead 3 : 1 ratios among

normal and mutant offspring. This year, the heterozygous Wedge plants obtained by crossing an *inermis* Wedge with an armed normal have likewise given disomic 3 : 1 ratios when selfed, although Cocklebur after similar treatment would have been duplex for *inermis* (Aa_2) and would have thrown the trisomic ratios 5 : 4 among normals and 7 : 2 among mutants.

"It appears, therefore, that a heterozygous Wedge plant is always simplex (Aa) for these genes in question. We ventured the suggestion in the last report that Wedge and other secondary mutants might be primaries modified by a deficiency in a portion of the extra chromosome. Dr. Belling, from studies of the sizes and configurations of the trisomes of primaries and secondaries, offers evidence that in Wedge and certain of the other secondaries the extra chromosome is in fact deficient for one half but in addition has the other half doubled. This conception brings into line many of the peculiarities in morphology and breeding behavior shown by secondaries. Of especial interest in this connection is the occurrence of complementary secondaries in the Rolled, Buckling, Poinsettia, and possibly in the Echinus group. In these cases the primary is intermediate in morphological characters between the two secondaries, each of which shows certain characters manifested in a lessened degree by the primary but not shown by the other secondary. In two groups we have found that one of the secondaries fails to give trisomic ratios thrown by its primary. In a single group in which complementary secondaries have been identified, one of the secondaries gives the trisomic ratios shown by its primary, while the other secondary gives only disomic ratios. By following the inheritance of genes carried by the extra chromosome, it seems we are able not only to locate a given factor in a specific whole chromosome, but also to tell in which half it is present. The mutants in which the extra member in the trisome is a doubled half-chromosome ($2n + \frac{2}{2}$) may be considered to constitute our first subgroup among secondary mutants. They differ from their primaries by being duplex for the portion of the chromosome which is missing and quadriples for the portion which is present in doubled dose.

"A second subgroup of secondaries is represented apparently by Wiry, in which it appears from Dr. Belling's cytological evidence that the extra member in the trisome is a single half-chromosome ($2n + \frac{1}{2}$). In this case we have the secondary differing from its primary by a deficiency of one-half of a chromosome. Wiry, therefore, would be duplex for the missing half-chromosome, but triplex, like its primary, for the other half. It is possible that in one group we have, in addition to the primary mutant, the two complementary ($2n + \frac{2}{2}$) secondaries and also the two complementary ($2n + \frac{1}{2}$) mutants.

"A third subgroup is probably represented by the mutants Nubbin and Spinach. Both throw an extremely high proportion of other trisomic mutants in their offspring, and in both Dr. Belling has found attachments of chromosomes apparently between members of different sets. More evidence is available in regard to Nubbin. This mutant has been placed in the Echinus group on account of its general appearance, its anatomical structure, its breeding behavior (in that it throws a high percentage of the primary Echinus in its offspring), and also on account of the fact that, like Echinus and its secondary Mutilated, it shows a dimorphism of pollen-grains with half devoid of the starch characteristic of normal pollen. Although the pollen dimorphism as well as the morphological appearance indicates that Nubbin has in excess the same part of the chromosome that is in excess in Mutilated, yet the

expressions of the Mutilated characters are less extreme and in certain respects, especially as regards the shape of the capsule, Nubbin shows characters not represented in Mutilated. It is too early to venture a detailed hypothesis in regard to the chromosomal constitution of this type. In view of the foregoing, however, and of the further fact that Nubbin regularly throws two secondary mutants related in appearance to the two $(2n + \frac{2}{2})$ secondaries of Rolled (only less extreme), and of the fact that if Rolled throws trisomic ratios when heterozygous for certain factors for White, Nubbin throws abnormal ratios for those same factors, a relationship is suggested between Nubbin and both the mutant Mutilated and the complementary secondaries of Rolled.

“Possibly all the types of secondaries so far studied involve in their origin the division of a chromosome into halves or unequal segments. It is perhaps significant that all the 6 primary mutants, for which no secondaries had been discovered up to the time of the last report, involved a duplication of the small chromosomes. The fact that the larger chromosomes seem to break in two to form secondaries more frequently than the small ones suggests that the frequency of such breaking is a function of distance, as it is believed to be in chromosomes involved in ordinary disomic crossing-over.

DISTINCTION BETWEEN DIFFERENT WHITES IN DATURA.

“In previous reports it has been stated that the Poinsettia mutant gave typical trisomic ratios when heterozygous for Purple and White if the latter came from a line derived from Washington, but that a consistent increase in the number of White offspring occurred if the Poinsettia was duplex (Pp_2) for a white brought in from a line obtained from Germany. This line has been called a B white and the abnormal ratios B ratios, in distinction from the normal A white from Washington and the A ratios, thrown when two of its chromosomes helped to make up the Poinsettia trisome. Another peculiarity of the B whites is that they are in some way connected up with the spontaneous appearance of Wiry, which appears to be a $(2n + \frac{1}{2})$ secondary of Poinsettia, with the extra chromosome carrying the factors for purple and white. At our last tabulation over 70 cases of spontaneous occurrence of Wiry are listed, and all of these came from parents heterozygous for B whites, but none from parents in which A whites were represented. A preliminary test of whites in nature by means of Poinsettia ratios shows that one found on the island of St. Thomas is an A white, while two others (one from the island of Montserrat and one from near Naples, Italy) are B whites. These two new B whites have also thrown Wirys.

“A more remarkable situation has been found to exist in regard to the mutants Rolled and Nubbin. During the winter we had in the greenhouse 4 series of trisomic mutants made heterozygous for different white lines in an attempt to connect up with the specific chromosomes a number of factors in respect to which these lines differed. The F_2 offspring this summer (June 1924) show that among these whites there are two classes. In one class, normal trisomic ratios occur from simplex (P_2p) Poinsettia, and normal disomic ratios from the other mutants. In the other class, represented by two Whites, both Poinsettia and Rolled throw trisomic ratios, and Nubbin throws a great excess of whites (as many as 7 times the number expected in a 1 : 1 ratio). These two whites are provisionally called C whites, since, although there are some suggestions of a relationship with B whites, it will not be possible definitely to connect the two before a later date in the summer or in the coming winter. It will not be desirable to present in full the evidence at present available in regard to the different kinds of whites, since critical

tests can not be recorded until later. It may be mentioned, however, that Sugarloaf, one of the secondaries of Rolled, fails to give trisomic ratios, and Polycarpic, its other secondary, has thrown a relatively large number of Wirys, although the number of offspring so far obtained is not sufficient to determine the type of ratio. These facts added to the possible connection which has been indicated between Rolled and Nubbin, as well as the appearance of Wirys from parents heterozygous for B whites, suggest that the peculiarities of these abnormal whites are connected in some way with the Polycarpic half of the Rolled chromosome and the Wiry half of the Poinsettia chromosome. The problem is being further investigated by breeding tests of the origin and nature of Wiry, segregation ratios in the mutants involved, the linkage relations between the genes for Curled and the different types of whites and also detailed cytological study of these mutants and the different pure white races. All the evidence at hand points to the conclusion that the difference between our whites is due to differences involving whole chromosomes or relatively large portions of chromosomes and not to simple gene mutations. The abnormal whites include races which have been taken from the wild, show no excessive amount of pollen abortion, and have obviously successfully withstood the struggle of existence in nature. The discovery of these different whites appears to offer a unique opportunity to study evolution of chromosomes in nature; and for some time we have believed that evolution of organic forms has been conditioned by the evolution of their chromosomes."

EXTRA CHROMOSOMES IN BUD SPORTS.

We have previously reported bud sports or sectorial chimeras in which the generative tissue could be represented by the formula $(2n-1)$, the chromosome deficiency being in the Rolled set. Last fall Dr. Blakeslee found a plant, otherwise normal in appearance, with a branch having leaves and capsules suggesting the Globe mutant in appearance. By sowing seed from the two types of branches and obtaining a high proportion of Globe seedlings from the abnormal branch only, it has been shown that the generative tissue of the branch must have had the formula $(2n+1)$ with the extra chromosome in the Globe set. Probably the extra chromosome of the bud sport arose by non-disjunction in somatic tissue. Since the appearance of the abnormal branch was not entirely typical of the Globe mutant, it is possible that the bud sport was in fact a periclinal chimera having the epidermal tissue with the formula $(2n-1)$ and the subepidermal tissue (which alone was tested by breeding) with the formula $(2n+1)$.

GENE MUTANTS IN DATURA.

The search for gene mutants goes on in *Datura*, since they are essential as labelers of chromosomes and parts of chromosomes. Dr. Blakeslee has already shown that the mutant character Swollen is conditioned by genes in the Ilex chromosome and that the gene for Curled is in the Poinsettia chromosome, more specifically in the Wiry half of this chromosome. Since the genes for Purple and White flower-color are also in the same half of the Poinsettia chromosome, the opportunity is being taken of studying the linkage relations between these two pairs of factors in disomic, trisomic, and tetrasomic inheritance.

MEASUREMENT OF DATURA CHROMOSOMES.

Each of the 12 primary mutants of *Datura* is believed to be due to the addition of a whole chromosome to a different one of the 12 chromosome sets

(I to XII) of this plant. It is clearly important to be able to identify these chromosomes, which are a good deal alike in general form but differ in size. Accordingly, Dr. John Belling has undertaken to measure them in the early metaphase. He reports as follows:

"The chromosomes were measured in the trivalents of $(2n+1)$ plants. Thus the identification of each of the 12 different chromosomes was assured in every case. Camera drawings were made at the constant magnification of 2100. These drawings were measured under a binocular magnification of 3.5. The unit of measurement was 0.5 mm., which corresponded nearly to the practical limit of microscopic detail under the circumstances, namely, a quarter of a micron. The product of length by average breadth was taken for each chromosome of the trivalent. Thirty-six chromosomes were found to be sufficient in any case. Half the necessary measurements were made in the summer of 1923. The time-consuming operation was not the measurement, nor the drawing, but the isolation of the trivalents. The following results were obtained.

"Chromosome I, extra large; size 53 to 55 units. This is the extra chromosome in the $(2n+1)$ form, Rolled. Sugarloaf has been proved to have an extra chromosome of this size. The trivalent of Polycarpic probably comes in here.

"Chromosomes II, III, IV, and V, large; size 37 to 48 units. Differences of size in this class will doubtless appear when the measurements are complete. The extra chromosomes of Wedge, Strawberry, and Maple belong to this class; as probably do those of Cocklebur and Buckling. Elongate and Undulate have not been measured yet, but their trivalents seem of this size.

"Chromosomes VI, VII, and VIII, large medium; size 31 to 32 units. Echinus, Microcarpic, and Mutilated have been proved to belong here, 36 chromosomes having been measured from each.

"Chromosomes IX and X, small medium; size 23 to 28 units. Reduced has this size of extra chromosome, and possibly Spinach also is included.

"Chromosome XI, small; size 21 units. Globe has this size of extra chromosome.

"Chromosome XII, extra small; size 19 units. Ilex, so far as measured, has a trivalent with this size of chromosome.

"In several of these cases only 12 chromosomes have as yet been measured. (Of Glossy and *Poinsettia*, no chromosomes have been measured.) Wiry seems to have a half, or part, chromosome in excess of the diploid number, and to be, not a $(2n+1)$, but perhaps a $(2n+\frac{1}{2})$ plant. Its trivalent, so far as observed, has the form of a V; with a large chromosome at the point of the V, and a small one at one of the ends, corresponding to a large one at the other. Such extra small chromosomes were found by Miss Lutz in *Oenothera*.

ATTRACTION BETWEEN THE HOMOLOGOUS ENDS OF CHROMOSOMES.

"It has been shown that in haploid, diploid, triploid, and tetraploid *Daturas*, the chromosomes at the metaphase of the first maturation divisions are joined in such a way that the homologous chromosomes are in contact at the ends only. (This is not the case in some other plants, such as *Hyacinthus* and *Uvularia*.) In the above-mentioned *Daturas*, the homologous chromosomes are grouped in configurations which agree with the assumption that only corresponding or homologous ends of the chromosomes come together. So that if the ends of a chromosome are designated with regard to their different homologies by *a* and *z* respectively, then *a* joins with *a*, but

not with z , and vice versa. (Junctions are not usually found between non-homologous chromosomes.) About 16 types of configurations in agreement with this assumption have been met with, which comprise nearly all that are possible. Configurations of different kinds which do not agree with the above assumption, but require that one or more chromosomes should have similar ends, are 10 or more in number, and have not been found for certain in haploids, diploids, triploids, or tetraploids. (The apparent occurrence of two triangles in triploids admits of an alternative explanation.)

"In the 11 primary $(2n+1)$ forms which occur in approximately equal numbers in the progeny of triploids, the chromosomes combine to form trivalents in the ordinary ways, only one exception being met with in over 100 cases. Here then, as in triploids, the chromosomes of any trivalent are all az . This gives about 5 possible kinds of configurations, all of which were found. But in some of the secondary $(2n+1)$ forms (which do not appear regularly in the progeny of triploids) configurations occur commonly which are only intelligible on the hypothesis that one of the chromosomes of the trivalent (and only one) has similar ends; that is, is aa or zz . Four of these secondaries gave about 80 trivalents, 52 of which were rings of three. Of the types of configuration of the primaries, only one is excluded from the secondaries on this hypothesis; and it was not found in them. Of the configurations of the secondaries, two kinds occur in about two-thirds of the cases; and these two did not occur in any primary (the one exceptional cell has been already mentioned).

"Those secondaries (except Wiry) which have been accurately measured as to their trivalents have given the same chromosome sizes as their respective primaries. Since the chromosomes of *Datura*, when perfectly fixed and stained, show a central or nearly central constriction in all cases, it seems not improbable that in connection with the crossing over, or segmental interchange, in a trivalent, irregularities consequent on the presence of three chromosomes instead of two should lead to the interchange of non-homologous segments or halves; and it may be supposed that in this case the chromosomes separate more readily at the constriction, as has in fact been observed in *Uvularia*."

Dr. Belling has synthesized his observations, and those of others, as to the classes (by origin) of chromosomal mutations, as follows:

"(1) *Non-conjunction*.—In this case the chromosomes, which normally unite to form one of the bivalents or trivalents, remain separate at the late prophase and metaphase of the first division. This state has been found in triploids (and tetraploids) of *Datura*, *Canna*, and hyacinth. It also occurs in diploid uvularias and has been seen in *Tradescantia*. Such unattached chromosomes may be expected to go to different poles on half the occasions and at other times to the same pole. In the latter case, the effect is the same as is produced by non-disjunction; namely, $(n+1)$ and $(n-1)$ pollen-grains.

"(2) *Non-disjunction*.—This is typically a delay in separating shown by the constituent chromosomes of a bivalent, so that both chromosomes stay on the same side of a cell instead of passing to opposite poles. This delayed separation has been observed at the metaphase in *Canna* and in *Uvularia*; and the results have been seen in *Datura*, where about 0.8 per cent of the pollen-mother-cells of diploid plants showed a division into groups of 11 and 13 chromosomes. This would give about 0.4 per cent of $(n+1)$ pollen. Somatic non-disjunction would increase the number of $(2n+1)$ mutants resulting from synaptic non-disjunction.

"(3) *Non-reduction*.—In this case in *Datura* (and in *Canna*) the bivalents (or univalents, trivalents, or quadrivalents) do not separate into split chro-

mosomes which pass to the poles, but all the constituent chromosomes remain in the metaphase plate, and divide there. Pollen-grains with the $2n$ number of chromosomes are produced. Non-reduction has also been seen in $(2n+1)$ and in $(4n+2)$ *Daturas*.

“(4) *Non-division*.—This term is used (after Bridges) for the omission of the second division in the pollen-mother-cells, pollen-grains with $2n$ chromosomes resulting. Evidence of the occurrence of this would be difficult to obtain in *Datura*, but in *Uvularia*, after forcing in the winter, there was an occurrence of this chromosomal mutation. In one plant of *Uvularia* there had been over 20 per cent of non-division in the one bud examined. This had led to the production of many $2n$ pollen-grains.

“(5) *Detachment*.—This consists usually in one chromosome being left between the two groups, at the anaphase of the first division. It was the most common form of chromosomal change in the plants examined; and has been seen frequently in all forms of *Datura stramonium*, in *Canna*, *Hyacinthus*, *Uvularia*, *Tradescantia*, *Secale*, and *Cypripedium*. Pollen-grains with $(n-1)$ chromosomes result. In *Cypripedium acaule*, observation seemed to show that the $(n-1)$ pollen-grains were later in dividing (for the separation of the vegetative and generative nuclei) than the n grains. The $(n-1)$ pollen-grains and egg-cells do not seem to survive in *Datura*. Somatic detachment would lead to the formation of branches with $(2n-1)$ cells in one of the layers, and if this were the subepidermal layer, the immature pollen-grains of the resulting flowers would be n and $(n-1)$ in equal numbers, as has been found in more than one case.

“(6) *Fracture*.—This is the separation of a chromosome into two parts, usually at the constriction. (A constriction is present in all the chromosomes of all the plants belonging to 7 genera, studies of which are briefly reported here.) It has been observed to take place mostly at the separation of the constituents of the bivalents at the first division. Several instances of this have been observed in *Uvularia*. In one case, the long segment of a chromatid remained attached to one of the homologous chromatids after the latter had moved to the opposite pole, and was present at the anaphase of the second division. In *Datura* it is presumed that fracture of a chromosome occurred in the formation of Wiry, and that fracture at the constriction possibly occurred in the formation of Sugarloaf, Wedge, Strawberry, and Mutilated.

“In *Secale*, half of a chromosome seems to be detached in certain plants, so that, as was found in 1922, some rye plants have twice 7, and others twice $7+\frac{1}{2}$ chromosomes in all. The half chromosomes form a small bivalent at the metaphase, one constituent of which is not infrequently detached from the groups at the anaphase. This interesting phenomenon is still under investigation. (The fact has also been observed lately in Japan.)

“(7) *Attachment*.—This is the connection of non-homologous chromosomes at the first metaphase. Such connections have been found in certain $(2n+1)$ *Daturas*, such as Nubbin. In *Tradescantia*, the metaphase chromosomes have been found to be usually connected in fours, in the one plant examined. Such attachment may lead to increase in non-disjunction.”

APPARENT DOUBLE DIPLOIDS AND DOUBLE TRIPLOIDS.

“Further studies have been made of the ordinary ‘diploid’ hyacinths. It has been proved that the different chromosomes which occur in apparent sets of 4 each, and which correspond in size, shape, and position of the constriction, form bivalents, not quadrivalents, at the first metaphase. Also, bivalents of the same size do not attract one another, visibly. Hence the plants are probably not tetraploid, but may be ‘double diploid.’ A double

diploid is presumed to have originated from a tetraploid, but to have developed preferential attraction between the members of each of 2 pairs in each set of 4 chromosomes. Full proof or disproof of this assumption could be given by Mendelian work with individual genes. In this genus there occur 2 species with half the number of chromosomes of the ordinary hyacinth (de Mol). The short, medium, and long chromosomes of the hyacinth, when measured horizontally, are nearly in the length ratio of 1 : 2 : 4. The triploid hyacinths examined had 6 chromosomes of each size, which formed 2 trivalents, with 3 homologous chromosomes in each. Hence they may be "double triploids." The long chromosomes in the bivalents and trivalents of hyacinths were connected at several points. In cases where careful observation *ad hoc* was made, these points seemed to be homologous; that is, at equal distances from the homologous ends of the bivalents or trivalents."

SEPARATION OF CONSTITUENTS OF BIVALENTS AT THE FIRST DIVISION.

"A special study was made of this in *Uvularia*. Single or double rings were common at the first metaphase, resembling the prophase and metaphase rings of certain insects described so fully of late by Janssens. The configurations and modes of separation, of which a complete series was obtained, can all be accounted for by the hypothesis that the rings sometimes lie in the plane of the cell equator and split then into separate chromatids, and sometimes lie at right angles to this plane, when they separate into 2 half rings whose chromatids remain in contact, temporarily. In other words, the mode of separation seems to be the same as that long known in the Orthoptera, etc."

DROSOPHILA.

ASSOCIATION OF HOMOLOGOUS CHROMOSOMES.

To the studies of Belling on polyploid plant species those of Dr. C. W. Metz on *Drosophila* form an interesting complement. He finds that not only in the ordinary diploid cells but also in the cells of triploid, tetraploid, and octuploid organisms the homologous chromosomes are associated both in somatic and in germ-cells. In somatic prophases such chromosomes are in the above-named types arranged in groups of 2, 3, 4, and 8 respectively, corresponding to the numbers of homologues present in each case.

ARCHITECTURE OF CHROMOSOMES OF *DROSOPHILA VIRILIS*.

The breeding work on this species, a first full study of which was published by the Carnegie Institution in July 1923, has been continued, largely in the hands of Miss Mildred S. Moses. To the 40 mutants described in Publication No. 328 and the 20 reported last year, 44 new mutant characters have been found during the year ending June 30, 1924. Several of these represent remutations or are allelomorphs of previously known characters, but most of them probably represent new loci. They have not all been tested fully as yet, so the exact number can not be given.

Particular attention has been paid by Dr. Metz and Miss Moses to sex-linked characters and to characters in linkage groups IV and VI (dot chromosome) of this species. In the sex-linked group (or the sex-chromosome) 30 loci are now represented by mutant characters. The evidence from these, when compared with that from other species of *Drosophila*, continues to support the view mentioned in last year's report that a genetic relationship (or "homology") exists between the sex-chromosomes of these species, but that rearrangements of genes have taken place. The evidence is not sufficient, however, to indicate how extensive these rearrangements have been.

HOMOLOGIES OF GROUP VI IN *DROSOPHILA VIRILIS*.

Dr. Charles W. Metz has paid particular attention to the homology of group VI in *D. virilis*. He reports:

"The best method of identifying the dot-like chromosome with its proper linkage group would be by means of non-disjunction, but all of our efforts to obtain non-disjunction of this chromosome have failed, and it seems probable that in this species a fly haploid for the small chromosome can not live. If so, *Drosophila virilis* differs in this respect from *D. melanogaster*, in which such flies are viable, as shown by Bridges.

"The question of proper identification of these linkage groups with their respective chromosomes receives additional importance from the fact, noted in Year Book for 1923, p. 98, that two of the characters in group VI resemble characters in *D. melanogaster*, that are known to be in the linkage group represented by the small, dot-like chromosome of that species.

"If our hypothesis outlined above is correct, then the evidence becomes strong that the similar dot-like chromosomes in the two species contain corresponding or 'homologous' genes."

ABERRANT BEHAVIOR OF CHROMOSOMES IN RESPECT TO CROSSING-OVER.

The haploid chromosome group of *Drosophila virilis* consists of one small dot-like chromosome and 5 long, rod-like chromosomes approximately equal in size. Each of these 6 chromosomes is now represented by a group of linked mutant characters. 4 of the groups (including the sex-linked group) include several characters each (from 5 to 30) and the characters in each of them give large amounts of crossing-over, so that the "maps" are long. The shortest is 65 units in length. These 4 groups we consider as representing 4 of the 5 large chromosomes. This leaves 2 groups of characters (groups IV and VI) to represent the remaining large chromosome and the small, dot-like chromosome respectively.

Theoretically the linkage group which represents the long chromosome should include a relatively large number of characters and should give a large amount of crossing-over, while the other (representing the dot-like chromosome) should include few characters and give little crossing-over. Actually, linkage group IV contains 6 characters and gives no crossing-over, and linkage group VI contains 4 characters (2 of which are probably allelomorphs) and gives a small amount of crossing-over (about 5 per cent). Based on the number of mutant characters involved, group IV should represent the long chromosome and group VI the dot-like chromosome. But neither group gives the amount of crossing-over expected of a long chromosome. Apparently a cross-over modifier is present which reduces or inhibits crossing-over in this particular chromosome.

In Dr. Metz's opinion the number of mutant characters is more important than the amount of crossing-over as a criterion in this case, because it is well known that frequency of crossing-over may differ irrespective of chromosome size. On this view linkage group IV should represent the large chromosome and linkage group VI the small one. If this is correct, then group VI behaves according to expectation in that it has few characters and gives a small amount of crossing-over, and group IV is the only one showing aberrant behavior. On the alternative view both groups would be aberrant.

IRREGULAR BEHAVIOR OF REDDISH IN *DROSOPHILA VIRILIS*.

Dr. M. Demerec has discovered in the sex chromosome of *D. virilis* a new yellow body-color which was named reddish, as it was redder than the color

determined by the old gene yellow. F_1 flies from a cross reddish \times yellow are yellow. This suggests that reddish and yellow are allelomorphs; but in the F_2 generation of this cross among 10,971 flies 127 showed the wild color, indicating that reddish and yellow are not in homologous loci. When reddish was crossed with sepia, pilose, or scute, i. e., with factors located at the yellow end of the chromosome, then the reddish-sepia, reddish-pilose, and reddish-scute cross-over classes were significantly lower than the cross-over classes without reddish, the differences from equality being respectively 7.8, 10.7, and 13.3 times the probable error. This difference could hardly be due to the greater mortality of the reddish classes, because reddish flies are very viable and in the same experiments were as numerous as, or more numerous than, non-reddish flies. When reddish was crossed with factors in the other parts of the sex chromosomes (cross-veinless, vermilion, rugose), the cross-over classes were practically equal to corresponding ones without reddish. While linkage tests show that reddish belongs to the yellow end of the sex chromosome, yet, in spite of a large amount of data, its exact position can not be determined. The results are not in agreement, Dr. Demerec concludes, with a linear arrangement of the gene for reddish in the same line with the other genes. Dr. Demerec suggests the working hypothesis that reddish, an allelomorph of yellow, is located in a duplicated piece of the yellow end of the sex-chromosome.

NEGATIVE RESULTS OF CENTRIFUGING.

To test the possibility that centrifugal force might disturb the normal distribution of chromosomes, females of *Drosophila virilis* were centrifuged when young, by Dr. Demerec, presumably at the time of the reduction division. These treated females were then mated with non-treated males; the matings being so arranged that the behavior of the sex-chromosome could be ascertained through several factors located in that chromosome pair. The matings sepia-crossveinless-short-rugose \times yellow-vermilion-short were used mostly. Sepia (se) is located near the left end and rugose (r) close to the right end of the sex-chromosome, other factors being scattered in between. The behavior of autosomes was not ascertained through the factors located in them, the assumption being made that most of the disturbance in the distribution of autosomes, if not lethal, would at least affect the soma of the fly so that they would be obvious without special matings.

An electric centrifuge, size 2, made by the International Instrument Co., Cambridge, Mass., was used in the experiments. Numerous experiments were made in which speed and time of exposure to centrifuging were changed. Several speeds from the lowest to the highest were combined with different lengths of exposure, i. e., from 5 to 120 minutes continuously and up to 440 minutes at several intervals during the day. From a total of 149 treated females, 11,133 offspring were examined and among them 16 exceptional ones were found, which were caused by non-disjunction of the sex-chromosome. 106 non-treated females, taken from the same stocks as the treated ones, gave 9,334 offspring with 15 non-disjunctions. Centrifuging, apparently, Dr. Demerec concludes, had no influence on the frequency of non-disjunction.

DEFICIENCY IN X-CHROMOSOME.

Among 8,420 offspring from treated (centrifuged) *y v s* females, which were mated with *se c s r* males, Dr. Demerec found two females which were *se r*. The simplest hypothesis which accounts for the occurrence of these

females is that the two ends of the *y v s* chromosome of the treated females, homologous to the places where *se* and *r* are located, were inactivated or lost. This process would be responsible for the absence of the dominant allelomorphs of *se* and *r* and would allow for the development of sepia and rugose characters. This hypothesis also accounts for the fact that rugose appeared in females, which is an exception, since rugose is a character limited to males and has never before been observed in females. The hypothesis, however, could not be tested further, because both of the *se r* females were sterile. The flies were husky and well developed, and lived for more than a month, but did not give any progeny. One fly was dissected and large ovaries full of eggs were found. It could not be said that treatment caused the occurrence of *se r* females, because the numbers are too small to draw any conclusion.

EXPERIMENTAL MODIFICATION OF THE GERM-PLASM.
GENETICS OF X-RAYED MICE.

H. J. Bagg and C. C. Little (also Little and Bagg) have published the results of their application of Roentgen rays to mice. Abnormal-eyed animals have been found in the third and subsequent generations of the descendants of a group of mice treated with comparatively light doses of unfiltered X-rays on 5 consecutive days. From animals thus treated 2 matings, involving wholly different individuals, produced very similar types of abnormality both morphologically and genetically. One was an eye abnormality, which varied from a slightly perceptible defect in one eye to nearly complete atrophy of both eyes. Club feet were also found. There is a general tendency to defective development, as shown by examination of young in utero. The eye abnormality is definitely inherited, is recessive in character (no abnormal-eyed animals having been found in the first generation of an abnormal \times normal cross) and apparently is mendelian in nature.

Dr. Bagg of the Memorial Hospital, New York City, is cooperating with Dr. E. C. MacDowell of this Department in a repetition of the X-ray experiment on mice to see if such abnormalities as are described in the last paragraph can be produced at will by X-rays. Dr. MacDowell reports as follows:

"As before, Dr. Bagg is responsible for the administration of the X-rays; the same dosage and technique of treatment is being employed as in Little and Bagg's experiment. The mice used and the procedure of the experiment differ in the following ways from the earlier experiment: (1) the mice came from 5 and 8 generations of the closest pedigreed inbreeding under experimental conditions; (2) the history and age of each animal is known; (3) each animal gave a litter before it was treated to test its fertility and to provide controls of the same parentage; (4) the number of controls raised is greater than that of the descendants of the tests; (5) treated males and females are mated alternately with treated and control sibs; (6) to increase the number of offspring each treated female is mated on the day she gives a litter and her young are raised by a foster mother.

"So far 15 mice, in three sets, have been treated; more than 1,400 controls in 4 filial generations have been recorded and a few more than 600 descendants in 2 filial generations from X-rayed parents. In one litter from an X-rayed mother by a control father a male was found with one ear short. This male, by 5 full sisters, has given 44 normal young. The second generation has not as yet been born. Among the controls, abnormalities of eye, mouth, or foot have appeared in 4 mice; of these, 3 died early and 1 is a runt. These abnormalities resemble the hereditary malformations discovered by Little and

Bagg, but there is no evidence that they depend upon the same or any specific gene. In an independent side branch of the same strain another abnormality was found that has been tested. This was a defective eye, which at birth looked like the abnormality occasioned by the gene designated by the letter *h*. When crossed to 5 mice carrying the inherited abnormality, that is, of the constitution *hh*, the mouse in question gave all (42) normal offspring; by its own sisters it has given so far 10 young, one of which lacks an eye. Whether or not this may be taken to indicate a heritable basis for this particular case, there can be no doubt but that the abnormal eye in this mouse is not due to the gene *h*.

"The delay in breeding, previously reported as a result of the X-ray treatment, is not verified; the females were non-pregnant when treated and began to breed according to standard when mated immediately after treatment.

"Further cooperation with Dr. Bagg has involved breeding certain selected abnormal families (200 mice) in connection with his discovery of the occasional absence of one or both kidneys as one of the abnormalities displayed by the animals that carry the gene *hh*. Mice with no external indication of any abnormality, the so-called normal overlaps, may lack one or both kidneys, although this abnormality is usually associated with the abnormal eyes or feet carried by the strain. In some cases mice with no kidneys may take in their first meal and live for several hours after birth. This work has been reported by Bagg in the Proceedings of the Society for Experimental Biology and Medicine for February 1924."

ULTRA-VIOLET RAYED MICE.

Mice have been exposed to ultra-violet radiation at Orono, Maine, by Dr. C. C. Little and his collaborators, and, in one family, the F_3 generation has shown a large number of mice that are distinctly smaller than the average. Most such die young, but one has been raised to maturity and when crossed with her normal brother produced 3 normal and 2 small young. The experiment is being continued.

SEX STUDIES.

CONTROL OF THE SEX-RATIO IN CLADOCERA.

Dr. A. M. Banta has continued his attempts to control the sex-ratio of the Cladocera which he has so successfully carried on with the cooperation of Mr. L. A. Brown of the University of Pittsburgh. Earlier results had shown that in crowded bottles the ratio of males was much increased; that most disturbances of the condition of the water in the crowded bottles diminished the proportion of males, but that the addition of carbon dioxide, uric acid, or pressure increased the proportion of males.

During the past 10 months some progress has been made. Thus it has been determined that test animals confined within a glass tube, the lower end of which is covered with silk bolting-cloth and immersed in a "crowded" bottle, produce as many males as those free in the crowded bottle, whereas others in such a tube but without "crowders" about the tube do not produce males. Hence the modifications in the culture medium produced by crowders readily pass through bolting-cloth.

Dr. Banta reports further:

"The usual crowded bottles which produce males contain 10 mothers and 75 c. c. of culture medium. In a similarly shaped vial containing 7.5 c. c. of culture medium and a single mother, males are likewise produced, showing

that the mother in a small amount of culture medium may create the male-initiating situation for herself.

"The changes which occur in the culture medium of a crowded bottle are not specific. Other species of Cladocera may be used as crowders and will produce the same effect as crowders of the same species."

NATURE OF MALE INITIATING FACTORS.

"The effects of aeration especially suggest the possibility of excretory products, possibly volatile excretory products, being involved. To test this out a series of experiments was conducted in which it was sought, if possible, to transfer the volatile substances from crowded bottles to uncrowded bottles. The set-up was as follows: Semi-crowded bottles containing young mothers from a single brood were placed at the beginning and at the end of a long series of heavily crowded bottles (about 20). By means of 2-hole rubber stoppers and glass and rubber tubing, connection was made through the entire series of bottles through which air was slowly bubbled. Other semi-crowded bottles containing young from the same brood were maintained outside of the bubbling series to serve as additional controls. In most cases these 'outside' controls produced a slightly higher percentage of males than the semi-crowded bottles at the beginning of the bubbling series. This would seem to indicate that the bubbling was extensive enough to produce some aeration effect at the start of the series. By the same warrant (if volatile excretory products were present as assumed) the semi-crowded bottles at the end of the series should receive some of these products from the slowly bubbling air-stream (which immediately before had passed through a long series of heavily crowded bottles) and should produce a greater percentage of males than undisturbed semi-crowded bottles. Such did not prove to be the case. The semi-crowded bottles at the end of the series actually produced no more males than those at the beginning of the series.

"This result was not entirely unexpected. Other evidence had already indicated that the male-initiating factors are very transitory, even when aeration had apparently not occurred. The evidence then inclines to the opinion that the excretory products (if such products are the key to the situation) are not necessarily volatile, but rather that they are unstable and that their break-down is facilitated by aeration and by other treatments.

"All the above experimental evidence may be thought of as consistent with the conclusion that the male-provoking condition is a complicated situation in which excretory products conceivably play an important part. Clearly some factor or a balance of factors involved in the culture medium is unstable and easily disturbed."

Other factors that influence crowding have been detected. Temperature is one of these. Semi-crowded bottles have been kept at approximately 15°, 20°, and 25° C. With remarkable uniformity the mothers reared at the lower temperatures produced the most males. Thus, the average percentage of males for 39 experiments at the three temperatures named above were respectively 48, 13, and 5.

Low temperatures and crowding have a common effect—namely, retardation of development; and such retardation may in itself be a factor in male production. But low temperatures have not caused male production in the absence of at least partial crowding. Low temperatures and slow development seem to accentuate the effect of crowding—which is believed to be due to physico-chemical changes arising in the culture medium.

ABNORMAL BEHAVIOR OF SEXUAL EGGS.

In one strain of Cladocera in which males are absent, *sexual eggs* are produced which may develop and hatch without being fertilized—as they have to be in other Cladocera. The chief interest in this phenomenon lies in the problem of the number of chromosomes in these ephippial eggs. It has been generally concluded that these eggs have the reduced (haploid) number of chromosomes and that the diploid number is restored by fertilization. But these eggs are not fertilized, hence the number can not be restored. Are these sexual eggs, then, diploid, and, if so, why do they differ so strikingly from ordinary parthenogenetic eggs? Dr. Banta advances the hypothesis that, just as the Cladocera are tending toward parthenogenesis in other types of reproduction, so perhaps their sexual eggs, which exist for fertilization and as resistant bodies to carry the species through unfavorable conditions, may have begun to lose the first-named function. We have been fortunate in securing the cooperation of Dr. Franz Schrader of Bryn Mawr, who is studying the chromosome history of this race.

THE FUNDAMENTAL NATURE OF SEX DIFFERENCES IN MUCOR.

Miss Sophie Satin, formerly mycologist in the University of Moscow, has been associated with us since January 1 under a grant from the Committee of the National Research Council for Research on Sex Problems. We have started a cooperative investigation upon the fundamental differences between sexes in the mucors, using various biochemical tests. The investigations are as yet in too early a stage to warrant a detailed report of our results. Dr. Blakeslee offers the following preliminary statement of Miss Satin's results, so far as obtained:

"We have demonstrated the existence of physiological differences between races of the same sex, a fact which shows the necessity of testing a large number of individual races of both sexes before reaching conclusions as to the biochemical bases of sex in these or other forms. Most extensive have been our tests of the ability shown by certain living cells to reduce tellurium and selenium from salts of these elements. A total of 264 races (131 Plus, 128 Minus, and 5 Neutrals) was investigated. In all, 7 genera and 13 species are included, and the collection may be considered fairly representative of the group of dioecious mucors. The strength of reaction is indicated by the intensity of pigmentation due to the deposited Te and Se (black for the former and red for the latter element). Grades were recorded by aid of the Color top. It was found that, if the races were grouped according to their power of reduction, Plus races predominated among the strongest reducers (63 Plus to 27 Minus), whereas Minus races predominated among the weakest reducers (36 Minus to 12 Plus). So far as their power of reduction is concerned, there are two groups in our collection. In the first, or larger group, there is a greater or less predominance of Plus races among the strongest reducers and a reversed condition among the weakest reducers. The second group is smaller and shows no essential difference between the Plus and Minus races among the strong and weak reducers. As yet we have found no group in which Plus races are more frequent among the weak reducers or Minus races among strong reducers.

"What significance, if any, is to be attached to the evident greater average reducing capacity of the Plus race can not be told as yet. It is conceivable that the sex differential directly influences the reducing power of the living cells, but that there are other non-sexual factors in respect to which the races of either sex differ which are also of influence. Tests in progress with other reagents upon the same races may throw light upon the question."

SEX-REVERSAL IN ADULT RING-DOVE.

Dr. Riddle has described a case of "sex-reversal" in a dove. This bird had laid 11 eggs at times exactly observed between January and April 1914. In the latter part of 1914, the female on 3 occasions "went broody" without having laid eggs; but incubated eggs of other hens placed under her. In February and March 1915, she was seen to take the part of a male in copulation and in October 1915, coo-ed as a male. She died in December 1917. Autopsy revealed advanced abdominal tuberculosis. Two testes were found, removed, and weighed. The history of the bird was not fully in mind at the time of autopsy and no unusual search was made for traces of ovary or oviduct; which, if present, were obscured by disease.

Dr. Riddle emphasizes the conclusion that the dove probably passed through a stage when its left gonad was partly ovary and partly testis and would have been described as an hermaphrodite gonad; and he thinks that many cases of hermaphrodites in the higher vertebrates have this history. He points out that since sex is a "chromosome-determined" character, this case shows that such a character may become transformed or reversed in its final condition. He suggests, moreover, that other chromosome-determined characters may also have the course of their development altered; and thus heredity may not have the fatefulness usually ascribed to it. "It does not follow that the hereditary factors are transformed, nor that the character-transformation at all affects the succeeding generation."

RIGHT AND LEFT GONADS IN BIRDS AND MAMMALS.

As is well known, the left ovary only is functional in birds. In at least several cases of hermaphroditism in birds it is reasonably clear that the right testis arose on the site of a previously degenerate and never-functional right ovary. On the left side, however, there must have been prolonged stages, Dr. Riddle concludes, at which both a growing or functional left ovary co-existed with a newly growing left testis to form an ovo-testis. Essentially this condition is found in the 11 cases of hermaphroditic fowls in which both right and left gonads have been found present. In other birds all of the 4 known cases having bilateral gonads are found to follow the same rule—right side testis; left side ovo-testis or ovary. Of the 12 best authenticated cases of human hermaphroditism, 7 show a high proportion of testicular tissue on the right side, 2 show the reverse, and in 3 the point is doubtful. "All the evidence," says Riddle, "supports the points: (1) that many cases of hermaphroditism among birds, at least, are really stages of sex reversal, and (2) that the right and left sides of the bird's body, at the point of origin of the sex-glands, are not equally favorable for the growth of testis and ovary; the ovary being favored on the left side and the testis on the right." Dr. Riddle has summarized 12 cases of probable true hermaphroditism that he has found in pigeons. In 9 of them, the right gonad had, or appeared to have, a higher proportion of testis tissue than the left. In 1 case the opposite seemed probable. In 2 cases the relative proportions were not estimated. Of these 12 cases 11 arose in hybrids, 8 of them between different genera.

The atrophy of the right ovary begins in birds at about the time of hatching, and this fact has been considered an expression of unequal femaleness of the right and left sides of the body of the female bird. In all species of pigeons examined by Dr. Riddle (when free from disease and when not kept

too long in confinement), the right testis is usually larger than the left. But under disease, confinement, and hybridity, the proportion of pairs of testes in which the right is larger is diminished. Other observers have concluded that, in birds in general, the left testis is the larger. Dr. Riddle believes that this discrepancy may be due to a failure of the other observers to consider the effects of confinement, disease, and the relation to the bird's breeding-season. To be sure, in some wild birds the left testis is larger during at least most periods of the year, yet in other species examined the left is not larger than the right. Moreover, conditions adverse to testis growth in pigeons usually produce either greater reduction or more frequent reduction in the right testis; and the shape of the left testis more nearly resembles that of the ovary than does that of the right testis.

Dr. Riddle also points out that in hybrids of pigeons the more distant the cross and the larger the proportion of male offspring, the larger the proportion of hybrids with heavier left testis.

BIRDS WITHOUT GONADS.

In 16 cases pigeons have occurred that showed no trace of gonadal tissue; and in 10 of these the birds were healthy or otherwise preclude the hypothesis that the birds had lost their gonads through disease. In 15 other cases one gonad (only) was abnormally absent—evidence that gonadlessness is a developmental phenomenon. Despite this probable congenital absence of testicular tissue, some of these birds developed the behavior and some other secondary sex characters of the male. Dr. Riddle points out the very important bearing of these cases on the theory of the rôle played by the internal secretions of the gonads.

CALCIUM METABOLISM AND SEX.

Earlier investigators having suggested that the sexes of mammals differ in calcium metabolism, Dr. Riddle and Dr. H. E. Honeywell undertook a re-examination of the subject in pigeons with an improved method—that of Kramer and Tisdall. Brothers and sisters of two genera of pigeons were taken (also some male family hybrids). Conditions of diet and sunlight were the same for the two sexes. Results suggest that female pigeons normally show a higher percentage of calcium and magnesium in the blood than do male pigeons.

GENETICS OF SPECIAL TRAITS.

THE TISSUE FLUIDS OF EGYPTIAN AND UPLAND COTTON AND THEIR HYBRIDS.

These studies have been continued along the lines indicated in previous reports. The results of a first study on Pima Egyptian, Meade, and Acala Upland and the F_1 hybrid of Meade Upland and Pima Egyptian cotton have been published by Harris, Lawrence, Hoffman, and Lawrence and Valentine in the *Journal of Agricultural Research* for February 2, 1924. The conclusions of this paper, which represent the results of determinations made in 1920, have been fully substantiated by more extensive subsequent investigations. The high electrical conductivity of the tissue fluids of the Egyptian cotton indicates greater capacity for the absorption and tolerance in solution of electrolytes. Large series of analyses have shown that the chloride content is higher in the tissue fluids of the Egyptian than in those of the Upland plants grown under the same conditions. A detailed report by Harris, Lawrence, and Lawrence is now in press.

Investigations on the sulphate-content of the two types of cotton have shown that while the chloride-content is higher in the Egyptian cotton the sulphate-content is higher in the Upland type. A discussion of these results by Harris and Hoffman is ready for press.

The clear-cut differentiation of the Egyptian and Upland types with respect to physico-chemical properties of their leaf-tissue fluids affords an opportunity for the investigation of the behavior of these physiologically highly important variables in hybridization. Studies of the F_1 and F_2 hybrids are to be investigated in association with each other and with the parent forms during the summer of 1924.

Because of the great susceptibility of all of these characters to environmental influence, a study of the tissue-fluids of the other species of plants in immediate association is essential for valid comparisons.

ALBINISM IN MAIZE.

In cooperation with Professor R. A. Emerson of Cornell University, Dr. M. Demerec has continued the experiments on the genetical analysis of white seedlings. If F_1 data alone are taken into consideration, a conclusion can be drawn from the obtained results that there are at least 10 genetically different factors which determine albinism in maize.

VARIATION IN DELPHINIUM.

During the last year, tests of the various factors that affect the development of the chlorophyll were completed and the genetic relations of 7 such were established. Three genetically different factors were found for variegated leaves (V_1-v_1 , V_2-v_2 , V_3-v_3), one for albinism ($W-w$), one for pale-green seedlings and plants ($P-p$), one for piebald plants, i. e., plants with irregular white spots ($Pb-pb$), and one for virescent seedlings ($Vi-vi$), i. e., seedlings which are white at the beginning and turn green later. It was found, also, that the factor for virescent is very closely linked with one of the factors for variegated leaves.

The analysis of mature plant characters as well as further study of variegations has been continued in cooperation with Dr. Metz. The data collected up to this time show that there is one dominant factor which determines anthocyan color in the stem of plants.

VARIATION, CORRELATION, AND INHERITANCE OF EGG PRODUCTION IN THE DOMESTIC FOWL.

Much new material has been organized and these studies are being summarized for publication by the Carnegie Institution; but no new results have been published during the year.

SUSCEPTIBILITY OF MICE TO ALCOHOLIC INTOXICATION.

During the year, the second definitive series of tests of alcohol susceptibility has been started by Dr. MacDowell; in this series the parents and inbred descendants are studied. The reactions obtained from 200 mice belonging to 7 strains have been tested in this series by methods which standardize the age, number of tests, length of treatment, amount of alcohol, criteria of reactions, etc. To simplify the problem, the experiment is now concentrated on 4 of the original 7 strains. Striking similarities have been found between different litters and different generations within the same strain, and differences equally striking between different strains have appeared.

Heredity is a factor in reactions of mice under the influence of alcohol fumes. Before attempting to determine the method of this inheritance it will be necessary to reduce the extraneous influences that act upon the tests and to reduce genetic variability by several generations of selection.

NON-INHERITANCE OF THE EFFECTS OF TRAINING.

Perhaps none of the recent experiments on the modifiability of germinal material has done more to reawaken general interest in this subject than the brief report given by Pavlov of some experiments in which successive generations of mice formed a given association more and more rapidly. Although details of this experiment are still lacking, the tendency in the popular mind has been to apply this conclusion to all training and to arrive at the conclusion that the training of parents is inherited by children. In connection with the study of the effects of alcohol upon the learning ability of albino rats in different generations, Dr. MacDowell made a large collection of records from normal control animals. These had been studied only as controls for the test rats, but they offered also a mass of data bearing critically on the problem of the inheritance of training. An analysis of these records from this point of view has now been completed by Dr. MacDowell. The learning records of 200 normal albino rats, trained for two and three generations to find their food in a maze, were found to satisfy the requirements of this study. The comparison of the different generations led to the unquestionably clear conclusion that the training of the ancestors did not facilitate the learning of the descendants.

GENETICS OF TRANSPLANTABLE CANCER.

Under Dr. C. C. Little's direction, Miss E. E. Jones has been continuing at Orono, Maine, on a steadily increasing scale, the work on isolation of single-factor lines of mice susceptible to implants of the two carcinomas dBrA and dBrB. This has necessitated the breeding and inoculation of a very large number of mice. This year 66 males have been tested, individually; 7 of these are being tested further, the preliminary tests having shown that they possessed certain of the required factors.

Miss B. W. Johnson, also at Orono, has in process of preparation for publication a paper on the genetics of a transplantable tumor, dBrO3. She has shown that this tumor depends for its growth upon the simultaneous presence of three independent Mendelian factors; and that none of these factors is in any case linked with the dilution factor, as is at least one of the genes which underlies susceptibility to the tumor dBrA.

Dr. Little has published a somewhat detailed criticism of Leo Loeb's Individuality Differential Theory, and has tried to show that his classification into the groups of homoio- and hetero-differentials will have to be revised on the basis of our present knowledge of genetics. It also seems that the class of transplants which he groups under the term "syngenesio transplants" is a purely artificial one, and breaks down entirely when genetic rather than pedigree relationships are considered.

Data are also on cards and in process of analysis to interpret Slye's results on the genetics of cancer. Strictly speaking, her work deals with spontaneous rather than with transplanted tumors. It is, however, more convenient in the preparation of this report to include it with the latter than to make a special section for it. Without attempting to enter into a detailed account of the evidence, it may be stated that there is fairly clear proof in Slye's own

work that mammary tumors are genetically distinct from the other types which she has described, and, further, that they depend for their expression upon a dominant mendelizing factor. It also seems that there is evidence that the other types of tumors depend upon multiple factors. While these last two papers are of a destructive-critical nature, they are believed to be justified if they only raise a scientific doubt as to the finality of the individuality differential hypothesis, or the recessive nature of all types of cancer.

Dr. L. C. Strong has continued, at St. Stephen's College, work which he began here on the reactions of mice to transplantable tumors. In general there appear to be genetic factors which permit tumor growth in certain strains of mice only. One sarcoma (Crocker Research Lab., No. 180), however, has been discovered that grows almost uniformly in a number of different strains of laboratory mice. The existence of this sarcoma seems to be an obstacle in the way of the general acceptance of the genetic view. Dr. Strong has, however, found that mice differ in their reaction to this tumor variously. Thus the tumor grows faster in young mice than in adults, whether an inbred albino strain or heterozygous. But in very old mice in which the gonads are not functioning the tumor grows as fast as in immature mice. Mice of certain wild strains castrated while immature were non-susceptible, but those castrated when adult were completely susceptible. Dr. Strong concludes that No. 180 does not disprove the theory that transplantability is controlled by genetic factors, and that the evidence suggests that the gonads have some influence on the assumption of tissue specificity on the part of the host.

THE GENETICS OF SPOTTING.

This field of genetics has been a well-known source of interest and difficulty, and has provided some of the most complex problems that investigators have been called upon to face. As contrasted with the ill-defined spots worked with by other authors, the Orono group has been able to secure two relatively simple forms of spots. A race of black mice yielded a white tail-tip (wtt), also an unpigmented band around the tail "white on tail" (wot). Wtt is recessive to self-color. Occasionally two wtt parents may produce self young, but they are genotypically wtt. Also, occasionally, in this strain the tail-spot is transferred to the belly (with or without white on tail), but the animals are genetically also wtt and breed the same as phenotypically white-tailed animals. Another strain of mice shows a ventral white patch which varies in position and in size to complete absence. Work is being done on the relationship of these types and to throw light on the problem of spotting in general. In this work a new histological method of studying skin pigment has been developed.

GENETICS OF ABNORMAL FOOTED MICE.

Further genetical studies are being made by Dr. Little and his group on abnormalities of feet and legs that followed X-ray treatment of remote ancestors. There is no simple Mendelian inheritance. Apparently two factors, F and L, are involved in production of normal feet and legs—ffll is lethal and ffLl is genotypically and usually phenotypically abnormal; ffLL is usually phenotypically normal. Since all abnormal-footed animals have at least one L factor, two such never give 100 per cent abnormal progeny.

There is no evidence that abnormal-eyed mice are more apt to have abnormal feet than normal-eyed mice. Hence, the factor L has at least a dif-

ferent effect upon the two genetic combinations LL (eye abnormal) and ff (foot abnormal). This suggests that l and f are not identical.

In the line that has given abnormal-eyed and abnormal-footed individuals arose a polydactyl female, which, when crossed with her normal-footed brother, gave 4 young, 1 polydactyl. The same polydactyl mother mated to her polydactyl son gave 11 young—2 polydactylous, 2 club-footed. The polydactylous father of the above was crossed with unrelated, normal-eyed females and sired 46 young, all normal eyed and normal footed. Dr. Little concludes that, in this strain, polydactylism is not dominant.

SADDLE MICE.

The study of the localized shortening of the hair on back and flank known as "saddle" is being continued by the Orono group, but meets with difficulty because of heavy mortality or sterility of the most typical examples of these mice.

SPONTANEOUS ABNORMAL EYE.

A mutant (called r, reduced) in mice is being studied by Miss Elizabeth Jones at Orono. In the reduced eye both lens and eye opening are affected and total blindness sometimes occurs. The indications are that it is a recessive, sex-linked character; but, since no true breeding strain of abnormal-eyed animals has been produced, modifying factors may also be involved.

RABBITS.

Professor H. D. Fish of the University of Pittsburgh, as Associate of this Department, has continued his researches, on the unique strains of rabbits, which he has been carrying on since 1917. He reports the production of a truly homozygous white Dutch strain. By selecting the phenotypically whitest individuals of his whitest strain he secured a line which is the whitest yet produced (having black about eyes and tail only) which has varied not more than 4 per cent through 3 generations.

Professor Fish has devised a new method of describing the distribution of color areas. The coat of the living animal has been marked into squares and the corresponding forms and sizes of such squares found when the pelt is removed and stretched. By this means the descriptions of the various investigators, whether made from living animals or from stretched hides can be compared.

GENETICS OF THE THOROUGHBRED HORSE.

During the year studies were continued in the genetics of the thoroughbred horse by Dr. H. H. Laughlin in collaboration with Mr. Walter J. Salmon. Researches were undertaken in England, the home of this breed of horse, and special research was begun into the methods of mate selection followed by the English breeders. A personal visit was made by Dr. Laughlin to several of the most important English studs, and finally a field worker, Miss May Carter, was secured for the purpose of gathering biological data concerning soundness, speed, and stamina of the several members of selected strains of horses. Headquarters have been provided for her at the rooms of the Eugenics Education Society, 11 Lincoln's Inn Fields, London.

In Kentucky, in collaboration with Professor W. S. Anderson of the Department of Genetics of the University of Kentucky, Mr. A. R. Quarles was employed as field worker for making studies on the family strains of selected groups of American thoroughbreds.

A third field worker is maintained with headquarters at the Eugenics Record Office, making similar family studies of the horses which compete in the great races held near New York City.

The work in horse genetics is now well established with a staff comprising Miss Alice Hellmer, the principal scientific assistant, and three field workers and one office assistant. A highly specialized library on horse genetics is being built up, and the whole work organized for the principal purpose of securing facts in reference to the family distribution of soundness, speed, and stamina, and the inheritance and variability of these qualities, and to the principles of mate selection followed in building up and maintaining highly specialized strains within the breed of Thoroughbreds.

Data are being critically collected and systematized so that such questions and problems as the following can ultimately be answered or worked out:

1. Have the best stallions been consistently put to the best mares, or has the matter of fashion and reputation played an undue part?
2. Has the type of inbreeding been a definite factor in speed production?
3. What influence has the age of the sire, the age of the dam, the order of birth, and the interval between births played in speed production?
4. The working out of a near-kin index for speed in which the probable hereditary speed constitution of a given animal can be predicted within a definite range of error.
5. The collection of pedigrees showing the family distribution of definite unsoundnesses, which now are known to run in families, for the purpose of seeking more definite rules of inheritance.

TWINNING IN SHEEP.

In 1924, the same ram was used as in the past 2 years (No. 379, a single of the twin strain). There were born 7 singles, 10 twins, 2 triplets, and 1 quadruplet (so large that they caused the mother's death). This is an average of 1.85 young per mother as contrasted with 1.75 last year and 1.38 the year before. The ram, increasing yearly in strength and vigor, has thus at the same time increased in fecundity. This again emphasizes the importance for multiple births of a vigorous male.

Through the kindness of the estate of Dr. A. Graham Bell, this Department was presented with two ewes from Dr. Bell's famous multi-nippled twin-bearing flock (Nos. 28-29 and 25F), both 6-nippled twins. The latter, having been mated to the best sire of the Bell flock, bore 6-nippled twins in March.

HUMAN GENETICS.

HEREDITY IN ARISTOGENIC FAMILIES.

Dr. H. J. Banker has concentrated on the collection of data for a study of inheritance of special scholarship, using the school records of the town of Huntington and compiling pedigrees of the families involved. At this time about 100 families are involved, comprising 450 students. Only families are considered for which there are records for both parents and one or more children.

HEREDITY IN CACOGENIC FAMILIES.

Dr. A. H. Estabrook has continued his field work in Virginia and in Kentucky. His study of the Indian-negro-white racial complexes in the south-eastern States has been completed. This included a study of the "Isshies" of Amherst County, Virginia, in cooperation with Sweet Briar College. The

group is segregated by geographical and social barriers and is much inbred. On account of much promiscuity, in certain sections accurate pedigrees have not been obtainable. Other groups like the "Isshies" have been examined in Amherst, Rockbridge, Halifax, Charles City, New Kent, and King William Counties, Virginia. In all cases the Indians are mixed with negro and white bloods. In Robeson County, North Carolina, were found the Croatans, a group of 10,000 Indians, partly diluted with negro. In Marlboro County, South Carolina, are two groups of Indians, partly Croatan, partly Cheraws. They number 3,000 and are partly mixed with whites and with negro. Similar Indian-negro-white mixtures are found at Pontiac and at Summerville, South Carolina, and in Butler County, Tennessee. These groups present a problem, partly on account of the mental defect present in many of them; partly on account of the social barrier which causes these whites, because of traces of Indian and negro blood, to be segregated.

The major field operation in the mountains of Southeastern Kentucky has been continued. The genealogies of about 20 of the old families have been compiled and data collected about each member of these families. Due to the loss of the more ambitious and keener persons by emigration, the stock that has been left behind has deteriorated. This appears to hold only for the heads of the creeks of the Kentucky River—not for the mountain areas with more fertile valleys and better transportation. Mental testing was carried on in the schools of the area and the economic factors involved in migration have been considered.

A cursory survey was made of the mountainous region east of Knoxville, and much use was made of the records of Maryville College, which has served the county for many years.

ENDOCRINES IN DEVELOPMENT OF HUMAN TRAITS.

A study was made by the Director of 100 mongoloid idiots, to throw light on their striking resemblance. Work was done at Letchworth Village with the cooperation of Dr. C. S. Little, superintendent; at Vineland, with the assistance of Prof. E. R. Johnstone of the Training School and Mr. Moore of the Girls' Home; at Elwyn, Pa., Dr. Martin W. Barr, superintendent; at Waverley, Mass., where every facility was afforded by Dr. W. E. Fernald, and at Randall's Island, Dr. C. G. McGaffin, Medical Superintendent. A series of measurements was made on children at the Orphan Asylum of Brooklyn under arrangements made with Miss L. Elizabeth Thomas, superintendent. The latter series serves as control. Miss Anna W. March assisted in the reduction of the data. Some results of these studies were presented in May before the American Association for the Study of the Feeble-Minded.

INHERITANCE OF EXCEPTIONAL INTELLIGENCE.

A study of the family histories of 90 families of students at Public School No. 165, New York City, who showed a high-intelligence quotient by the Binet test, has been made by Miss Grace Allen, working under my direction and in collaboration with a committee of Teachers' College, New York City. These histories are now being prepared for publication.

GENETIC CONSTRUCTION OF THE AMERICAN POPULATION.—NATIONAL IMMIGRATION.

From August 8, 1923, to February 14, 1924, Dr. H. H. Laughlin was in Europe making a study of American immigration at its sources. The study was facilitated by Dr. Laughlin's appointment by the Secretary of Labor as

United States Immigration Agent to Europe. In all, 11 countries, namely, England, Holland, Germany, Sweden, Denmark, Belgium, France, Italy, Switzerland, Spain, and Algiers were visited. The work divided itself into two sections: first, experimental studies in personal and family history records of would-be emigrants to the United States; second, through the American consuls, securing first-hand facts about the historical, anthropological, social, economic and political conditions which were and are influencing emigration to America, with particular reference to the constitutional capacities of the specific classes affected.

The investigations of the personal and family histories of applicants for the American visé of passports to America were made with the collaboration of the consuls under the theory that the viséing agent is entitled to sufficient knowledge concerning applicants. Four histories were thus worked out in Belgium by Madame Varchaver, field worker; 4 in England, with the collaboration of the Eugenics Education Society, by Miss E. E. Mudd; 4 in Sweden with the State Institute of Race Biology, Herman Lundborg, Director, by Guimar Dahlberg, field worker. The information obtained included (a) short biography, individual analysis card, conduct, community reputation, occupations, achievements, moral and social instincts, temperament; (b) physical, physiological, pathological, anthropometrical, and racial data, (c) tests of literacy, general mental ability, special talent, and defects; (c) pedigree chart and descriptions of the near kin of the applicant. Provision was made for an analysis of the case showing (a) the probable development and values of the individual gauged by his juvenile promise and by the stock from which he springs; (b) whether the possible offspring of the individual would constitute an asset or a debit to the American nation, based on the average inborn physical, mental, and moral qualities of the family stocks already existing in the United States. The study led to the conclusion that, because of the desire of the applicant to emigrate to the United States and because of the increasing value placed on this privilege on account of the policy of restriction of immigration adopted by this country, it will be feasible to secure necessary data concerning the applicant, by agents of this country; though special cases may arise where obstacles would be placed by a foreign government to the way of making the necessary inquiries. It was concluded from these studies that the cost of making them could readily be borne by the applicant; also that a decision of the question whether a would-be emigrant meets the individual and family stock standards set by American law can be determined much more surely in the home territories of the emigrant than in the isolated and foreign environment in which he is placed after he arrives in America. From the biological viewpoint, it was demonstrated by these researches that if our legal standards of individual and family stocks were sufficiently high, immigration could be made to add to the family stock values of the American people.

In making the studies described above, special courtesies were received from Dr. A. Govaerts, director of the Belgian Record Office, established at the Solvay Institute. Most of the 128 consular offices of the United States in Europe and the Near East rendered assistance in the study; and of them 25 were visited by Dr. Laughlin. Data concerning immigration conditions in their territory were received from most of the consulates. The results of this study are being published as a hearing before the House Committee on Immigration and Naturalization, March 8, 1924, under the title *Europe as an*

Emigrant Exporting Continent and the United States as an Immigrant Receiving Nation; A Preliminary Report of Field Investigations Concerning Present-Day Human Migrations, with Particular Reference to Racial and National Fortunes, Statistically and Biologically Considered. The manuscript comprises 152 typewritten pages and is accompanied by 29 charts and tables.

THE PHYSIOLOGY OF REPRODUCTION AND DEVELOPMENT.

NUMBER OF CORPORA LUTEA IN MICE AND ITS MODIFICATION BY ALCOHOLIZATION.

In order to get a more adequate criterion of the activity of the ovaries than is given by size of litter (influenced as the latter is by failure of fertilization and by early intra-uterine deaths), Dr. MacDowell has been counting corpora lutea by the surgical technique described in Year Book No. 22, p. 117. As a result of prolonged testing of the method the following conclusions are warranted: (1) the operation does not affect the number of young subsequently born; (2) it does not increase the number of young found dead at birth; (3) the operation may safely be repeated many times on the same mouse; (4) the method is entirely satisfactory for determining the number of ova produced under given experimental conditions and of prenatal mortality under especial modifying conditions.

"The analysis, by this method, of the influence of relatively light doses of alcohol upon reproduction in mice has been completed. Mice treated daily with the standardized 'light' dose of alcohol fumes for an average of 4 months before their first pregnancy, and after this, on all but the last few days of the succeeding two or three pregnancies, produced as many corpora lutea as their untreated sisters. In 48 test operations the corpora lutea averaged 9.95 per pregnancy; in 49 control operations, 9.90 per litter. In these matings the same normal male was used for the treated and control sisters from the same litter. Counting only the young born alive, the litters from treated mice averaged 5.79; those from the controls, 5.79. Since the litters from the treated and control females were started by the same average number of ova, and the number of young successfully surviving birth averaged the same in each group, it is clear that the prenatal mortality in each group must also have been the same. In the last Year Book (p. 117) certain general statements were presented as to the independence of the number of days between successive ovulations (the oestrous cycle) and this alcohol treatment. This may now be expressed more exactly by the following summary: 106 oestrous cycles in unmated treated mice averaged 9.3 days; 89 cycles in the untreated sisters averaged 9.5 days. The difference is insignificant. The same result is given by each four strains taken separately, as well as by each pen of treated females compared with the controls living in the same pen.

"Although the number of cases is not large, the practical identity throughout of test and control averages speaks for the adequacy of the data. The findings here presented, supported by certain others not cited, lead to the general conclusion that three and four months of a daily alcohol treatment called 'light,' but sufficiently strong to produce complete anesthesia in certain mice every time, has had no effect upon the reproductive processes of the mice so treated.

"This result resembles that previously obtained by the relatively light treatment of albino rats. Work upon the next step, the testing of the effects of heavy doses, is in progress. In this experiment every mouse is made dead drunk every time, starting at weaning. The unit experiment consists of 4 females from one litter, 2 of which are treated; these are mated at weaning with a normal male sib, whose fertility has been proven, in order to obtain

pregnancy as soon as possible. As the attention is focussed upon the corpora lutea counts, the young are always killed at birth and the mother immediately remated. Beside the comparison with the untreated females, the activity of the ovaries in the early part of the treatment is compared with their activity after prolonged treatment. So far 39 operations have been performed upon 25 treated females; 46 operations on 26 controls. The average number of corpora lutea in the treated mice is 9.50 per ovulation; in the control mice, 9.02 per ovulation. The average number of mice found at birth from the treated mothers is 4.93 per litter; from the control mothers, 6.02 per litter. This is an indication that the activity of the ovary is probably not affected by this treatment, and that the smaller number of young born is due to uterine conditions. There remains the possibility that the germ cells themselves are damaged and that the direct effect of the alcohol upon the developing embryos is not the whole explanation. To test this point an experiment is being carried out in which the males alone are treated. The criterion used is the prenatal mortality, based upon corpora lutea counts, in the same females when mated alternately by treated and control males from the same litter."

ABNORMAL YOUNG IN ALCOHOL EXPERIMENTS.

"Among the offspring of one family of mice treated with alcohol were found striking lethal abnormalities of the lower jaw and head that closely parallel the otocephalic monsters described by Wright in guinea pigs. This character varied from a reduction of the lower jaw that left just a pin-point mouth, to the deformation of the whole snout region, forming a cycloplan monster with ears drawn together ventrally and with extended proboscis. In some cases the eyes in these monsters were normal, in others one or both showed the condition characteristic of the inherited eye-abnormality in the X-ray lines; this abnormal-eyed condition has also been found in this family associated with a normal jaw.

"The first appearance of the otocephalic abnormality was in the offspring of an alcoholized female; five cases were recorded. The abnormality reappeared in the offspring of the surviving children, which had also been treated. A treated sister of the first mother threw the same unmistakable abnormality. Such a dramatic effect, found in two generations of treated animals would supply the most appealing evidence of the deleterious results of alcohol treatment, had this evidence not been cancelled by the appearance of the same abnormality among the immediate controls. Two untreated sisters of the first two mentioned gave otocephalic, or jawless, young, and in the fourth inbred generation from another untreated sister, other jawless young appeared.

"In the large number of young born during alcoholic treatment by mothers treated with alcohol, there is no evidence that the alcohol has been the cause of any abnormality."

REGENERATION OF THE OVARY IN MICE.

In some studies on fecundity and of transplantation of ovaries, the Director was led to make an extensive series of ovariectomies on mice belonging to our highly inbred strains. About two-thirds of all operations were followed by a more or less complete reappearance of an ovary. Regeneration occurs equally when the mice are only a month old or 3 or 4 months old. It may take place within a month or two after operation but the proportion of regenerated ovaries increases until 6 months have elapsed. Adhesions and minor infections do not inhibit the reformation of the ovary and such reformation is neither facilitated nor inhibited by pregnancy. The evidence is practically complete that we have to do in most cases with a new ovary and

not merely the regeneration of a fragment left behind. The results favor the view that the ovary may be formed at almost any time in the life cycle of the mouse from the peritoneum.

THYMUS AND EGG-SHELL PRODUCTION.

In the investigation of a peculiar type of reproduction disturbance in pigeons Dr. Riddle has discovered that the thymus gland—long the “enigmatic organ” of the human body—is indispensable to the production of the egg-envelopes. This action he believes to be due to a hormone, which he has named thymovidin. He summarizes his results as follows:

“A prolonged study of the etiology of several types of reproductive abnormalities in pigeons has resulted in the isolation of one type of disorder which is readily corrected by the oral administration of ox thymus.

“This particular type or syndrome involves: Eggs with yolks of normal size but deficient in shell and albumen; frequent reduction of normally paired ovulations to single ovulations; diminished fertility, and a restricted hatchability of eggs. In addition, birds showing these abnormalities initially had shown quite normal reproduction. All of the five birds showing these abnormalities were found at necropsy to have extremely small thymi.

“Only birds of the particular type described were affected by thymus administration. Dosage with other substances, including a few tests of other desiccated tissues, had no effect on this type of abnormality.

“Complete thymectomy is difficult to obtain in pigeons and there are many sources of error in evaluating the completeness and the results of the operation. From one partially successful test data were obtained in conformity with Soli’s more extensive but inadequately interpreted results with thymectomized fowl.

“The whole of the data seems to demonstrate the presence in the thymus of a substance having a highly specific action on the oviduct of birds—and presumably, of all those vertebrate animals which secrete egg-envelopes. The substance is indispensable to the production of normal egg-envelopes. It is apparently of the nature of a true hormone. To characterize it with reference to its place of origin and the principal point of its action the name *thymovidin* is suggested.

“Several facts indicate that thymovidin is only very slowly destroyed in either the blood or the digestive fluids; but no step in its isolation from thymic tissue has been attempted.

“Though not necessary to the life of the individual, thymovidin would seem essential to the perpetuation of those vertebrate species whose eggs are protected by egg-envelopes. Such animals were the ancestors of mammals and thus mammals also probably could not have come into existence without the thymus.”

RELATION OF BLOOD SUGAR TO SIZE OF THYROIDS AND SUPRARENALS IN PIGEONS.

Dr. O. Riddle and Dr. H. E. Honeywell with the assistance of Mr. J. R. Spannuth obtained the following results as to blood-sugar content in a fraternity of pigeons.

“In a group of brother and sister hybrids it has been found that the group of birds giving abnormally low blood sugars had large thyroids and large suprarenals. Those giving abnormally high blood-sugars had small thyroids and small suprarenals. Less conclusive evidence indicates that large gonads are associated with the large thyroids. An adequate interpretation of this relationship is not attempted. A suggestion is made concerning this sugar-glandular association. The results probably assist an understanding of

cases of normal individuals of the same race or strain which show consistently low or consistently high blood sugar. The data supply an unusual indication that thyroid and suprarenal are both in some way concerned in the establishment of the normal concentration of sugar in the blood."

In a second study some new light was thrown upon the interaction of the suprarenals and pancreas in the regulation of the carbohydrate metabolism. Following earlier studies, reported last year, in which it was found that ovulation could be suppressed in pigeons by an appropriate dosage of insulin, it has now been learned that very heavy or quite continuous insulin dosage results in an hypertrophy of the suprarenal glands. This study was carried out by Dr. Riddle with the assistance of Dr. H. E. Honeywell and Mr. Walter S. Fisher, and has been summarized as follows:

"The earlier reported fact that normal pigeons survive disproportionately large injections of insulin has been further confirmed and is probably of significance to each of the results described here. The administration of single heavy doses of insulin, or of repeated less heavy dosage, usually results in suprarenal enlargement which is measurable by weighing.

"Some evidence was obtained indicating that repeated heavy insulin dosage is followed within a few days by a lessened capacity of this insulin dosage to maintain the blood sugar at a low level during the usual length of time. Such dosage is also often followed within 6 hours by abnormally high sugar level. It seems probable that the time of appearance of the most striking of these irregularities is approximately the time at which the enlargement of the suprarenals is demonstrable. Among the animals studied by us it was mainly those with largest suprarenals which either died or showed most pronounced effects after administration of large amounts of insulin. To the extent that data obtained on the bird are applicable to the human, these results supply an additional reason for avoidance of heavy insulin dosage in man.

"The results indicate that the suprarenals of normal doves make one response which is not merely immediate and quickly transitory to insulin administered heavily or repeatedly. This delayed or prolonged response takes the form of enlargement, certainly involving hyperplasia of the cortex, and is usually associated with an abnormally increased concentration of the sugar of the blood. The data obtained are in harmony with the view that such insulin administration is accompanied by an increased production of adrenin."

OTHER INVESTIGATIONS.

INVESTIGATIONS ON THE TISSUE FLUIDS OF THE CEREALS AS GROWN UNDER DRY FARM AND IRRIGATION AGRICULTURE.

Some progress has been made in the statistical elaboration of the results of experiments presented in preceding reports.

METHODS WITH PLANT FLUIDS.

Considerable progress has been made in the development of methods suitable for dealing with various genetic and physiological problems. Mr. and Mrs. Lawrence successfully employed the Folin-Wu method for reducing sugars on extensive determinations on the tissue fluids of Egyptian and Upland cotton in collaboration with Doctor Harris.

Lawrence and Harris have published the tests of a rapid and accurate method for the determination of chlorides in plant tissue fluids (*Journal American Chemical Society*, June 1924).

The method has been practically used in several hundreds of determinations on native vegetation of the, in part, highly saline Lake Bonneville Basin (see previous report) and in investigations on Egyptian and Upland cotton.

ADMINISTRATIVE RECORD.

ARCHIVES OF THE EUGENICS RECORD OFFICE.

Dr. Elizabeth B. Muncey has continued as archivist, and has been assisted by Misses Helen Bowen and Margaret Martin as indexers. An estimate of the extent of the records and the index as of June 30, 1924, is as follows: 1,695 books in the archives; Field reports, 61,242 sheets; Special traits file (A), 27,413 sheets; Record of Family Traits (R and M files), 6,580 parts; 1,040,471 cards in the index involving several million references. A satisfactory flow of data of good quality is maintained through contact with educational institutions. Over 2,000 Records of Family Traits (many comprising also individual analysis cards) have been received through such collaboration, in the 10 months ending June 30, 1924.

TRAINING CORPS.

Arrangements have been completed (June 30) for giving training in field investigations to 10 women and 2 men. Owing to various considerations it seems probable that this is the last year of the Training Corps, which has proved in the past an indispensable adjunct to research in eugenics, and will have trained about 258 persons, many of whom are still making investigations in eugenics and related fields. To these field workers most of our 60,000 sheets of field reports are due.

SPECIAL ACTIVITIES OF AND CHANGES IN STAFF.

The principal change in staff is the resignation of Dr. J. Arthur Harris who has been connected with the staff of the Department of Genetics for 17 years and leaves us to take charge of the Department of Botany of the University of Minnesota. Dr. Harris has been extraordinarily prolific in his researches and in them he has shown an unusual versatility which has permitted him to assume a leading position in research in biometry and in the physico-chemical properties of plant tissue fluids.

As reported elsewhere, Dr. Laughlin spent 6 months in Europe on immigration studies.