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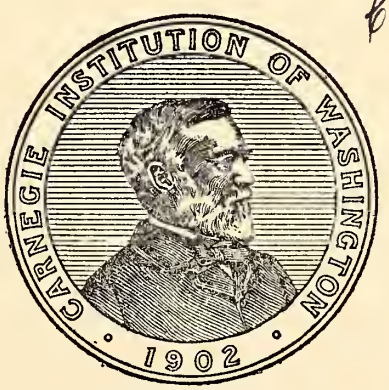

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DEPARTMENT OF GENETICS.[1]

C. B. Davenport, Director.

GENERAL STATEMENT.

Outstanding results of the year's activity of this Department are outlined in the following paragraphs.

A new type of chromosomal relationship has been discovered between the sexes in certain flies (*Sciara*), accompanied by a new type of spermatogenesis. The further analysis of reddish in the sex-chromosome of *Drosophila virilis*, leads to the conclusion that it is an allelomorph of yellow that is mutating in extraordinary fashion. The investigation of the chain of events stretching between the chromosomes of the fertilized egg and somatic quality has been advanced by the use of the Manoilov test of the chemical differential of the sexes, which we have applied to mucors as well as other plants and animals. A seasonal range in size of the thyroid gland in pigeons has been found associated with gonadal activity, so that the period of decline in thyroid size coincides with that of active reproduction in the pigeon; and at the period when the thyroid is smallest the female offspring are most numerous. A method has been devised for producing dwarfs in mice by operations on the thyroid gland of the mother, which may throw light on the production of human non-cretinous dwarfs.

Light has been thrown on the problem of varying sex ratios of young born in various species of mammals by the discovery that where there are no inter-uterine deaths the numbers of the two sexes born are equal. In mice, at least, there is no relation between the amount of prenatal mortality and the sex-ratio at birth. In *Cladocera* the sex-ratio of the offspring is more fully controlled, since it has become possible by improved technique to call forth practically 100 per cent male offspring in an ordinarily exclusively female producing species.

A method has been elaborated for expressing quantitatively the racing qualities of the thoroughbred horse and predicting the speed of their progeny.

In general, it may be said that the work of the Department is moving toward a better understanding of the nature of the gene; the rôle of the chromosome, as a whole and of its mutations, in directing development; the interpretation of abnormal sex-ratios; the nature of variations in sex-expression; certain chemical processes that direct development, especially of sex-limited traits, and other qualities that are under the influence of the endocrine glands; and the applications of genetical principles to mammals, including man. Without neglecting fundamental studies into the nature of chromosomes and their genes which initiate development, we must push forward, as opportunity offers, into the field of the chemical processes that direct the later development of those traits whose genic basis has been established.

It is on this account that we are glad to have had working at the Department during the summer of 1925 the laboratory force of Dr. George K. Falk, of the Harriman Research Laboratory, of which Dr. W. G. Lyle is

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Director. Miss Helen Noyes has been in immediate charge of the researches, which have included a study of the enzyme actions during the various developmental stages of mice and fishes. The researches are giving a clearer picture than we have had hitherto of the changes during development of those catylists in the body upon which growth and differential development depend.

DETAILED REPORTS ON CURRENT INVESTIGATIONS.

THE GERM PLASM.

DATURA AND OTHER SPERMAPHYTES.

Studies on mutations in *Datura* have been continued by a group consisting of Dr. Blakeslee, in charge, Dr. Belling, cytologist, Gordon Morrison, associate, and Miss Betty P. Watt, assistant.

Trisomic Types of Datura.

In reports of former years, 11 of the possible 12 Daturas that belong to the 2n+1 series have been found with certainty. A preliminary study of the offspring from the cross 3n×2n, which should throw all of the primaries in equal numbers, has shown only 11 primaries. During the summer of 1925 out of 1,500 offspring from triploids a weak-growing type has been found in numbers approaching those of the other primaries and this directs suspicion upon itself as the possible twelfth member of the primary series. It is being grafted upon normal stock in the attempt to force the type into bud formation. It is possible, however, that the twelfth primary is not viable.

Three new chromosomal mutants have been discovered since our last report: "Dwarf," a secondary of "Poinsettia;" "Smooth," a secondary of "Glossy;" and "Scallop," a secondary of "Reduced."

"A few new Mendelian characters," reports Dr. Blakeslee, "have been discovered in collections from abroad, as spontaneous gene mutations in our cultures, and as segregates from the interspecific cross between *D. stramonium* and *D. ferox*. We have previously been able to locate the genes for white-flower color and for curled cotyledons in the Poinsettia chromosome by the trisomic ratios produced when Poinsettia parents were heterozygous for these genes. The genes should, therefore, show linkage in disomic inheritance. Rather extensive series of cultures have shown, in fact, that such expected linkage does exist and that there is about 12.5 per cent crossing-over between these genes.

"It will be remembered that the secondary mutants with an extra chromosome were believed to be (2n+2/2) types with the extra chromosome made up of one half of the chromosome doubled. No facts have been found, as yet, in conflict with this conception and the Dwarf secondary of Poinsettia appears to offer a further confirmation. The types of ratios being produced this season by heterozygous Dwarf parents seem to indicate that the Dwarf half of the Poinsettia chromosome may convey the genes for curled and normal cotyledons, but not the genes for purple and white-flower color. If our provisional interpretation of these ratios turns out to be correct we may have a method of determining in which half of a particular chromosome a given gene is located.

"Further information has been obtained in regard to the peculiarity of the Nubbin mutant. Nubbin not only throws types like itself but also two new types, Hedge and Pinched, which latter are related to the two secondary ones of Rolled, both by appearance and by the fact that they regularly throw some

Rolleds in their offspring. Nubbin further throws the two primaries Echinus and Buckling but not Rolled. Hedge throws Echinus and Pinched throws Buckling. The breeding behavior is summarized below, the arrows indicating the types of offspring thrown by the different mutants involved in the complex.

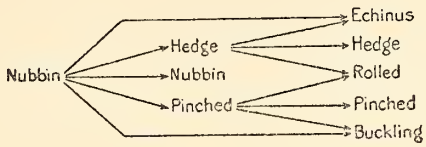

FIG. 1.

"The Nubbin problem may be solved by further cytological study, possibly aided by further evidence from the breeding behavior, if genes can be found with which to tag the chromosomes involved.

"The mutant Nubbin is of present value as a tester for abnormal whites mentioned in our last report, since Nubbin parents heterozygous for these whites throw distinctive ratios. When heterozygous for abnormal whites, Nubbin parents throw a large excess of purples among the Nubbin offspring and a similar excess of whites among the normal offspring. They also throw a new type resembling Dwarf and Sugarloaf. Tests of the various whites in our main lines indicate that the abnormal whites are not uncommon in nature."

DISTRIBUTION OF DATURA MUTANTS IN SOUTH AMERICA.

As a delegate to the Third Pan-American Scientific Congress, held in 1925 in Lima, Peru, Dr. Blakeslee made a 4-months' trip to South America and while there studied the variation and geographical distribution of Daturas in the countries visited. He reports as follows:

"It is too early as yet to report in detail on the types now under cultivation from the seed collected in South America. We appear, however, to have obtained a number of new Mendelian characters from our collections which bid fair to be of value in our breeding experiments. Some facts discovered in regard to the geographical distribution of the species and its varieties may prove of interest. In irrigated regions of the West Coast from Lima, Peru, as far south as Arica, only the purple variety of *D. stramonium* was found. The purple form also was found in irrigated fields and at railroad stations inland from Lima up to about 8,000 feet elevation and at Ollantaytambo in one of the valleys of the Andes at about the same elevation. Higher than about 9,000 feet the species has not been reported. In regions of Chile from Valparaiso to Conception and Angol, where irrigation is not necessary for vegetation, both the purple and white varieties were encountered, with the purple more abundant. On the east side in Brazil only the white variety was found, and all the material sent us from this country has also been white-flowered. In Argentina and Uruguay all the jimson weeds, so far as could be judged from our own observations and from the herbarium material examined, belonged to another species—*Datura ferox*—related to *D. stramonium* but perfectly distinct. In Santiago, Chile, we found the border line between the two species and discovered natural hybrids between them. What the causes are which have determined the distribution of these two species and of the two conspicuous color varieties of *D. stramonium* has not yet been determined. It may be of interest in this connection to note that two collections sent us from the Belgian Congo, as well as one collection from French Somaliland, have been *D. stramonium*, while collections further south from Pretoria,

Africa, have been hybrids between *D. ferox* and *D. stramonium*. Further collections from Africa may show that the distribution of the two species from this continent is similar to that in South America. It is our growing belief that in order to connect our work with the problems of evolution, geneticists should become familiar with the variability and distribution in nature of the forms we are studying. We trust that the collection of biotypes which we are assembling may not only furnish us with new Mendelian characters but also may afford us some clue in regard to the course of evolution in this and related species."

Chromosomal Mutants.

Dr. Belling has continued his studies on aberrant chromosome complexes in aberrant Daturas. He has been led to look for cases of chromosomal aberrations in other species, and has described a number of them. Thus, in some "lady-slippers" (*Cypripedium acaule*) removed from the woods to the greenhouse he found microspores with one chromosome lacking and microcytes of such small size that they comprised only one chromosome, obviously that missing from the abnormal microspores. He suggests that the change in the winter from out-door conditions to the heat of the greenhouse may have produced these anomalies of division. There is some reason for concluding that the abnormal microspores are aborting, since microspores with deficient chromosome numbers abort in Datura.

Association of Chromosomes in Diploid and Triploid Hyacinths.

In tetraploid Daturas there are 4 chromosomes of a kind instead of the ordinary (diploid) pair. This leads to the inquiry whether new species may not have arisen by "accidental" doubling of the chromosome number through failure at a critical stage of members of the pairs to divide. In not a few genera, indeed, one species (or variety) differs from another in having double the number of chromosomes. This is strikingly true in Hyacinth where *H. romanus* has 4 pairs of chromosomes and *H. orientalis* has 8 pairs. If the 8 pairs are derived by doubling of the 4-pair condition then the tetraploid sets should be of the same size and perhaps tend to keep near each other as the pairs of chromosomes in ordinary diploids do. To test the hypothesis, Belling measured the chromosomes in *H. orientalis* and found, indeed, that there are 4 chromosomes of a kind that are about as alike as the pairs of ordinary diploids. But there was no perceptible attraction between the members of the pairs of similar bivalents at the first maturation division. The two pairs of small bivalents were, to be sure, near the center of the cell but this was doubtless due to the tendency of small chromosomes to drift toward the center. In triploid *H. orientalis* the trivalent chromosomes were usually very clearly associated in sets of three.

Distribution of Chromosomes in a Triploid Hyacinth.

Dr. Belling finds that while in the typical diploid hyacinth there are (in root-tip cells) 8 large, 4 median and 4 short, chromosomes or 4+2+2 haploid, in certain clones the root-tips show 12 large, 6 medium, and 6 small, chromosomes. Under these circumstances

"8 of the chromosomes in the pollen grain will probably have come from pairing with 8 similar chromosomes, at the first metaphase in the pollen-mother-cell. The remaining 8 chromosomes of the pollen-mother-cell would probably be distributed according to the laws of chance to the two nuclei

resulting from the reduction division, and hence to the two pairs of pollen grains which came from each pollen-mother-cell."

This expectation is realized, so that cells with no extra chromosomes or with 1, 2, 3, 4, 5, 6, 7, 8 extras, respectively, occur in the frequency of the coefficients of the expanded binomial $(a+b)^8$. Also extras of each size occur with a frequency expressed by the binomial law.

Origin of Chromosomal Mutations in Uvularia.

Dr. Belling has published details, with suitable illustrations, of the different types of chromosomal mutations observed in the bell-wort. He treats the subject under the headings: detachment, non-disjunction, non-conjunction, non-reduction, non-division, and fracture as described in the Year Book for 1924, pp. 29, 30. He discusses the bearings of chromosomal mutations on the science of genetics and points out: The study of the genes in relation to each chromosome or segment of a chromosome, when deficient or in excess, adds to the proofs of the chromosome theory of inheritance. Especially tetraploidy and hexaploidy may play a part in the striking changes of the chromosome group from species to species. The formation of triploids and tetraploids may also be of practical value in other cases besides the large flowered and nearly seedless triploid *Canna* and hyacinth clones among ornamental flowering plants and the more or less parthenogenetic triploid mulberries among fruit trees.

Interovular and Gamophytic Selection.

Professor John Buchholz of the University of Arkansas has been associated with the work in Daturas during the past four summers and has been engaged particularly in carrying on experiments on the effect of different types of developmental selection in the elimination of chromosomal mutations. The Globe mutant has been used because it is easily recognized in seedling stages. It appears from Professor Buchholz's researches that, other things being equal, the large seed capsule conserves a larger percentage of Globe progeny than a small one. In Globe×Normal the correlation between the size of the seed capsule and the percentage of Globe progeny is $r = +0.339 \pm 0.043$. In ordinary Normal×Globe crosses, where only a small proportion of Globes is transmitted through the pollen the correlation between size of capsule and proportion of Globes is $r = 0.224 \pm 0.034$. Thus in Normal×Globe crosses also there is greater elimination through interovular selection (fewer Globes) in small seed capsules than in large ones.

In a study of gametophytic selection an effort was made to change the proportion of Globes transmitted through the pollen (Normal×Globe) by using small numbers of counted pollen grains. The result was complicated by the fact that when small amounts of pollen were used the resulting seed capsules were small and resulted in a decrease in the proportion of Globes through interovular selection. Nevertheless there was in this experiment an average of 4.5 per cent Globes in seed capsules with counted pollination as compared with 1.36 per cent in all of the controls. The proportion of Globes was, therefore, increased more than three-fold through lessened competition between the pollen tubes having n chromosomes and those having n+1 chromosomes. The number of pollen grains applied in the counted pollen range from 200 to 600. Many pollinations were made with small numbers of pollen grains but no seed was set. In the counted pollen series the correla-

tion between the percentage of Globes and the size of capsules was $r=0.154 \pm 0.028$. It was found that the upper half of any seed capsule contains mostly seeds from the early arriving pollen, the lower half from slower growing pollen tubes. In the counted pollination series there was probably no significant difference between the proportion of Globes in the upper and in the lower portions of the small seed capsules. But in the control series, with much pollen, an intense competition between the pollen tubes and reduced interovular selection because of the large seed capsules, there was a marked difference. The upper halves of such capsules contained only 0.445 per cent Globes while the lower halves contained 2.08 per cent. This supports Dr. Buchholz's conclusions that the pollen tubes with n+1 chromosomes grow slower than those with N chromosomes.

DIPTERA.

Aberrant Chromosomal Relations in Sciara.

In continuing his exploration of the field of the relation between the inheritance of somatic qualities and chromosomal conditions, Dr. Metz has dis-

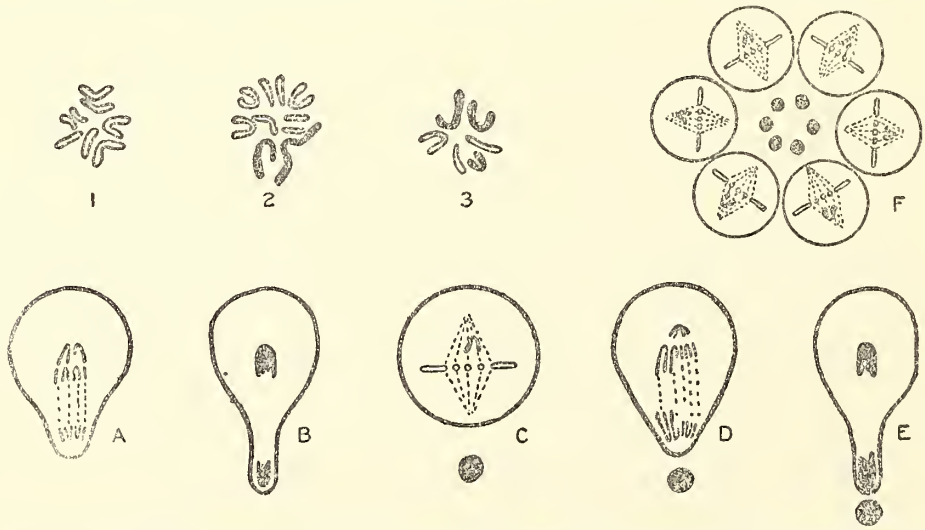

Fig. 2.—Figures illustrating the chromosome groups and spermatocyte divisions in the fly *Sciara similans* Joh. Figs. 1–3, Camera lucida drawings of the female chromosome group, the male chromosome group, and the second spermatocyte group respectively. The two extra or "sex-limited" chromosomes of the male are shown in solid black. The precocious chromosome in the second division is shaded. Diagrams *A-F*: Schematic illustrations of chromosome behavior during spermatogenesis. *A*, Anaphase of first spermatocyte division showing the two sex-limited chromosomes going intact to the inner pole. *B*, Telophase of same, showing process of budding. *C*, Side view of second division showing precocious chromosome going to inner pole opposite the bud nucleus cast off at first division. *D*, Anaphase of same showing division and equal distribution of all chromosomes except the precocious one. *E*, Telophase of same showing formation of the second bud. *F*, Schematic cross-section of a cyst of second spermatocytes showing in center the group of bud nuclei from first division and around this the cells uniformly polarized, with the precocious chromosome always going toward the periphery of the cyst (inner pole of cell).

covered, in the genus *Sciara*, chromosomal relations of the sexes that are apparently different from those known in any other organism. Dr. Metz reports:

"Apparently the conditions are essentially the same in all four of the species thus far studied. *Sciara similans* (Johannsen manuscript) may be

taken as an example. Both sexes of this species are diploid. The chromosome group of the female consists of 4 symmetrical pairs of chromosomes, 2 of which are rod-like and two V-shaped, as shown in figure 1. That of the male consists of 4 pairs like those of the female, and in addition 2 larger and individually distinct chromosomes, one V-shaped and the other J-shaped as seen in figure 2.

"Thus the male possesses 2 more chromosomes than the female. These 2 chromosomes are sex-limited; i. e., they are confined to the male line, passing from father to son in each generation. In the latter respect they resemble the ordinary Y-chromosome, but they differ from the Y-chromosome in other features. The Y-chromosome is a member of a pair and segregates at maturation. It has a mate, X, which is derived from the female parent and which passes into the female offspring. The 2 large chromosomes in *Sciara*, on the other hand, are unlike all the other chromosomes and have no mate or mates among them; they do not pair with and apparently do not segregate from any of the others.

"In the other three species—*S. pauciseta*, *S. prolifica*, and *S. coprophila*(?)—the size relations of the chromosomes differ somewhat, but the situation is essentially similar, showing that we are not dealing with a condition confined to a single aberrant case.

"In two of the four species (*similans* and *coprophila*?) peculiar sex-ratios have also been found. In the latter species, and in certain lines of the former, broods from individual mothers are consistently unisexual or nearly so. This is true both of laboratory stock and wild flies, as indicated by the sample counts in the accompanying table.

Sample counts of offspring from individual mothers in Sciara coprophila (?)

Counts from wild females.				
Offspring.	(1)	(2)	(3)	(4)
No. of ♀'s.....	55	53	0	52
No. of ♂'s.....	0	0	10	0

Counts from laboratory females.																
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
No. of ♀ off.....	48	3	25	51	88	0	0	0	0	62	0	75	102	123	125	1
No. of ♂ off.....	0	77	1	1	0	80	69	140	77	0	67	0	0	1	1	131

"An explanation of this behavior is not yet available, but preliminary experiments indicate that the female parent is immediately responsible for the sex-ratio and that probably female-producing females and male-producing females are produced in approximately equal numbers.

"In *S. pauciseta*, on the other hand, the broods are consistently bisexual—although the ratios may vary.

"For an adequate analysis of the problems presented by these species a detailed cytological and genetic study will be required. As a first step a study of spermatogenesis has been carried on during the past year. This has brought out a series of peculiarities, among which are the following: (See fig. 2, *A–F*.)

"Both spermatocyte divisions are unequal and result in the casting off of buds resembling the polar bodies of an egg. In consequence each primary spermatocyte gives rise to only one spermatid, instead of four.

"The first spermatocyte division is anomalous. Apparently the chromosomes do not undergo synapsis and do not form a metaphase plate, but are segregated into two groups at opposite ends of an imperfect spindle. The 2 large 'sex-limited' chromosomes and 4 others go to the 'inner' pole, while the remaining 4 are cast off in the bud. These latter are usually long and slender, while those going to the inner pole are short and thick.

"The apparent absence of synapsis between maternal and paternal chromosomes, together with the peculiar relations of form and behavior of the chromosomes in the first division suggest some unusual relation between the maternal and the paternal chromosomes. One possibility is that the maternal chromosomes are regularly cast out of the spermatocyte at this division and hence are never present in the spermatozoa. If this should occur it would lead to interesting genetic consequences, which breeding experiments now under way are designed to test. It should be noted that the above details of spermatogenesis are known to apply to one species, but not certainly to the others, although present indications are that they hold for all four.

"The second spermatocytes appear to be all alike, instead of composed of two kinds as in most Diptera. Each spermatocyte contains 6 chromosomes, including the 2 large sex-limited ones (fig. 2: 3). The latter and three of the others divide equationally at this division. The remaining member splits, but goes precociously to the 'inner' pole, opposite the bud nucleus cast off at the first division. Apparently this chromosome is double and both halves enter the spermatid.

"Since the cells are arranged in clusters and definitely polarized as shown in figure 2, *F* the constancy of the chromosome behavior is easily demonstrated.

"As noted above, all the spermatids receive both of the sex-limited chromosomes—from which it would be inferred that all spermatozoa are male-determining. If so, females should arise by parthenogenesis. Simple parthenogenesis, however, does not occur, for experiments have shown that females must be fertilized to give offspring. It is possible, however, that female-producing eggs are stimulated to develop by the sperm, without nuclear fusion (gynogenesis). Other possibilities exist also.

"The following working hypotheses are being followed in planning further studies on this subject:

"Females arise by gynogenesis (modified parthenogenesis) and hence represent essentially a 'pure line.'

"Males arise from fertilized eggs and hence are always derived bisexually.

"The two large sex-limited chromosomes (or one or more chromosomes which agree with these in distribution) are 'male determining.'

"In oogenesis a differential division of some sort occurs which differentiates two types of female-producing eggs—i. e., the male-producing and the female-producing females. (Possibly two corresponding types of males are produced, but no indication of this has been noted.)

"It also seems necessary to assume a differential division in oogenesis which will compensate for the retention of both daughter halves of the 'precocious' chromosome in the spermatid.

"Other equally interesting phenomena, such as variations in chromosome numbers and an unusual type of mitotic spindle, have been found in these flies, but have not yet been studied enough to warrant discussion.

"Considerable time has been devoted to the work of perfecting a technique for breeding the flies—which is a prerequisite to any accurate genetic study."

ARCHITECTURE OF CHROMOSOMES OF DROSOPHILA VIRILIS.

Under Dr. Metz's supervision, Miss Mildred Moses has continued work on the linkage groups IV and VI in *Drosophila virilis*. It is group VI which was considered that of the "dot-like" chromosome, comparable with the small chromosomes of *D. melanogaster*. The other four linkage groups in *D. virilis* all represent long chromosomes (as has been shown in detail in published reports) and one of the two considered here also represents a long chromosome. Dr. Metz reports:

"Our task has been to determine which of these two linkage groups (IV and VI) represents the small dot-like chromosome and which the long chromosome. The latter is about 20 times the size of the dot-like one.

"The question takes on especial interest because two of the characters in linkage group VI resemble characters associated with the small dot-like chromosome in the well-known *Drosophila melanogaster*.

"Two lines of evidence are available, based on number of mutations and amount of crossing-over respectively. Expectation calls for a much larger number of mutant genes or 'loci' in the large chromosomes than in the small one. And it also calls for a much larger amount of crossing-over in the large chromosome.

"When last year's report was written, almost no crossing-over had been detected in either case and we noted that, on the basis of number of mutants found in the two groups, group VI should represent the small dot-like chromosome.

"Within the last year, however, Miss Moses has been able, by the discovery and study of additional mutant characters, to show that probably the relation is just the reverse of this, i. e., that group VI represents the large chromosome and group IV the dot-like one. This interpretation is based on the fact that in group VI one character has been found which appears to give about 17 per cent and 13 per cent of crossing-over, respectively, with the two others thus far studied in this group.

"The data are open to some question because this character is very inconstant and irregular in its appearance. Consequently they should be corroborated by the study of additional and more reliable characters. But unless the present results are due to some aberrant genetic behavior which we have not been able to detect, they indicate such a large amount of crossing-over in group VI as to make it highly probable that this group represents the long chromosome.

"The case is noted here, as a correction of our previous tentative conclusion. It will be discussed further when the necessary additional data are obtained.

"It may be noted, however, that in any case the small dot-like chromosome in *D. virilis* has given rise to a surprisingly large number of mutations as compared with the other chromosomes and also as compared with the dot-like chromosome in the well-known *D. melanogaster*.

"Group IV contains four characters which show no indication of being allelomorphs and a fifth which is probably not an allelomorph of any of these. Thus it represents at least 4 or 5 loci. Group VI contains three characters which are not allelomorphic, and thus represents 3 loci. In the other three autosomes (each of which is about 20 times the size of the dot-like one) the numbers of loci are 8, 8, and 5 respectively. In *Drosophila melanogaster*, which has been studied many times, as much as *D. virilis*, the dot-like chromosome, resembling the one in *D. virilis*, contain only 3 known loci.

INCONSTANCY OF REDDISH IN D. VIRILIS.

Dr. Demerec has accumulated a large amount of data, concerning the gene basis of this character, during the past year. This supports the tentative conclusion made in last year's report, that reddish is an allelomorph of yellow. The evidence for that conclusion Dr. Demerec summarizes as follows:

"(1) The F_1 generation from a cross between reddish and yellow is always yellow. (2) The linkage relations between reddish and pilose, sepia, scute, and vermilion (e. g., factors closely linked with yellow) are identical with those between yellow and these factors. They show that reddish is located between sepia and scute approximately in the same region as yellow."

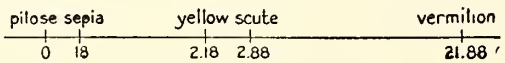

FIG. 3.—Map of the part of sex chromosome of *D. virilis* in which yellow is located.

Very remarkable is the mutability of this character. Dr. Demerec reports:

"As mentioned in last year's report, the F_2 generation from a cross between reddish and yellow includes wild-type flies in addition to the expected yellow and reddish classes. Extensive tests with the compound material involving several factors located in the yellow region of the sex-chromosome show conclusively that the wild-type flies have the X-chromosomes in which wild has been substituted for reddish.

"The mechanism, by means of which this substitution is made, is not known as yet. From the results of numerous experiments, however, it is evident that the change is not due to ordinary crossing-over. Since the change is hereditary, the word 'mutation' (used in its broadest sense) will be applied in describing it. It is assumed that wild-type flies found in the F_2 generation of the cross between reddish and yellow are the result of the mutation of reddish to wild type.

"In studying the behavior of reddish, more than 150,000 flies were examined and more than 1,000 mutations of reddish to wild were observed. The main conclusions from these studies can be summarized as follows:

"All mutations of reddish to wild, so far observed, occurred in females.

"Mutations occur only when the female is heterozygous, having reddish in one chromosome and in the other its allelomorph yellow or wild.

"Mutations do not occur in groups, indicating that one mutation affects a single egg. No case of somatic mutation was observed. These observations suggest that the mutation period is limited to the time of maturation.

"The frequency of mutations decreases rapidly in successive generations if selection is not applied. The observed frequency being in the second heterozygous generation 25 per cent, in the third 3.2 per cent, fourth 1.2 per cent, fifth 0.64 per cent, sixth, 0.083 per cent, and in the seventh none in 4,041 individuals.

"By selection it was found possible to keep the frequency of mutations to between 5 and 10 per cent.

"From mutating stocks practically constant reddish lines were obtained by selection. Constant reddish behaves in every way like a stable gene allomorphic to yellow. There seems to be no question that the differential (i. e., the genetic basis) for reddish behaves like an ordinary sex-linked gene after it has once become fixed.

"Females, having in one chromosome mutating reddish and in the other constant reddish, so far, have not given mutation.

"There is a definite relation between the rate of crossing-over and mutations. When the percentage of crossing-over is calculated on the basis of the flies which came as mutations it is increased in the yellow-scute region from 0.7 to 13 per cent (about 18 times) and it is decreased in adjoining regions (e. g., in the sepia-yellow region) from 2 to 0.2 per cent and in the scute-vermillion region from 19 to 14 per cent.

"The chromosome in which reddish has changed to wild type behaves normally in every respect. It gives normal crossing-over values, and also when tested with mutating reddish it keeps reddish mutating.

"Wild obtained as a mutation of reddish, so far as tested, has never mutated back to reddish.

"It was found that with the age of the female the frequency of mutation decreases."

EXPERIMENTAL MODIFICATION OF THE GERM-PLASM.

Under this heading there have been described in earlier reports of this Department some results obtained by Dr. Little and Dr. Bagg in the application of X-rays to mice. The descendants of the X-rayed individuals have, in some cases, shown abnormalities of eyes, face, and feet which have recurred in successive generations.

As noted in last year's report Dr. MacDowell has begun cooperating with Dr. Bagg of the Memorial Hospital, New York City, in a repetition of these experiments, to see if the results can be obtained again. At the time of the last report positive results had not been obtained. The breeding for this experiment, which is more rigidly controlled than any made before, has been continued throughout the year and the following results from mice raised at least 4 weeks are presented by Dr. MacDowell.

"The inbred descendants from one X-rayed ancestor total: first generation, 163; second generation, 765; third generation, 615. From 2 X-rayed ancestors, first generation 22, second generation 493, third generation, 233. Control matings from the same mice before treatment have given: first generation, 229 mice; second generation, 961; third generation, 1,416. Among the 1,543 descendants from one treated ancestor 4 mice (0.2 per cent) with abnormal eyes, ear, or jaws were found. Among the 748 descendants from matings with both animals treated no abnormalities were found. Among the 2,606 descendants from matings before any treatment, 10 mice (0.4 per cent) with abnormalities of the eye, jaw, or skull were found.

"A second experiment, also with the cooperation of Dr. H. J. Bagg of the Memorial Hospital, has been undertaken, using a different strain of mice, but the same X-ray treatment and breeding technique as in the above experiment; only 4 females and 1 male were treated. In the matings involving one X-rayed parent the following number of mice, reared to 4 weeks, have been examined for abnormalities: first generation, 111; second generation, 393; third generation, 185. In the matings between 2 treated mice: first generation, 54; second generation, 362; third generation, 177. The control young number: 46 in the first generation, 698 in the second, 713 in the third. Three abnormalities (0.4 per cent) appeared among the 689 mice with one treated ancestor; one of these involving the eye was in the first generation. Two (0.3 per cent) of the 593 mice with two treated ancestors showed abnormalities of the head. Of the 1,457 controls, 5 (0.3 per cent) abnormal mice were recorded; these abnormalities involved the eye, foot, nose, jaw, or skull. In many cases the abnormalities appeared on mice found dead at birth, or before maturity. Of those that could be tested genetically none gave evidence of

Mendelian inheritance, although the reappearance of an abnormal eye in succeeding generations parallels the irregular occurrence of eye abnormalities in certain families of the Bagg albino strain and suggests that the genetic constitution of the family plays a part in the frequency of abnormalities. But as far as the influence of the X-ray treatment is concerned, the consistency of the rate of occurrence of abnormalities in the different parts of the experiments and in the two strains is evidence bearing toward the conclusion that most of the abnormalities found were due to certain conditions during development that, in general, are met by 3 or 4 mice in every thousand, rather than to a specific genetic constitution, preexisting or experimentally produced. This case falls in line with a rapidly growing list of characters, identical in their final stage, which may be attained by a chain of causation extending to the germinal material or only to some non-genetic source.

"With such a mass of negative results with the use of the original X-ray dosage, it has seemed wise to employ heavier doses. In view of the relatively enormous doses Snyder had to use in order to induce sterility in rats, this seemed especially advisable. The desirable treatment would cause sterility in a given time so the germ-cells close to the border line could be used for the genetic testing. The first step in determining a satisfactory dose is to establish the sterilizing limit. Accordingly experiments are in progress testing the treatment necessary to cause sterility in males, with a reduced spark distance and the time of exposure increased from a divided dose totalling 60 seconds to one continuous treatment of 10, 15, or 20 minutes. Only young males and females of proved fertility are used, each treated male being given weekly a new box of 6 females. Preliminary results indicate that these treatments will cause sterility, at least temporarily, by the second week after treatment. All but the 20-minutes dose left the males fertile in the first week. This agrees with results previously reported to the effect that the X-ray treatment does not cause an immediate suspension of fertility, as was supposed to be the case in the original experiment."

SEX STUDIES.

In the development of modern genetical studies it early appeared that the group of primary and secondary characters associated with sex were in some way tied up with a special chromosome called the sex-chromosome. In the attempt to find out how any chromosome directs the development of adult traits, the chain of events leading from sex-chromosome to adult sex-qualities seemed that which would be most useful to follow; and we have traced parts of this chain in several species in pigeons, in mucors, and in the fluids of many other organisms.

SEX DIFFERENTIAL.

Under a grant received by the Department from the Committee of the National Research Council for Research on Sex Problems, Dr. Blakeslee has been continuing, with Miss Sophia Satina, his studies on the fundamental differences between the sexes in the mucors. While evidence continued to accumulate that the Plus races of mucors have, on the average, a greater reducing capacity of certain salts of the rare earths than the Minus races, a new phase of the investigation was entered upon with the application of the Manoilov test to this material. By such application it appeared at once that the Plus races give the same reaction as the female sex in the higher forms. The test has been tried with about 100 races of mucors. It was found possible correctly to identify the sex of slightly over 90 per cent of the individuals tested. The reaction as so far used by Dr. Blakeslee and Miss Satina is,

therefore, not capable of giving 100 per cent correct identifications of the sex in any of the species extensively tested, but in all it does appear to give a high proportion of such determinations.

As related elsewhere Miss Satina and Dr. Banta have secured positive results in the application of the Manoilov reaction to *Cladocera*, and some studies are being made on the blood of mammals and birds.

PIGEONS.

Guiding Principles in Sex Studies.

For the past 11 years Dr. Oscar Riddle has continued at this Department researches on sex and the general physiology of reproduction in pigeons. He has published, during the year under review, certain of his conclusions resulting from an analysis and consideration of the kind of information required for an adequate knowledge of any hereditary characters. He has summarized this paper as follows:

"Present studies on heredity and evolution offer what is mainly a two-sided attack on a many-sided problem. An attempt to identify the radically diverse aspects necessary to the comprehension of any hereditary character, together with a concrete examination of these neglected attackable aspects of the subject, brings into clearer view the inadequacy of the present attack. Some of these deficiencies are such as can be adequately met only through a wide inter-departmental cooperative effort. On contemporary students of heredity and evolution and on laboratories devoted to studies in this field rests the responsibility of obtaining this cooperation, and of so directing some of their main efforts that the results of this cooperative effort may soon be attained. Where individuals or laboratories are already prepared to conduct this type of work it should receive immediate, active, and encouraging support. Our knowledge of heredity will be more advanced by securing all the kinds of fact necessary to an understanding of some one—any one—character than by a duplication of much information of a few kinds on many characters. At the present time, sex is one favorable character for such a comprehensive study. Heredity, as a branch of science, is assuming new aspects which give it an ever-increasing human value and a greatly increased human interest."

Seasonal Variation of Thyroid Size in Pigeons.

Dr. Riddle, in collaboration with Mr. Walter S. Fisher, has summarized and published the results of a 3-year study of seasonal variation in thyroid size in three kinds of pigeons. These results provide a notable contribution to our knowledge of the thyroid gland. They were sought and obtained, however, partly to learn a natural method of classifying the months of the year into breeding seasons, in place of the classification on a purely arbitrary basis hitherto used.

The results of the study have been summarized by Dr. Riddle as follows:

"Three kinds, or species, of pigeons were kept on the same diet throughout the year and individuals killed during each of the months of a 3-year period. The weights of the thyroids from these 3 species indicate a nearly simultaneous enlargment in autumn and winter months and a progressive decrease in size during the months of spring and summer.

"These size changes promptly follow the onset of colder autumn, and warmer vernal temperatures. Promptness of change, rather than evident delay, is indicated by practically all of the data obtained.

"This seasonal enlargement of the thyroid is probably associated with seasonal increase of thyroid function and increased heat production.

"The changes, as measured, are probably essentially free from the complicating effects of variations in the diet, care, locality, race, age, length or degree of confinement, health, or body-size of the animals used in the study.

"Earlier studies on seasonal changes in thyroid size, and on size changes induced by subjection of animals to short periods of heat and cold, have been considered at length. Some probable inaccuracies of the data previously obtained on seasonal changes in thyroid size of mammals have been pointed out. Data of these two kinds have been shown to be related, and evidently in better accord than was hitherto apparent.

"This considerable body of earlier and present data suggests and supports the following generalization: Normally and typically the thyroids of higher vertebrates respond promptly to autumn temperatures by enlargement; and to spring and summer temperature by a decrease in size; and these responses are capable of being induced by the temperature alone.

"The seasonal changes in thyroid size observed in pigeons have a direct and important application to the seasonal changes in sex-ratios and in reproductive processes as these have been previously observed in this laboratory. The season of active reproduction in the pigeon covers the period of decline of thyroid size—from its peak to its lowest point. The period of excess of male offspring coincides with the period of larger thyroid size; the period of excess of females is coincident with the period of smallest thyroid size.

"These results in the pigeon are also in full agreement with the thyroid-sex data obtained by Adler on frogs. They supply new evidence that in both bird and frog the successful experimental modifications of sex-differentiation have been effected through changes in the rate of metabolism in the ova and early embryos."

Reciprocal Seasonal Size Changes in Thyroids and Gonads.

Data showing that the gonads of pigeons—both ovaries and testes—undergo opposite seasonal size changes to those found in the thyroids have been summarized and published. These results connect the thyroid with changes in the sexual glands of the parent animals and reinforce the conclusions of the paper summarized immediately above. Dr. Riddle abstracts his paper as follows:

"Data are given showing coincident seasonal changes in the weight of thyroids, testes, and ovaries of three kinds of pigeons.

"The seasons (autumn and winter) of increased thyroid size are seasons of diminished size of testis and ovary. The actual reduction of gonadal tissue is probably greater in testis than in ovary. The seasons (spring and summer) of decreased thyroid size are seasons of increased size of testis and ovary.

"The seasons of free or frequent ovulation coincide with periods of decreased thyroid size and of increased gonad size. The period of restricted ovulation—and of numerous clutches composed of single eggs—coincides with the period of enlargement in the thyroid.

"One species of pigeon which has at all seasons a large amount of thyroid tissue in relation to ovarian tissue has a markedly less ovulation, or egg-producing, capacity than have two other species with small thyroids and large ovaries.

"These reciprocal size changes do not represent mere coincidence; they probably reflect actual functional relationships of these organs.

"The data, however, are not regarded as evidence for a general antagonistic action of thyroid and gonad. Both of these organs exercise functions which are related both to sex and to reproduction. Antagonism is here suggested only between the seasonally enlarged thyroid and a single reproductive function, namely, ovulation and spermatogenesis. This apparent antagonism may rest upon opposed actions of the thyroid and suprarenal."

A Study of a Large Fraternity of "Family Hybrids."

"Earlier experience (involving about 15 different matings) with a particular cross of pigeons belonging to two different zoological families has shown that males only (i. e., birds bearing testis-like organs) result from this cross. In all cases hitherto observed the percentage of infertility of the eggs was so high (often 80 to 90 per cent) that there was always a possibility of the selective development of (a part of) the male-producing ova. In a breeding test conducted during 1923, 24 of the 28 eggs produced were fertile, and this percentage of infertility was found to be less than when the female was mated to a male of her own species. From 24 fertile eggs, 19 males were produced. Moreover, 11 *consecutive* eggs produced males. Calculation of probabilities here indicates that 11 consecutive males would be expected to occur in such a test only once in 9,384 trials, and 19 males from 24 eggs is expected only once in 395 trials. Both of these expectations were actually realized in the first trial in which as many as 11 young were produced.

"Other studies have been completed on this material. 14 members of the fraternity lived to maturity. It was found on autopsy that 8 of these had larger right testes—a condition characteristic of a normal male pigeon; and that 6 of the 14 had larger left gonads—a characteristic of the normal female. Further, 2 of these 14 birds had well-developed *left* oviducts. These conditions, therefore, in addition to the above-noted probabilities, afford," Dr. Riddle concludes, "convincing evidence that some ova with the zygotic constitution of females developed into birds bearing testis-like gonads.

"Finally, in order to obtain an entirely adequate test of the nature of these gonads, all of the 14 pairs of adult testes have been sectioned and carefully searched for ovarian tissue." In this part of the work he was assisted by Mr. Daniel Ludwig. "In a thorough and painstaking examination no ovarian tissue could be found in the case of any gonad; and spermatozoa and typical testicular tubules were found in every case."

Right and Left Gonads in Birds.

Dr. Riddle has continued his investigation of the relative size of the gonads of birds as an index of their relative sexuality. In male pigeons the right testis is usually larger than the left, but under conditions of confinement, disease, hybridity, and in relation to the acme of sexual activity, this relation may change. A further examination of the gonads of wild species affords additional evidence, some parts of which seem opposed to other parts, and the conditions found are sometimes difficult to interpret. In the main, however, the new data indicate, in Dr. Riddle's view, that the exceptions to the presence of larger right testis are fewer than was earlier supposed, and that the exceptions are fewer at the height of the birds' breeding season than at other periods of the year. Dr. Riddle finds that it is not rare for the right ovary to persist in feral individuals of various families of birds. This is opposed to the views of Benoit who, having observed the appearance of right testis in female chicks, ovariectomized when young, has sponsored the view that the suppressed right ovary of birds is in reality, and in zygotic constitution, a testis.

"The numerous cases of incompletely suppressed right ovaries in many kinds of birds has been cited to demonstrate the truly ovarian character of this gland, and to indicate that Benoit has, in fact, accomplished true sex-reversal in his ovariectomized chicks."

MAMMALS.

Primary Sex Ratio in Mice.

Dr. MacDowell reports on this topic as follows:

"Since the fact of a higher proportion of males than females at birth can not be doubted, the theory that male embryos are more liable to die demands the corollary that the sex-ratio at the time of conception, the primary sex-ratio, is very high. Estimates of the primary sex-ratio in man, obtained by adding all cases of sexed abortions to the living births, range from 108 to 134.

"Among the litters of mice for which the number of corpora lutea and the sexes were known, certain ones were found with no prenatal mortality, that is, litters in which the number of young was no less than the number of corpora lutea. The sex ratios given by these litters has been unmodified by losses before birth and accordingly reveals directly the primary sex-ratio. Of such litters, 109 have been found. These total 427 males and 428 females—as close to equality as possible with an odd number of animals. The equality in the totals has been closely maintained as the cases were accumulating. This result is consistent with the findings on the relation between the prenatal mortality and sex-ratio in mice, but calls in question the high primary sex-ratios proposed for man; it presents the ratio, 1:1, demanded by the well-supported theory of equal numbers of male and female determining sperm, without doubtful subsidiary hypotheses. A fuller discussion of these results is given in a paper, *Data on the Primary Sex-Ratio in the Mouse*, now in press."

Prenatal Mortality and Sex Ratios.

Human statistics have led numerous authors to conclude that the male fœtus is more liable to death than the female, since in abortions there appears to be a strong tendency for the proportion of males to decrease as the age of the fœtuses increases. While this seems to be unquestionable for the later stages, the absence of records for the very early stages of gestation and the difficulty of sexing correctly the abortions that occur about the third month (and these include the majority of all recorded cases) raises a doubt as to the applicability of this generalization to the whole period of gestation. Until some method is found for determining the whole total prenatal loss in man, studies on animals must be made. Since the corpora lutea of pregnancy found in the ovaries of litter-bearing mammals record the number of ova that began the pregnancy, it is possible to judge the prenatal mortality in each litter by comparing the number born with the number of the corresponding corpora lutea.

Records have been made by Dr. MacDowell of the number of corpora lutea associated with 840 litters of mice and of the sexes of the young born in each of these litters. The analysis of these data leads unquestionably to the conclusion that the sex-ratio of the young at birth does not decline as the prenatal mortality increases. When the litters are classified according to the percentage of prenatal mortality, the proportion of males fluctuates above and below 50 per cent in passing from low to high values of mortality. The coefficients of correlation show the same absence of relationship between the prenatal mortality and the sex-ratio; in different sub-divisions of the experi-

ment the correlation coefficients are: $+0.077 \pm 0.045$; -0.015 ± 0.053; $+0.032 \pm 0.052$. This subject has been treated more fully in a paper by Dr. MacDowell entitled: *The Relative Viability of Male and Female Mouse Embryos*, now in press.

CLADOCERA.

Male Production in Moina macrocopa.

During the past year Dr. A. M. Banta has continued experiments which he is carrying out, in cooperation with Mr. L. A. Brown of Harvard University, on the calling forth of males in parthenogenetic species of cladocera that ordinarily produce only females. Earlier results had shown that, through crowding of females, males are called forth in large numbers in the presence of some products of catabolism and of low temperature. That is, an unripe ovum, which under ordinary circumstances would give rise to a female, under these unusual conditions undergoes a modified development and produces a male individual. Banta and Brown now find that with the use of temperatures at 12° C. bottles containing only single mothers produced as high a percentage of males as 2 and 3-mother bottles and produce a percentage of males which is normal for fully crowded bottles at laboratory temperatures. Hence, Dr. Banta reports:

"The normal male percentages for male-producing bottles are obtained without any element of crowding. Thus the accumulation of a 'balance of excretory products' is eliminated as an essential factor in male production.

"Series of experiments with mothers crowded to various degrees have yielded data showing a remarkably close correlation between (1) the degree of crowding, (2) the amount of retardation of the production of young, and (3) the percentage of males produced. Curves constructed using values for any two of these items approximate straight lines. It is possible to estimate fairly closely any one of these factors if both, or either, of the other factors is known."

Chloretone was found to be an agent (when a single dose is applied shortly before the critical period) for the determination of the sex of the ovarian egg, inasmuch as it increases male production in a semi-crowded bottle. This increase of male production is accompanied by delayed reproduction. However, the use of chloretone is uncertain, as the animals apparently quickly recover from its effects.

The delay of reproduction associated with increased male production seems to be a general phenomenon. The average observed difference in the time at which sisters in the same bottle who produce female young and male young release their broods was 39 minutes in 455 observations; the difference being about 8 times the statistical probable error.

Other agents which have been tested as to influence on the calling forth of males are as follows:

Crowded mothers, treated when their eggs were near their critical period with sufficient alcohol to render their culture medium to between 0.2 per cent to 0.1 per cent alcoholic, produced only one-third as many males as control, untreated bottles. *Desiccated ox thyroid* gland has given results similar to those obtained with light alcoholic treatment. Desiccated *adrenal cortex*, of the ox, applied to crowded bottles practically eliminated male production. Thus in 32 such experiments "the crowded controls produced

21.5 per cent males, while crowded *sisters*, treated with adrenal cortex before the critical period produced only 0.3 per cent males. These 32 experiments involved 802 mothers and over 6,700 young. This very low percentage of males produced by adrenal-cortex treated mothers approximates that arising from the exceptional production (from causes unknown) of males by isolated mothers at laboratory temperature. Theoretically then adrenal-cortex treatment eliminates male production otherwise caused by the effects of crowding."

The precise way in which lowered temperature and generally depressing agents induce the production of males remains undetermined. The agents are such as lower the rate of development of mothers, retard metabolism, in general, reduce the irritability of the protoplasm of all cells of the body, including the germ-mother cells. What is clear is that the agent is effective when applied to the reproducing organism within about 4 hours before the eggs are extruded into the brood pouch. This, doubtless, corresponds with the period of the ripening of the egg.

Male Production in Daphnia magna.

While the work done on male production has been chiefly on *Moina macrocopa* which tolerates a higher temperature range than most of the laboratory stock of Cladocera, some experiments have been made on *Daphnia magna*, the range of temperatures for whose activities are much below those of *Moina*. *Daphnia magna*, because of its physiological difference from *Moina macrocopa*, was selected for certain work on male production and some experiments have been made with this form by Miss Thelma Wood.

"This form reproduces slowly for a cladoceran and appears less amenable to control measures than *Moina*. While the experiments have not been carried very far the indications are that its reactions in male production are similar to those of *Moina* and the other species previously worked with, viz., that crowding and low temperature are factors favoring male production."

The Thelytokous Cladocera Race.

Dr. Banta reports that:

"The work with the thelytokous race of Cladocera, which produces pseudo-sexual eggs which hatch without fertilization, has been completed and is in press, together with a paper by Dr. Franz Schrader of Bryn Mawr on the cytology of the pseudo-sexual eggs. Dr. Schrader finds that, as was anticipated, there is some cytologically peculiar behavior but that the ordinary parthenogenetic eggs in this form share in the peculiar behavior. The point of most interest is that the pseudo-sexual eggs do not undergo reduction, as they are believed to do in Cladocera in normal sexual reproduction."

Hybridizing Mutant Stocks of Cladocera.

Attempts have been made, in cooperation with Mrs. George G. Snider, to secure hybrids between the different mutant stocks of *Daphnia longispina*. The results, if any, will be reported next year.

A Biochemical Reaction Associated with Sex in Cladocera.

Miss Satina, in cooperation with Dr. Banta, has applied the Manoilov test to some Cladocera material. Samples of Cladocera fresh from a pond were separated into three groups, (1) females bearing sexual eggs (about 200 individuals), (2) adult males of the same Cladocera form (about 350), and

(3) females of another type of *Daphnia*, the maleless race, which were bearing the usual parthenogenetic eggs. Samples of equal weight (after removing all possible water by means of filter paper) were tested. The sexual female samples gave a pronounced violet coloration. The parthenogenetic females showed a similar color, but with much less intensity. The males showed no coloration. This reaction is quite in accord with that obtained by Miss Satina and others for the two sexes of many plants and animals and extends the application of the Manoilov reaction to Crustacea.

COMPLETION OF THE SELECTION EXPERIMENTS WITH SEX-INTERGRADES OF SIMOCEPHALUS EXSPINOSUS AND DAPHNIA LONGISPINA.

"These selection experiments were conducted for a period of 4 years with the former species and 7½ years with the other. In a strain of Cladocera sex-intergrades, the intergrade character is quite variable in its manifestation. This suggested the possibility that individuals manifesting the sex-intergrade characters to a higher degree might be genetically different from those less intergrade. In general, however, such is not the case—a 'low' intergrade produces as many intergrades and as high intergrades as a 'high' intergrade of the same strain, except when a mutation occurs. In order to demonstrate and to utilize such mutations as might occur the selection experiments were planned.

"The simple procedure was as follows: In certain strains only highly intergrade individuals were selected as mothers with which to continue the strain. These were the selected 'high' strains. In other strains only slightly intergrade mothers were used in the selections. These were the 'low' strains. The results are that selection is effective. The selected high strains sooner or later became as high in intergrade characters as was compatible with continued functioning in reproduction. The low strains became less and less intergrade until some of them produced very few of even the slightest intergrade individuals. Indeed some of the *Simocephalus* low strains ceased to show intergrade characters at all. Curves, plotting average grades of intergradedness by generation, show evidence of mutations having occurred at various points. Return selection was likewise successful; a low or a high strain if subjected to reverse selection may become after a time a strain of the reverse type. We have selected from low to high and back to low again; and from high to low and back to high again.

"At the close of the selection work with *Daphnia longispina* intergrades two types of 'test' series were conducted. One consisted in taking high mothers and low mothers (sisters) from a single moderately high strain, subjecting them simultaneously to identical treatment and carefully recording by arbitrary numerical values the degree of intergradedness of their young. 14 high mothers with an average grade of 28.7 produced 554 young with an average grade of 18.5; while an equal number of low mothers (clutchmates of the high mothers) with an average grade of 11.6 produced 590 described young with an average grade of 14.2. The average grade of young from the low mothers was thus somewhat lower than that from the high mothers. This is apparently due to the fact that two of these low mothers were really mutants in the low direction. Even disregarding this probable mutation it is clear that the offspring of high and of low mothers of the same strain differ very little, and that genetically high and low mothers from the same strain are approximately equal.

"The other 'test' was made by taking low mothers of a high strain simultaneously with mothers of identical grade from a low strain, subjecting them to identical conditions, and numerically grading the young. 12 mothers (of

average grade of 10.58) from one of our high strains were thus kept side by side with 12 mothers of the same grade from a moderately low strain. The 564 young from the high strain had an average grade of 20.3; while the 543 young from mothers of identical grade but from the low strain had an average grade of only 1.9 or only one-tenth as high. Hence it is clear that all the individuals *within a given strain* are genetically alike (except as a mutation arises) so that high or low mothers produce the same grade of offspring; and that the grade of offspring of a mother with a given degree of intergradedness is correlated not with the mother's grade (unless she chances to be a mutant), but with the genetic constitution of the strain to which she belongs.

"The two strains from which mothers of the same grade were used in the test series mentioned above were originally genetically quite similar. After the period of selection, involving the occasional utilization of a mutation, they were markedly divergent. The interpretation perhaps most favored by these results is that sex-intergradedness is due to a single complex genetic factor; that this factor may, not frequently, undergo a minor change; that such a minor change may later be followed by another change in the same direction (thus accounting for the cumulative effect of selection); and that changes are readily reversible (this accounting for the success of return selection).

"Equally successful selection experiments are being conducted with another mutant character, excavated head, which likewise yields to selection and to which the same interpretation may be applied."

GENETICS OF SPECIAL TRAITS.

ALBINISM IN MAIZE.

Continued genetic analysis of white seedlings has been continued by Dr. M. Demerec, in cooperation with Dr. R. A. Emerson of Cornell University. The results obtained indicate that in the great majority of varieties of white seedlings which were investigated the condition is determined by genetically different factors.

"Since the material used in the study of albinism in maize involved several other factors" Dr. Demerec found it "possible to use the same material to study the linkage relations between those factors. In this way five linkages were found in the past year, e. g., a linkage between W_{11}–w_{11} and Sh–sh with 22 per cent crossing-over, a linkage between D_3–d_3 and Sh–sh with 23 per cent crossing-over, a linkage between Gm_2–gm_2 and R–r with 31 per cent crossing-over and a linkage between V_8v_8 and Su–su with 33 per cent crossing-over.

"Investigations with zebra-like striped leaves in maize which were carried on for several years were concluded during the past year. They show that zebras which were found in different varieties of maize were determined by four genetically different factors."

VARIEGATION IN DELPHINIUM.

Dr. Demerec has continued his studies on this genus of plants and reports that:

"Preliminary to detailed studies of chlorophyll and other flower variegations, an analysis of other characters has been made for the purpose of finding their linkage relations. This will facilitate the studies on the main problem. By an analysis of colors and morphological characters 19 genetically different factors were established and an indication of linkage between one of the color factors and one of the factors for chlorophyll variegations was found."

GENETICS OF THE THOROUGH-BRED HORSE.

This investigation has been conducted by Dr. H. H. Laughlin, using a group of computers at Cold Spring Harbor and field workers in London (England) and Kentucky. The latter have furnished 665 schedules descriptive of traits of soundness and conformation of selected mares and stallions. This work has been generously financed by Mr. Walter J. Salmon, whose continued interest has made these investigations possible.

During the year considerable headway has been made in finding the mathematical measures for the definite qualities which heretofore have been expressed only in descriptive terms. A detailed account of these measures is furnished herewith by Dr. Laughlin.

The Biological Handicap (Measure of the Phenotype).

"The principal task has been to find a measure of the Biological Handicap, which is defined, in terms of pounds, as the measure of a particular horse's racing qualities in which each of the four major factors of speed, distance, weight carried, and age is properly stressed.

"Because these relations are shown to be non-linear, multiple correlation is not available for use and other devices for the determination of relative values have to be worked out.

"In reference to distance it is found that, for the better type of American thoroughbreds, other factors being most favorable, distance cuts down speed in accordance with the following rule: Doubling the distance increases the average number of seconds required to run one furlong (other factors being equal) by approximately 6 per cent.

" Regardless of sex or age, the quality of a particular race-performance of an individual horse is, in general, directly proportional to the weight carried. It is also, in general, inversely proportional to the number of corrected seconds required to run one furlong (that is, directly proportional to speed properly corrected for distance). Then, finally, the relative stress or importance which should be given to weight carried and to seconds per furlong corrected for distance, must be gaged. By correlating, in 1,000 typical American races, the weight actually carried with biological handicaps (assigned by the best professional, but non-mathematical handicappers) a correlation of 0.6392 is found. Similarly a correlation between seconds per furlong corrected for distance and the biological handicap, as above rated, gives r=0.7131.

"The next step is to find mathematical expression for quality of performance (regardless of age, sex, or condition) for a given race by a given individual. The best single expression thus far found for this complex of factors is represented by the following formula:

$$\text{Q.P.} = \frac{(\text{wt.})}{\text{c. s. f.}^{1.1156}}$$

in which 'Q.P.' is the quality of the individual performance, 'wt.' is the weights (in pounds) carried on the horse's back, 'c.s.f' is the seconds per furlong corrected for distance, and the exponent 1.1156 is the relative stress given to speed when weight is given a stress of unity. While this formula, when applied to practical tests, works better than any yet tried out, it still gives, for good horses, too much relative importance to weight and not enough to speed. Experiments are being made systematically on small empirical adjustments for this logically deduced tentative rule, in order to find, if possible, a still better formula for the race quality of a single performance.

"In the determination of the formula for biological handicap one more essential major factor has been studied, but no definite set of rules yet deduced for it, namely the age factor in relation to quality of performance. It is shown that for fillies the average age of best performance is approximately 2½ years, while for colts the same climax comes at approximately 3½ years, and for geldings at approximately 5½ years. The work continues to determine quantitatively the rate of approaching and passing these climax periods.

"Thus, in order to gage the biological handicap (i. e., to measure a horse as a successful racer), quality of performance, modified by the age factor, will be worked out for the best 25 per cent of the individual's races; the mean of such values (transformed into handicap pounds by use of regression indicated by the final correlation between B. H. and Q. P. corrected for age) will be used as the basic measure.

The Near Kin Indices. (Measure of the Genotype.)

"The analysis of pedigrees, in so far as racing quality is concerned, comes back, ultimately, to the major performance factors of weight, speed, distance, and age for the nearest blood-kin. In the present work each of these four factors is gaged in reference to each of the three others, separately, and also to the complex of all four. In working out the Near Kin Indices the four principal measures, based upon tentative biological handicap values (assigned by the professional handicappers) of the near kin of the particular horse have been given preliminary mathematical expression. In the development of these indices the biological handicaps for the nearest blood-kin are first determined. In this group of the nearest blood-kin are included: (*a*) the grandparents, (*b*) the parents, (*c*) the full sibs, (*d*) the half sibs, (*e*) the F_1 offspring, (*f*) the F_2 offspring, and, finally, (*g*) the propositus himself. Tentatively, each of these sub-groups, used in the particular index, is given equal stress or weight. In perfecting these measures the next step consists in giving each of these several blood-kin sub-groups a definite and proper weight or stress, in proportion to the actual correlations which such sub-group is later found to possess in relation to the propositus.

"In the particular groups of thoroughbreds being studied (the winners of all the best races since 1870, and their near kin) the indices, thus far tentatively used, are (*a*) The 'Average Biological Handicap' of the near kin. This is based synthetically upon the whole number of the near kin found in the above listed near kin groups which have racing records. (*b*) The 'Futurity Index' which could have been called equally well 'The Mate Selection Index' or the 'Index of Promise.' It is based upon the performance values of the four grandparents, the two parents, the older full sibs and the older half sibs. (*c*) The third measure is the 'Breeding Index.' This is based entirely upon the children and the grandchildren of the particular propositus. (*d*) The fourth gage is the 'Near Kin Index.' At present, in its tentative form, it is based upon the performance values of the following near kin groups: grandparents, parents, best 25 per cent of the full sibs, best 25 per cent of the half sibs, propositus himself, the best 25 per cent of the F_1 offspring, and the best 25 per cent of the grandchildren. In order that the final Near Kin Index of a horse may be completed, it is necessary that the horse's F_2 offspring have performance records.

"Of the several indices the Near Kin Index is proving the most reliable indicator of the genotype, just as the perfected biological handicap is being developed into a mathematical measure of the phenotype. The following table, based upon quality of actual race performances of the nearest blood-kin, with each near kin-group given proper relative stress, gives the result of some of the preliminary determinations:

Analysis of the Near Kin of a Group of American Stallions, 1925.

Name of Stallion.	B. H.	Date foaled.	Constitutional Indices.				
			Near kin.		II. Futur. Index.	III. Breed. Index.	IV. Near kin Index.
			No.	I. Mean B. H.			
Dunboyne	120	1916	48	107.97	112.37	.....	111.88
Peter Pan	128	1904	49	115.9	117.82	114.65	119.03
North Star III	120	1914	57	112.5	113.5	113.	113.33
Fair Play	127	1905	53	116.2	115.5	120.2	117.81
Man o'War	138	1917	37	118.8	117.04	116.50	120.58
Ballot	128	1904	79	111.9	113.19	111.	115.04
Black Toney	120	1911	36	115.8	114.6	118.6	117.6
Spanish Prince II	120	1907	27	110.3	111.68	110.5	113.5
Hourless	129	1914	21	112.7	116.4	111.1	115.12
Ambassador	118	1911	23	112.9	113.88	120.7	114.23
Gay Crusader	128	1914	20	116.6	115.56	114.5	118.84
American Flag	119	1922	8	117.8	122.42	.....	121.2
Omar Khayyam	126	1914	43	111.7	114.88	110.8	116.28
Star Hawk	122	1913	48	112.7	114.88	102.	112.93
Ladkin	127	1921	31	120.5	122.78	.....	123.81

Abbreviations: B. H. biological handicap; Futur. Index, futurity index; Breed. Index, breeding index.

Age of Dam in Relation to the Production of Winning Foals.

"In analyzing histories and pedigrees for the purpose of gaging mathematically the phenotype and the genotype several supplementary studies have brought interesting facts to light, e. g., the matter of the age of the dam in relation to fecundity and the age at which her best foals were produced. It is found that of the 158 winners of American Classic Races (the Belmont Stakes, the Saratoga Cup, the Kentucky Derby, and the Lawrence Realization) since 1870 the dams show the following age relations in the production of their winning foals:

Age of dams at foaling.	Total winning foals produced at given age.
yrs.	*p. ct.*
4	2.5316
5	5.6963
6	5.6963
7	5.6963
8	9.4937
9	8.8607
10	9.4937
11	6.9621
12	5.6963
13	5.6963
14	8.8607
15	4.4303
16	5.0632
17	5.0632
18	1.8987
19	3.7974
20	1.8987
21	1.8987
22	0.6329
25	0.6329

Age of mare at foaling.	Chance of still producing best foal.
yrs.	*p. ct.*
3	100
4	97.4684
5	91.7722
6	86.0760
7	80.3798
8	70.8862
9	62.0255
10	52.5319
11	45.5699
12	39.8736
13	34.1775
14	25.3168
15	20.8865
16	15.8233
17	10.7601
18	8.8614
19	5.0640
20	3.1653
21	1.2666
22	0.6337
23	0.6337
24	0.0000

"For these factors there is a second table showing the chance of a given mare of a given age still producing her best foal."

TWINNING IN SHEEP.

In the autumn of 1924 No. 379♂ was used again as sire to the flock of sheep. There were born 23 lambs to 14 ewes, or an average of 1.64 per ewe. This is a marked reduction in the average number of young born to a mother and was correlated with a high rate of still-births and an apparent diminished vigor of the ram who has been used continuously for three years.

HUMAN GENETICS.

Heredity in Aristogenic Families.

Dr. H. J. Banker has devoted himself during the year to the tabulation of averages and other data based on the scholarship records in the Huntington schools. As a by-product two studies have been completed in the measurement of mentality by means of school accomplishment; but owing to the mass of statistical matter to be handled these have not yet been sent to press. They have served as a foundation for the studies in heredity. While doing this work Dr. Banker has developed a formula for deriving an intelligence index from teachers' marks which bears evidence of approximating a true intelligence quotient. Dr. Banker proposes to apply this test to the best body of data available for the purpose.

Heredity in Cacogenic Families.

Dr. A. H. Estabrook has continued his field work upon the population of a selected portion of the Southern Appalachians. He reports as follows:

"The greater part of the time was given to Leslie County, Kentucky, where the gathering of genealogical trees and the further study of individuals has been carried on. Continued study for the past two years has made Dr. Estabrook familiar with the behavior reactions of the people of these mountain areas so that more correct observation and interpretation of the behavior may now be made.

"Accordingly the work of writing up complete family histories has been begun. Records are sparse and much difficulty has been experienced in securing any data regarding traits of the earlier generations. While the verbal memory of many of the people is remarkable, yet the events which are recalled serve rather to illustrate situations than to analyze individuals. Dr. Estabrook has been obliged to depend mostly upon his own observation for a critical analysis of the people in the area he is studying.

"The field work has been carried on by means of talks with citizens who know and can furnish genealogical lines; by visits to the homes for observing the behavior of the people and the economic and physical conditions in which they live; by visits to schools to observe children singly and in groups and to make mental tests upon them; by attendance at group gatherings of religious, community, political, and legal nature; by conferences with those community workers who have shown an interest to cooperate in the field work; by searching public records. The area studied is the headwater region of the Kentucky River and comprises heads of hollows, narrow creeks with steep sides and, further down the forks, the more level bottoms.

"This area was settled by about 50 families during the period between 1790 and 1830. These families were mainly from North Carolina and Virginia, having reached these counties in the general movement westward along the wilderness trail after the Revolutionary War. Points of settlement were

determined by the richness of the hunting and fishing grounds so that the first settlements were made at the heads of the creeks and hollows where springs and salt licks were found, to which animals were attracted. When game and fish had ceased to be plentiful agriculture became necessary for subsistence and, accordingly, the movement was toward the more fertile bottom lands in the lower reaches of the streams.

"In the hundred years of occupancy of this area the descendants of the settlers have mated largely with their own folk. Travel has been difficult because of the absence of good roads, and propinquity has greatly determined marriage. Relatively few matings have taken place into stocks of outside areas so that the population can be considered as derived from a small number of progenitors.

"Migrations from this area have been taking place since the early settlement into the Blue Grass regions of Kentucky and Indiana, to manufacturing towns along the Ohio River, to the Boston Mountains in Arkansas, and to various points in Missouri, Oklakoma, Texas, and Oregon. These migrations became marked just before the outbreak of the Civil War, at a time when the saturation of the population began to occur and it seems probable that the emigrants were selected from the more energetic and intelligent.

"More recently many of the young people have been drawn away from the mountains to attend schools of more advanced grade. A study of former students of Berea College, which is in part recruited from this territory, indicates that the longer and the higher the training received in these schools the greater the tendency for the students to settle in areas outside the headwaters of the Kentucky River.

"The stocks remaining are, apparently, on the average, derived from the less intelligent and ambitious and their continued intermarriage is producing strains which are becoming cacogenic in nature."

Genetic Constitution of the American Population.

National Immigration.—Studies in immigration were continued by Dr. H. H. Laughlin, in collaboration with the Committee on Immigration and Naturalization of the House of Representatives. During the year the results of researches up to March 1924 were published (Nov. 19, 1924) by that Committee, entitled *Europe as an Emigrant-Exporting Continent and the United States as an Immigrant-Receiving Nation.* This publication (204 pages, 15 tables, and 10 charts) presented a preliminary analysis of the field investigations concerning present-day migrations, with further reference to the biological aspects of racial and national fortune. The data analyzed were the first-hand facts gathered in Europe during the European investigations mentioned in the annual report a year ago.

Economic-Population Complex.—"Work is progressing," reports Dr. Laughlin, "on the determination, for each immigration-controlling nation and country, of the situation-complex of area, density of population, population increase, national occupation, production, and national economic surplus or deficit, in relation to emigration-exporting pressure and immigration-receiving demand. For example, for Italy it is shown that during the year 1922, the net loss of emigration over immigration was 134,197; that the net gain of births over deaths was 463,765. Thus the total net gain of population was 329,568. In 1921 Italy had a density of population equal to 329.1 persons per square mile. In 1923, as a nation, she imported $3,353,018,500, and exported $2,152,550,280 worth of merchandise. Thus, internationally, the expenditures of her people were $1,200,468,220 more than her extra-national income. The analysis of this complex of population increase and economic

situation shows that Italy is a nation already over-populated and a nation expending more than she receives; a nation not highly industrialized, compared with the leading industrial nations of the world, still depending largely on agriculture, with a country generally mountainous and not particularly well adapted as a whole to agricultural production, and with no great colonies to which the youth of the nation can go to seek their fortunes. The measure of this complex is taken as the gage of the economic emigration-exporting force for Italy.

"At the present time there are 104 migration-controlling nations or colonies. Similar complexes of population increase and economic situation are being worked out for each of these 104 migration units. Accurate data are very difficult to secure for many of the more recently reorganized countries, and a still greater difficulty consists in an alignment of data, in all of these particulars, for the same country, under the same date. However, satisfactory headway has been made in this study and it is expected that the results of this particular research will be presented to the Committee on Immigration and Naturalization of the House of Representatives early next winter."

Fecundity Indices.—The fecundity index used for each nation as a whole and for geographical and group sections of the population was that derived by taking from the census records, first, the number of children under 5 years of age and dividing this number by the number of women within the ages of 15 to 44 years, inclusive, for the same geographical and nativity group and for the same date. This index applied to the United States census for 1920 gave the following results:

Whole population	0.4675
White population	0.4712
Negro population	0.4294
Foreign-born white population[1]	0.7120
Native-born white population	0.4263

Deportation.—Data on deportability and deportation of aliens in the United States have been accumulated during the past year by Dr. H. H. Laughlin and are now in process of analysis for presentation to the Committee on Immigration and Naturalization of the House of Representatives.

"This particular study attempts to take the objective view of the United States as an organism and to treat its reactions to the matter of deportability and deportation in much the same manner as the biologist observes reactions of an organism to a particular situation.

"An analysis of the laws and practices of the several individual states in reference to collaboration with the federal deportation service and also their interstate deportation has been completed. This shows that the states, as a rule, fail to initiate deportation processes, looking upon the matter as a federal duty. It shows also, in several centers, the inclination, on the part of the states, to demand reparation from the federal government for cost of maintaining aliens in state institutions in consonance with the theory that authority, and consequently the responsibility following the admission of aliens, is a federal matter.

"A new collection of nativity and deportability data has been secured from 676 of the 689 state and federal institutions for the socially inadequate classes. For 654 institutions thus far summarized, these data show that of a

[1] The children for this computation include all native-born white children under 5 years of age, both parents foreign born; plus (all native-born white children under 5 years of age, of mixed parentage)×(percentage of persons, 1920, of mixed parentage whose mother was the foreign-born parent); plus (all foreign-born white children under 5 years of age).

total of 455,644 inmates, 323,902 are native born, 79,109 are foreign born, and that for 76,499 the superintendents were not able to determine nativity. Of this foreign-born population, 3,192 were reported as 'deportable,' while during the entire past history of these 654 institutions, 11,015 inmates had been deported. In reference to 'interstate return,' 3,464 inmates were classed as 'returnable,' and the summary shows only 13,580 in the past returned to other states as 'non-residents.' The data upon which this summary is based are in process of analysis from the eugenical and legal points of view.

"In reference to the United States as a whole, the deportation practices of the states, and the situation in the institutions in which the inmates are public charges, measure statistically only a small portion of the whole field, but it is that portion which can be given, perhaps, the most exact mathematical measurement under the present facilities. The biological purpose of this particular study is to find out, by first-hand investigation, the degree to which the United States and the several states and communities, as organic entities, are attempting to control the admission and elimination of defective germplasm, and to gage the degree to which the principle of family, state, and national responsibility for production of defectives is coupled with responsibility for the care and maintenance of these defectives through the deportation processes."

Tentative Studies in Immigrant Selection.—"In the paper *Europe as an Emigrant-Exporting Continent and the United States as an Immigrant-Receiving Nation* appeared the first publication of the tentative studies in selective immigration which were conducted in England, Belgium, and Sweden.

"These tentative selective examinations covered four groups of information: (1) the Individual History under the sub-headings, Short Biography, Analysis of Individual Traits, Conduct, Community Reputation, Occupations, Achievements, Records of other Economic and Social Values, Moral and Social Instincts and Emotions; (2) Physical Examination, which included the Record of Physical, Physiological, Pathological, Anthropometric Tests and Measurements, Personal Indentification and Photographs; (3) Special Tests of Literacy, the Yerkes Test for General Mental Ability, Examination into Special Talents and Defects, Records of Education and Training; (4) Family Stock Values. These were determined by the biological pedigree-chart with descriptions of each of the nearest blood-kin."

Eugenical Sterilization.—The Eugenics Record Office has been kept in close contact with many state legislatures, state administrative officers, and state courts of law in seeking to find out the status of eugenical sterilization legislation, administration, and litigation in the several states. In return many of these collaborators have inquired about the eugenical aspect of particular phases of the problem, and have made requests for the model law based upon an analysis of all the facts in hand.

A further first-hand collection has been made by Dr. Laughlin of the facts in this field, which brings the record of the development down to date. This record, and its legal, statistical, and eugenical analyses, has been prepared for publication as a bulletin of the Eugenics Society of America. The text is now ready for the printer.

Analysis shows that since the publication of Dr. Laughlin's book on *Eugenical Sterilization in the United States, 1921*, 10 states have enacted eugenical sterilization laws as follows: Washington, Oregon, Montana, Delaware, Michigan, Virginia, Idaho, Minnesota, Utah, Maine.

"In several important features," reports Dr. Laughlin, "many of these new laws have been based upon the researches of the Eugenics Record Office.

Generally, then, they show progress in three directions: First, in constitutionality by eliminating all punitive elements and basing the theory of the law upon purely eugenical motives. The recent tests of constitutionality of the statutes of the states of Virginia and Michigan are cases in point. Second, provisions for simplified administrative procedure, including a court procedure analogous for the most part to the procedure required in commitment of defectives to custodial institutions. Third, the application of the selective principles of the statute to the population at large as well as to public charges."

Physical Traits of Australian Aborigines and Black-White Hybrids.

As a supplement to studies made by the Director in 1913 on negro-white crosses, some notes that he made in 1914 on the physical traits of some Australian aboriginals and their hybrids with whites were published this year. The measurements were taken at Brewarrina, New South Wales, in connection with the visit to Australia made at the time of the British Association meeting. 13 full bloods and 41 of mixed blood were observed. It appears that leg length, dolichocephaly, and darkness of skin color are extreme compared with other races of mankind; but the hair is not extreme in form, being prevailingly wavy. The first generation hybrids show an approach toward mediocrity in these traits. Hair and eye color of the Australian are dominant; while the skin of the hybrids is intermediate, as in negro mulattoes.

PHYSIOLOGY OF REPRODUCTION AND DEVELOPMENT.

EFFECTS OF ALCOHOL ON CORPORA LUTEA IN MICE.

Dr. MacDowell has practically completed his experiments (in cooperation with Elizabeth M. Lord and with the assistance of C. G. MacDowell) on the effects of completely anesthetizing doses of alcohol upon the reproduction of the mouse, outlined in the Year Book of last year (p. 47).

"These experiments consist of (1) the series in which half of the females were treated and tests and controls from the same litter were mated with the same normal males, and (2) the series in which half of the males were treated, each female (normal) being mated in turn with a treated and controlled male. At the end of June counts of the corpora lutea of pregnancy had been made for 1,590 pregnancies of 366 females. As previously described, the ovaries are examined surgically, and the litters corresponding to the corpora counts are born normally. No final summary of results can be given at this time as further operations upon certain females are required before the concluding tabulations can be made. Preliminary summaries support the result given a year ago for the treated females, namely, that even this intense treatment does not cut down the activity of the ovary as judged by the number of corpora lutea. A similar preliminary summary of the data from the experiments in which the males were treated, based upon 179 litters with treated fathers and 184 litters with control fathers, gives the average prenatal mortality, in terms of the number of corpora lutea, as 33.2 per cent and 32.2 per cent respectively. As far as these averages go, they indicate that if the treatment of the males has had any influence at all, it is slight."

HISTORIES OF MOUSE OVARIES.

Dr. MacDowell has made an advance in the knowledge of the activity of mouse ovaries through successive counts of the corpora lutea of pregnancy in the

same animal. These results are presented in a paper now in press, *The Number of Corpora Lutea in Successive Mouse Pregnancies.* He reports as follows:

"When the female is mated as young as possible by being placed at 4 weeks with a male already tested fertile, and remated at each birth without nursing the young, the average number of corpora lutea per ovulation rises rapidly for the first three litters. For later litters the number continues to rise but at a greatly reduced rate. As far as the tenth and eleventh litters there is no indication of any decline in the number of corpora lutea. Since the corpora lutea represent the ova that have been discharged, it follows that the decline in litter size so generally found in mammals after the first few litters is due to increasing prenatal mortality rather than to any falling off in the activity of the ovary. The coefficient of correlation between the number of corpora lutea and the order of the litter is $+0.36 \pm 0.03$. If the corpora counts are classified by the age of the mothers a similar positive relation is found, but the coefficient of correlation is smaller, $+0.29 \pm 0.04$, and suggests that the order of the litter has an influence apart from the age of the female. A peculiar fact is revealed by this last tabulation on the basis of the age of mothers, namely, the first pregnancies of the most precocious females, those having their first litters born from 40 to 59 days after their own birth, have distinctly larger numbers of corpora lutea than the females having their first litters more normally between 60 and 79 days.

"The influence of the number of previous litters upon the activity of the ovary aside from the factor of the age of the mother, is being investigated. When the influence of the age of the mother is reduced to a minimum by considering at one time only litters from mothers within a given age-group at the time of birth of the litter, it appears that the litters later in series tend to have higher corpora counts. This again suggests, but does not prove, that the number of preceding litters has some influence upon the number of corpora lutea, apart from the age of the mother. Special experiments will be required to demonstrate this point, and also to show the influence of age alone upon the number of corpora lutea by operating only upon first pregnancies from mothers of different ages."

MAMMALIAN DWARFISM.

The Director continued his study of the factors involved in Mongoloid dwarfism. He secured comparative data on over 400 individuals with the cooperation of Dr. J. M. Murdock, Superintendent of the State School at Polk, Pennsylvania; of Dr. Kay of the Michigan Home and Training School at Lapeer; of Dr. O. H. Cobb of the Syracuse (New York) State School; of Dr. E. W. Fuller of the Pennhurst (Pennsylvania) State School; of Dr. B. O. Whidden of the School for Feebleminded at Clinton, South Carolina; of Dr. C. B. McNairy of the Caswell Training School, Kinston, North Carolina; of Dr. C. T. LaMoure of the Mansfield (Connecticut) State Training School; of Dr. George McPherson of the Belchertown (Massachusetts) State School; of Dr. G. L. Wallace of the Wrentham State School; and of Dr. J. H. Ladd of the Exeter School of Rhode Island. These data are now being assembled.

Family history studies on many of these patients have been made by Miss Grace Allen. The results of some of these investigations were presented before the American Association for the Study of the Feeble-Minded.

A parallel series of studies has been made on mice with the cooperation of Dr. W. W. Swingle, of Yale University, with the purpose of inducing dwarfism in the young. Dwarfism was, indeed, obtained in great abundance, but some uncertainty exists as to the light it throws on Mongolism.

NORMAL INTERVAL BETWEEN BIRTHS.

In relation to the problem of human dwarfism a study was made by Miss Anne W. March and the Director of the normal interval between human births in a population that is reproducing freely and producing normal offspring. This standard seemed necessary before any inference could be drawn as to the validity of the explanation so often offered to account for a feeble-minded or dwarfish child—that it was the consequence of "uterine exhaustion" due to a too rapid succession of pregnancies. In the standard secured, 735 days appears as the modal interval between births, giving an interval between the birth of a child and conception of the next child of about 15 months.

ADMINISTRATIVE RECORD.

Archives of the Eugenics Record Office.

Dr. Elizabeth B. Muncey has continued as archivist, and has been assisted by Miss Margaret Martin and Miss Pearl Doty as indexers. An estimate of the extent of the records and of the index as of June 30, 1925, is as follows: 1,726 books in archives; Field Reports, 62,287 sheets; Special Traits file (A), 27,999 sheets; Records of Family Traits (R and M files), 8,150 parts; 1,133,000 cards in the index. The archives have been used by a number of visiting students of human heredity, including Dr. A. Brozek of the Czechish University at Prague and Dr. F. Breinl of the German University of Prague.

Staff.

Dr. J. Arthur Harris assumed his new duties at the University of Minnesota in September 1924, and at the end of the year, his chief biometrical assistant here, Miss Edna Lockwood, removed also to Minneapolis. A small statistical group has been organized at this Department to take their places.

Dr. A. F. Blakeslee went as delegate of the Institution to the Third Pan-American Scientific Congress at Lima, Peru, leaving in December and returning April 4, 1925. Some of the observations which he made on this expedition are described elsewhere in this report. He made important contacts with botanists, which may be expected to be of benefit to the researches going on at Cold Spring Harbor.

List of Publications issued by Carnegie Institution of Washington during the year ending October 31, 1925.

Year Book, No. 23, 1924. Octavo, xx+325 pages, 1 plate, 4 figures.

Index Medicus, Third Series. Vol. 4, 1924. Octavo, 1,083 pages.

Twelfth edition of an illustrated pamphlet on Scope and Organization of the Carnegie Institution of Washington. Octavo, 60 pages, 30 figures.

No. 228A. Crampton, Henry E. Studies on the Variation, Distribution, and Evolution of the Genus Partula: The Species of the Mariana Islands (Guam and Saipan). Quarto, vii+116 pages, 14 plates.

No. 310. Barus, Carl. Displacement Interferometry Applied to Acoustics and to Gravitation. Part III. Octavo, ix+165 pages, 25 tables, 221 figures.

No. 331. Stock, Chester. Cenozoic Gravigrade Edentates of Western North America with Special Reference to the Pleistocene Megalonychinæ and Mylodontidæ of Rancho La Brea. Quarto, xiii+206 pages, 47 plates, 120 figs.

No. 340. Papers from the Department of Marine Biology of the Carnegie Institution of Washington. Vol. XIX. Quarto.

This book, a memorial to Alfred Goldsborough Mayor, contains the following papers, five of them being posthumous works of Dr. Mayor:

Mayor, Alfred G.—Structure and Ecology of Samoan Reefs. Pages 1–25, 8 plates, 4 figures.

Mayor, Alfred G.—Causes which Produce Stable Conditions in the Depth of the Floors of Pacific Fringing Reef Flats. Pages 27–36, 1 figure.

Mayor, Alfred G.—Inability of Stream Water to Dissolve Submarine Limestones. Pages 37–49, 1 figure.

Mayor, Alfred G.—Growth Rate of Samoan Corals. Pages 51–72, 26 plates.

Mayor, Alfred G.—Rose Atoll, American Samoa. Pages 73–91, 2 plates.

Grey, Irving M.—Bibliography of papers of Dr. Mayor and associates. Pages 80–90.

Daly, R. A.—Geology of American Samoa. Pages 93–143, 11 plates, 2 figs.

Chamberlin, Rollin T.—The Geological Interpretation of the Coral Reefs of Tutuila, American Samoa. Pages 145–178, 7 plates, 5 figures.

Lipman, C. B.—A Critical and Experimental Study of Drew's Bacterial Hypothesis on CaCO Precipitation in the Sea. Pages 179–191.

Lipman, C. B., and P. E. Shelley.—The Chemical Composition of Lithothamnium from Various Sources. Pages 193–197.

Lipman, C. B., and P. E. Shelley.—Studies on the Origin and Composition of the Soil of Rose Islet. Pages 201–208.

Lipman, C. B., and J. K. Taylor.—Bacteriological Studies on Rose Islet Soils. Pages 209–217.

No. 342. Cushman, Joseph A. Samoan Foraminifera. (Paper from the Department of Marine Biology of the Carnegie Institution of Washington. Vol. XXI.) Octavo, 75 pages, 25 plates.

No. 343. Hoffmeister, J. Edward. Some Corals from American Samoa and the Fiji Islands. (Papers from Department of Marine Biology of the Carnegie Institution of Washington. Vol. XXII.) Quarto, 90 pages, 23 plates.

No. 347. Contributions to Palæontology from Carnegie Institution of Washington. Octavo, iii+92 pages, 10 plates, 54 figures.

Papers concerning the Palæontology of the Pleistocene of California and Tertiary of Oregon.

I. Merriam, John C., and Chester Stock.—Relationships and Structures of the Short-faced Bear, Arctotherium, from the Pleistocene of California.

II. Merriam, John C., and Chester Stock.—A Llama from the Pleistocene of McKittrick, California.

III. Merriam, John C., Chester Stock, and C. L. Moody.—The Pliocene Rattlesnake Formation and Fauna of Eastern Oregon, with Notes on the Geology of the Rattlesnake and Mascall Deposits.

No. 348. Contributions to Palæontology from Carnegie Institution of Washington. Kellogg, Remington. Additions to the Tertiary History of Pelagic Mammals on the Pacific Coast of North America. Octavo, iii+120 pages, 19 plates, 53 figures.

No. 349. Contributions to Palæontology from Carnegie Institution of Washington. Octavo, III+130 pages, 25 plates, 39 figures.

Studies on the Fossil Flora and Fauna of the Western United States:

I. Chaney, Ralph W.—A Comparative Study of the Bridge Creek Flora and the Modern Redwood Forest.

II. Chaney, Ralph W.—The Mascall Flora—Its Distribution and Climatic Relation.

III. Chaney, Ralph W.—Notes on Two Fossil Hackberries from the Tertiary of the Western United States.

IV. Chaney, Ralph W.—A Record of the Presence of Umbellularia from the Tertiary of the West.

V. Miller, Loye.—Avian Remains from the Miocene of Lompoc, California.

VI. Miller, Loye.—Birds of Rancho La Brea.

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