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DEPARTMENT OF EXPERIMENTAL EVOLUTION.*

C. B. Davenport, Director.

GENERAL STATEMENT OF RESULTS.

The progress in the year ending October 1, 1910, made by this Department in the subject under its charge may be considered under seven heads: origin of characteristics, their chemical basis, ontogenesis, transmission, modification by environment, relations, and the application of heredity to man.

THE ORIGIN OF CHARACTERISTICS.

While the breeder can as yet rarely induce at will a wholly new characteristic by experimental methods, yet in breeding large numbers of individuals new characteristics are occasionally found the proper breeding of which may result in a distinct strain. Thus, among the 17,000 pedigreed poultry bred by us such characteristics have appeared—at first hardly noticeable, but in the past few years becoming well marked and even striking. Among such are toes without nails; toes with double nails; extra tubercles on the side of the single comb which have given rise to a row of such tubercles in later generations; large depressions on the ridge of the beak (associated with an imperfect development of the nasal bone); and a horn on the ridge of the beak. Among plants, likewise, such characteristics have occurred, if not absolutely unparalleled, at least new to the species under consideration; such as æcidia or cup-shaped foldings of leaves, "quilling" of the lappets of compositæ, triple cotyledons, fasciations. We are not yet able to induce these at will in any strain, but have developed strains in which some of these conditions are normal.

The origin of spots on the wing-covers of lady-beetles has been particularly considered by Mr. Johnson, in his publication on that group, and he concludes that the evolution of any changes inside of species is chiefly the loss or the confluence of spots. The differences are often of a qualitative order.

THE CHEMICAL BASIS OF CHARACTERISTICS.

Substantial advance has been made in this subject during the current year in consequence of the appointment of Dr. Gortner and the equipment of a chemical laboratory. In the first place, fundamental defects in current methods of isolating the black pigment of hair, wool, and feathers were discovered. With the improved method the assertion that dominant white has a hyperoxidized black pigment was shown to be incorrect. In neither dominant nor recessive white is pigment formed; the additional factor in the dominant type is suspected to be an anti-enzyme.

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* Situated at Cold Spring Harbor, Long Island, N. Y. Grant No. 601. $30,970 for investigations and maintenance during 1910. (For previous reports see Year Books Nos. 3–8.)

THE ONTOGENESIS OF CHARACTERISTICS.

In the studies on the comb, tail, and feet of fowl conclusions were reached concerning dominance based on the relative frequency of occurrence of the dominant characteristic and its opposite in the second hybrid and subsequent generations. To test the hypothesis that dominance is due to the *presence* of something, while recessiveness is due to its *absence,* it was desirable to have studies made on the embryological development of the characteristics. For instance, there are "rumpless" fowl and the behavior of rumplessness in breeding suggests the hypothesis that this defect is due to a something that stops the normal development of the tail. Does the development of the tail region in the rumpless fowl give evidence on this point? Miss Elizabeth S. Lum has started an investigation of this point and some time will be required to complete it. It is significant that the rumpless fowl at first has a pointed tail, but its development seems to be prematurely interrupted as though there were present a local inhibitor of development.

Similarly the evidence from heredity indicated that the webbing (syndactylism) in the foot of some poultry is due to the presence of a factor absent in birds with non-webbed feet. The study of the developmental history of this characteristic has been begun by Mr. E. Carleton MacDowell, and is calculated to throw light on the process by which distinct digits are formed from the primitive paddle-like tip of the appendage. The extended studies that we have made on the inheritance of the varied forms of the comb of fowl raised so many questions concerning the factors involved in the development of the comb that we were glad to supply Mr. J. C. Stephenson, of the University of Chicago, with a variety of types of comb for the study of the embryology of this organ, upon which a report is soon to be expected.

THE TRANSMISSION OF CHARACTERISTICS.

This subject, heredity, has received more attention from us than any other, and the longer it is studied the more the subject develops. The two most voluminous publications of the year, that of Mr. Roswell Hill Johnson and my own, deal with this topic, and some account of their scope and general conclusions may be given. Mr. Johnson's paper is entitled "Determinate evolution in the color-pattern of the lady-beetles." These beetles are quite undomesticated and much labor was necessary to make them breed abundantly in captivity, the more so as most of them require living insects as food; nevertheless Mr. Johnson was very successful. He concludes that segregation of characters occurs in the hybridization of these beetles, but is not always clean-cut, and that dominance is irregular and variable in degree. He introduces the term "preponderance" to denote the fact of frequent excess in numbers of extracted "dominants."

Dr. F. E. Lutz, whose paper on heredity of characteristics in the fruit-fly has been submitted for publication, likewise finds "dominance" very irregular, and Dr. Shull has shown how in many cases it may be difficult or impossible to detect.

The "Inheritance of characteristics in domestic fowl" is a continuation of "Inheritance in poultry." The principal results are a demonstration of variation in the degree of dominance (illustrated by the relative proportion of the two elements in the hybrid between single and V comb) and of the inheritance of such degree. This variation in dominance shows itself also in polydactylism, syndactylism, and rumplessness. A study is also made of some characters that seem to blend, such as foot-feathering and nostril-height, and it is shown that even in these cases there is evidence of segregation, so that the probability is strengthened that segregation is never absent in inheritance and Galton's three types of heredity are merely different forms of segregated heredity. A case of apparent failure to transmit a character (comb-lop) is found. This adds another to the two or three previously known cases of non-inheritance of a right and left character. The complex factors of the plumage colors of several varieties of poultry were disentangled and simple formulæ discovered by which the proportions of any color in a given hybrid mating can be predicted.

Progress has been made in the analysis of the method of inheritance of sex by breeding over 200 families of a species of *Lychnis,* which affords male, female, and hermaphrodite individuals. To this problem Dr. Shull is devoting a large part of his attention.

The studies on inheritance of human characteristics have been greatly developed, and a booklet on "Eugenics," written by the Director, has awakened interest in the improvement of mankind by better breeding and has led to the establishment during the year of a eugenics record office at Cold Spring Harbor, in connection with the American Breeders' Association and supported from an outside source.

The studies on the relation of chromosomes to heredity, carried on by Miss Lutz, are yielding results of increasing interest.

THE MODIFICATION OF CHARACTERISTICS.

The results of Mr. R. H. Johnson's experiments in subjecting larvæ of lady-beetles to variations in temperature have been published. By subjecting larvæ to a low temperature new lines and spots of pigment appeared on the elytra. The study of the inheritableness of this changed pattern was not completed.

The relation of general vegetative vigor and variability to pure-line breeding in corn and to hybridization between pure lines has been further investigated by Dr. Shull and his earlier results sustained.

The Department is cooperating with Prof. H. H. Donaldson, of the Wistar Institute of Anatomy and Biology, in an experiment on albino rats. As Professor Donaldson has shown, albino rats have a nervous system that is much smaller in proportion to the weight of the entire body than that of Norway rats, and it seems probable that this is due to the fact that they have always been reared in cages. It was desired to set them at liberty in a place whence they could not escape. Accordingly it was decided to employ Goose

Island for this experiment, as it seemed to offer ideal conditions and as brown rats were known to inhabit it. An attempt was made to kill off the brown rats, and several pairs of white rats were then set free June 21, 1910.

The conclusions of Dr. C. C. Guthrie, that germ-cells of one race of poultry introduced into another race produced offspring with some of the characters of the foster-mother, was thoroughly tested by me, using pedigreed stock, and overthrown. There is at present no evidence that, in poultry, transplanted germ cells survive, much less that the "foster mother" modifies the inherent inheritable characters of the germ plasm.

On the other hand, the germ cells do receive nutritive materials from the maternal body and the details and limitations of this process are of great importance. Dr. Oscar Riddle, of the University of Chicago, spent some time at this Station during the year investigating this topic. Particularly he studied the permeability of the envelopes of the animal germ cell (fowl) to foreign bodies—especially to natural and artificial coloring matters. Positive results were obtained with nine such substances, and negative results with about forty others. He also studied the oxidizing and reducing properties of germinal elements and their surrounding tissues as these can be measured in the fowl by means of reducible and reoxidizable color-compounds. The investigation of both these subjects is still incomplete.

THE RELATIONS OF CHARACTERISTICS.

By means of extensive statistical studies Dr. Harris has determined that in *Staphylea* there is a real selective elimination of the fruit with fewer and more variable ovules and of those that are asymmetrical or have an odd number of ovules to a compartment of the ovary. To studies in elimination which stop at mere statement of the statistical fact there will always be the unsatisfied inquiry as to the mechanism of this elimination.

A case (land snails of the Bahama Islands) that has lately been cited as evidence against mutation was examined by me at New Providence and facts found that support the interpretation of their mutational origin or at least do not warrant the conclusion that the various forms can have arisen only by "selection."

STAFF.

Dr. G. H. Shull spent a larger part of the year than usual (all except January to April) on the Burbank work at Santa Rosa, and he will continue there until next spring. The necessary but difficult work of supervising the planting and hand-pollinating of Dr. Shull's cultures was done in a satisfactory manner by Mr. R. C. Rose, now of the New Hampshire Experiment Station, who was resident from June 1 to September 10. Dr. J. A. Harris spent some months in England and Germany during the winter, carrying on his computations and writing up results there. Dr. Banta visited Mayfield's Cave, Indiana, during a part of May in order to get cave animals for his studies at Cold Spring Harbor.

DETAILED REPORTS ON SCIENTIFIC WORK.

WORK ON HEREDITY IN ANIMALS.

Poultry.—In continuation of the experiments with poultry, 53 pens were maintained and over 3,500 chicks hatched. Fireless brooders were used exclusively for the outdoor brooding with entire satisfaction. Progress was made in developing rumpless, nailless, syndactyl, polydactyl, and combless strains; also new forms of comb, nostril, and boot. Several sets of experiments on potency and reciprocals were undertaken, and the results of grafting and abnormal temperatures studied.

Finches.—The breeding of canary birds was continued but, owing to the use of many young birds this year, the fecundity was small, only about 30 being reared. Interesting results were gained from the second hybrid generation of Java sparrows, since nearly pure white (with a little smokiness) were obtained from the gray hybrids of the first generation.

Sheep and Goats.—Fourteen sheep and six goats were born. The lop ear of the Indian goat is dominant over erect ear of the Irish goat as truly as accessory auricles are dominant over their absence. The black ram with 6 nipples, from Mr. Alexander Graham Bell's flock, is being replaced by a 4-horned, 3-nippled sheep, also a gift to the station from Mr. Bell.

Cats.—The new cat-house has proved well adapted to its purposes and the health and fertility of the stock are much improved.

WORK ON PLANTS.

The continuation of Dr. Shull's experiments was confided to the care of Mr. R. Catlin Rose, for whose guidance Dr. Shull prepared full detailed instructions. In order to simplify this work as much as possible, a number of problems which have been under investigation in previous years were omitted for this year and the more important ones somewhat enlarged.

Sex and Flower Color in Lychnis.—The studies in the inheritance of sex and color-characters in *Lychnis* have been Dr. Shull's largest project of the year. The results of the work with *Lychnis* are confirmatory of those already published, and numerous crosses have been made to test certain new phases of the subject. The attempt to secure a pure-bred purple-flowered strain of *Lychnis* has again failed of attainment, owing to the fact that in each cross made for this purpose one or the other parent proved to be heterozygous. The effort is to be continued in order that material of definitely known hereditary characters may be available for use in subsequent experiments. As in previous generations, several new mutants of *Lychnis* having hermaphrodite flowers have appeared this year, but they constitute an exceedingly small percentage of the individuals grown. The crosses in which hermaphrodites were used as the male parents have again been found to result in progenies in which the male members are hermaphrodites. Normal male mutants also appear rarely in these families. True males may occa-

sionally possess female organs as a purely somatic character. There was indication last year that the egg-cells of hermaphrodites do not possess the capacity to regularly produce hermaphrodite offspring, as the sperm-cells of the same plants do. The crucial test of this matter is a cross of unusual difficulty, in which the hermaphrodite is used as the female parent, and but little success has yet been attained in securing crosses of this nature. However, the one family of this type tested this year again indicates that the hermaphrodite condition is not regularly inheritable through the egg, but only through the sperm. Dr. Shull hopes that a concentration upon this phase of the question may in future give sufficient material to clearly demonstrate the relation between the sexes in *Lychnis*.

Indian Corn.—These cultures were also enlarged by Dr. Shull in order to thoroughly test the relation between self-fertilized and cross-fertilized offspring within the same families, not only in pure-bred, continuously self-fertilized lines, but also in first-generation and second-generation hybrid families. Special attention has been given also to the relative vigor and variability of second-generation hybrids as compared with first-generation hybrids and with pure lines. The result of last year's crop indicated that the first-generation hybrids between pure lines present the same degree of fluctuation as the pure lines themselves, while the second generation is considerably more variable. The second generation was also considerably less vigorous on the average than the first generation. Both of these results were in perfect accord with conclusions previously gained and already published. As the corn is not harvested at the time this report is made, the outcome of the further tests of these points can not be summarized here.

Oenothera Breeding.—The continuation of Dr. Shull's cultures of cross-fertilized and self-fertilized families in *Oenothera lamarckiana* and *O. rubrinervis* has been made possible through the kindness of Miss Lutz, who has carefully kept all notes and made the necessary crosses. A considerable number of new forms have been detected whose status as mutants it is hoped to test by subsequent breeding.

The number and size of cultures involved in Dr. Shull's investigations may be noted in the following table:

Name of species.	No. of families.	No. of individuals.	Name of species.	No. of families.	No. of individuals.
Chrysanthemum maximum	1	105	Lychnis(melaudrium) rubrum	5	277
Chrysanthemum nipponi	1	125	Oenothera	23	3,437
Digitalis	11	2,530	Rudbeckia hirta	1	100
Lychnis dioica	216	14,099	Zea mays	76	6,409
Lychnis haageana	3	110	Total	337	27,192

Variation in Wild Plants.—Pressure of experimental work has made it necessary for Dr. Harris to limit his work along these lines almost exclusively to fertility characters.

Quantitative Investigations of Fertility and Fecundity in Plants.—These studies have been carried forward by Dr. Harris, as time permitted, along the lines indicated in Year Book No. 8. Some of the data have been published and others are in press, while a very large mass of material awaits the final processes of reduction.

Investigations of Variation, Correlation, and Inheritance of Quantitative Characters in Garden Beans.—As stated in Year Book No. 8, where an indication of the chief problems may be found, Dr. Harris's attention since coming to the station has been chiefly devoted to these investigations. The cultures of the present season, involving the planting of about 20,000 seeds, were devoted to a comparison under like conditions of the offspring of ancestors grown for two generations under very dissimilar environmental conditions. Owing to the large amount of routine counting, weighing, tabulation, and calculation the results from these experiments can not be ready for a considerable length of time.

Studies in Vegetable Teratology.—The results of about 125,000 dissections of normal and proliferous fruits of *Passiflora*, grown in 1908 and 1909, are being studied statistically by Dr. Harris to determine various points concerning the nature of teratological variation and the frequency of the several types of anomaly to which a fruit may be subject. Until this routine can be carried through, further cultures of *Passiflora* have been suspended. Breeding experiments with teratological beans have been continued. Approximately 50,000 seedlings have been studied.

Quantitative Studies of Selective Elimination.—Natural selection is one of the factors of organic evolution least investigated by the quantitative biologist. Dr. Harris has attempted to gain some light on the structural characters which are least fitted for development by studying the characters of ovaries which fail to develop to maturity as compared with those which develop. The analysis of data for *Staphylea*, collected in the spring of 1906 and 1908, justifies the following conclusions:

The failure of ovaries to develop to maturity is not random, but is dependent upon structural peculiarities which would admirably be classed as "fluctuating variations." In short, the elimination is selective, whether we work within the range of variation of the ovaries of an individual or extend the studies to ovaries from a number of individuals. The changes brought about by selective elimination are:

1. An increase in the mean number of ovules.
2. A decrease in variability of number of ovules.
3. A decrease in radial asymmetry as measured by the standard deviation of number of ovules per locule for an individual ovary.
4. A decrease in the relative numbers of ovaries with one or more locules with an odd number of ovules.
5. Possibly an increase in the mean number of locules per fruit.

Preparations were made for carrying this work forward in 1910, but a severe freeze killed all the material.

CELL STUDIES IN HEREDITY.

Miss Lutz continued the study of the somatic chromosomes of the oenotheras and their hybrids begun four years ago and carried on ever since with great industry, over 4,300 fixations having been prepared for microscopical study; in the best-studied hybrids photographs have been made of type and exceptional forms to illustrate distinctive characters of early and late rosette stages, young and adult flowering plant, bud, flower, leaf, and fruit; in all about 350 plates.

Of the 14 or more topics upon which some data have been obtained the 5 following are nearing completion and will, it is hoped, be finished during the coming winter:

1. Chromosomal history of the F_1 offspring of *Oenothera lata* × *O. gigas*.
2. The F_2 offspring of *Oenothera lata* × *O. gigas*.
3. The chromosomes of mutants.
4. Pollen of the oenotheras and its relation to mutation.
5. Sex chromosomes of *Lychnis*.

STUDIES ON ADJUSTMENT TO CAVE LIFE.

During the winter a concrete cave was built, as described in detail under "construction," and a dark-room was fitted up with apparatus for the study of the reactions of organisms to light. The purpose of the cave studies is to learn the way in which body pigment is lost, eyes degenerate or disappear, and tactile organs hypertrophy in animals inhabiting caves, abysmal waters, and other dark situations.

Dr. A. M. Banta assumed charge of this work about November 1, 1909, and since that time has been busy collecting cave animals and installing and maintaining them in daylight as well as in darkness. Closely related species that ordinarily live in the light are being reared in the dark. A necessary, though laborious, part of the work has been acquiring the technique of maintaining the animals. Each species presents a problem in itself, and many of these problems have been solved. The artificial cave affords conditions approximating those of a natural cavern, with the advantages of constant accessibility and of convenience for caring for the organisms.

The following are now breeding within the cave:

Asellus communis.
Eucrangonyx gracilis (surface form).
Oniscus asellus.
Armadillidium vulgare.
Porcellio scaber.
Porcellio rathkei.
Copepoda.
Drosophila.
Tenebrio.
Silvanus.

The following animals are being kept in the cave for the purpose of breeding:

Guinea-pigs.
Goldfish.
Sunfish (Lepomis gibbosus).
Crayfish (Cambarus bartoni).
Myriapoda.
Thysanura.
Ceuthophilus.

In addition, larvæ of 4 species of amphibians are being reared in the cave.

The following cave forms are being kept in daylight:

Cambarus pelucidus.
Cæcidotea stygia.
Eucrangonyx gracilis.
Sinella cavernarum.
Rhagidia cavicola.

Some time has been devoted by Dr. Banta to a comparative study of the light reactions of the cave form of the amphipod *Eucrangonyx gracilis* and the form of the same species found in surface streams in the same localities. The work on the normal light reactions of these forms should be completed soon. Two parts of a similar study, "A comparison of the reactions of a species of surface isopod with those of a subterranean species," previously completed, have been published during the year in the Journal of Experimental Zoology. With the species used, *Asellus communis* and its near relative of cave habitat, *Cœcidotea stygia*, there was found a great difference in reactiveness to light and to mechanical stimulation. The cave form was responsive (negatively) only to rather high intensities of light, while it was exceedingly responsive to all sorts of mechanical stimulation. On the other hand, *Asellus* was responsive (also negatively) to comparatively low light intensities, though it fell far behind *Cœcidotea* in its responsiveness to tactile stimulation. With *Cœcidotea* there was increased sensitiveness to one sort of stimulation to compensate for partial loss of responsiveness to another sort. Having a bearing on the respective habitats of the two species was the fact that *Asellus* is *positive* in its response to light after retention in darkness for a time, while *Cœcidotea* is always negative to any intensity to which it responds at all. Hence *Asellus*, if happening within a cave, would tend to leave it after a time if, by chance, it came within reach of the light from outside, while *Cœcidotea* is always negative in its response and responds to a sufficient range of intensities to prevent its leaving a cave and passing into daylight outside.

Studies have been made on sex recognition and the breeding-habits of *Asellus*. An unsuccessful attempt was made to breed from an albino strain of *Asellus*, but the experiment is being continued.

Observations are being made for possible modifications in light reactions as well as pigment changes in the various forms in their changed environments; and upon the effect of absence of light upon the development of certain amphibian larvæ.

CHEMISTRY OF PIGMENTS.

During the past year Dr. R. A. Gortner has been in charge of the chemical laboratory fitted up for his use, in the study of organic pigmentation. He reports as follows:

During the past year the investigations carried out in the chemical laboratory have been largely of a preliminary nature. In pursuance of an endeavor to ascertain the origin, mode of formation, and chemical nature of compounds of the melanin class it was found necessary to determine the form in which the pigment is present in the animal body, skin, hair, or feathers. The greater part of the time has, therefore, been utilized in isolating the pigment from black sheep's wool by destroying the keratin structure with alkali or acid of varying concentration, then purifying the melanin and subjecting it to a chemical analysis. By a comparison of the data from this series the effect of alkali or acid upon the melanin molecule could be determined.

It was found that alkali in excess of 0.2 per cent concentration (calculated as sodium hydrate) readily destroyed the greater portion of the pigment molecule and caused a great loss in both the nitrogen and hydrogen content. The yields of the melanin obtained by the different methods are given in table I and the analytical data is shown in table II.

In addition to this work the pigmentation of the meal-worm (*Tenebrio molitor*) was studied and was found to be due to the interaction of an oxidase and an oxidizable chromogen.

A study of dominant and recessive white was also undertaken and the conclusions arrived at were that the plumage or hair of both varieties do not differ, chemically, to any appreciable extent, *i. e.*, the dominant whites do not possess a pigment which is lacking in the recessive whites, but that an inhibitory enzyme is probably present in the dominant whites which, acting as the determiner, prevents pigment formation, while the recessive whites have neither the power to form melanin nor the ability to inhibit its formation.

TABLE I.—*Percentage yields of ash-free melanin obtained from black wool by extraction with increasing strengths of alkali.*

	Acid-soluble pigment.	Acid-insoluble pigment.		Acid-soluble pigment.	Acid-insoluble pigment.
NaOH, 0.2 per cent...	8.10	1.36	NaOH, 10 per cent...	.....	2.43
NaOH, 1 per cent.....	.....	3.26	NaOH, 20 per cent...	.....	1.78
NaOH, 2.5 per cent...	.....	2.95	NaOH, 30 per cent...	.....	1.71
NaOH, 5 per cent.....	.....	3.62	NaOH, 50 per cent...	.....	1.56
NaOH, 6 per cent.....	.....	1.95	H_2SO_4, 25 per cent...	.....	2.00

TABLE II.—*Analytical data obtained by a study of the pigments isolated by the different methods.*

Method.	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen (by diff.).
	per cent.	*per cent.*	*per cent.*	*per cent.*	*per cent.*
0.2 per cent NaOH, acid soluble	52.60	7.28	13.52	1.33	25.25
0.2 per cent NaOH, acid insoluble	53.44	5.81	10.44	1.10	29.15
1 per cent NaOH	52.20	6.62	10.34	1.06	29.78
2.5 per cent NaOH	53.07	5.82	9 37	1.06	30.68
5 per cent NaOH	53 16	5.71	9.22	1.05	30.86
10 per cent NaOH	56.01	4.88	7.03	1.24	30.84
20 per cent NaOH	56.52	4.28	6.19	1.27	31.74
30 per cent NaOH	56.71	4.30	5 12	1.46	32.41
50 per cent NaOH	57.06	3.84	8.98	1.27	28.85
25 per cent H_2SO_4	57.81	4.40	5.50	1.75	30.52

HUMAN HEREDITY.

In connection with the eugenics section of the American Breeders' Association and its committees, the application of the new principles of heredity to man is making satisfactory progress. Mrs. Davenport and the Director have just completed a paper on "Skin-color in man," in which progress is made on the following points:

(*a*) It is shown that skin coloration of white races is not a blend, but segregates and follows the general law, first pointed out by us in the case of hair-color, that, in general, the skin-color of the children is not darker than

that of their darker parent. Consequently two blond parents have only blond offspring, but a blond and a brunet may have either blond or brunet children.

(*b*) It is shown that in crosses between negroes and Caucasians the same rule holds: that mulattoes produce "white" children, but (probably) rarely black, and that, consequently, the assumed blend of coloration is not a permanent thing.

(*c*) Intensive studies of about 30 albino families give every reason for concluding that albinism in man, in opposition to current opinion, is really inherited exactly as in rabbits and guinea-pigs. An explanation is given of the apparent departures from the rule for other mammals. New and relatively extensive evidence is given that the high consanguinity in the parentage of albinos that is to be expected actually occurs—that albinism is *prima facie* evidence of consanguineous marriages. From the evidence gained by the cooperation of the committees on feeble-mindedness, it appears that imbecility, insanity (of certain forms, at least), and epilepsy are inherited in like fashion, and that where both parents lack the factor for normal brain development all of their children will lack it also, and be defective.

The work on human heredity has grown to such proportions and its outlook is so vast that it became evident that the Director of this Department could not cope with it alone. Much assistance was needed. Fortunately, at an opportune moment, assistance was forthcoming. The Eugenics Record Office has been established in a place close by and placed under the control of your Director with funds for the maintenance of a superintendent, office assistants, and a number of field workers. The outlook for the development of this very practical offshoot of our work is bright.

EQUIPMENT AND CONSTRUCTION.

On January 11, 1910, the Institution purchased for the use of the Department 21 acres of land lying about a mile east of the station building. This is largely wooded. About 4 acres have been used during the present season for growing *Lychnis* in the sex experiment and for pedigreed beans. From about 4 acres in addition a hay crop was obtained. The land lies high and is otherwise favorably situated, but lacks means of irrigation which can be easily arranged for. The purchase provides for the natural expansion of the work of the Department for some time to come. It was made at an opportune time, in view of the rapid rise in the price of land, and gives great satisfaction to the Department.

During the winter an artificial cave was constructed, connected with the building at its northwest corner. The inside dimensions are 41 feet long, 8 feet wide, and 6.5 feet high. The top is 4 feet below the surface of the ground. The walls, roof, floor, partitions, and shelves are of concrete reinforced with one-fourth-inch steel rods. The cave is divided, by two partitions with iron doors, into three rooms, of which the first is separated from

the basement of the laboratory by a door of refrigerator construction. Each room contains two or three large tanks about 4 by 4 feet for fishes; two of the rooms contain a series of smaller tanks elevated 3 feet above the floor, for smaller aquatic animals, such as Crustacea. The bottom of each of the smaller tanks is sloping, affording a variable depth of water. Constantly running water from a flowing artesian well enters each compartment through ebonite cocks, and the overflow runs into the sand and gravel that forms the floor of the cave. No outlet pipe is possible, because the floor of the cave is below the level of high tide; the natural soil forms a dam to the influx of sea-water. After the concrete tanks were made it was found necessary to heat them and infiltrate with paraffine to prevent the formation of a limy acid that was fatal to the organisms. A shelf running above the tanks on one side affords room for jars containing terrestrial organisms. The cave is ventilated at each end and is provided with electric bulbs of ruby glass and also of clear glass. The cave opens into a dark basement room which has been provided with apparatus to test the light reaction of organisms.

In the early part of the fiscal year a chemical room was fitted up by partitioning off a portion of the north room on the first floor. All woodwork except the window trim was sheathed with asbestos board. A chemical table and hood were put in place. A gasolene gas-machine was installed, supplying not only the chemical room but also the six incubators, and is available for all the investigator's rooms.

Among other things a concrete wall 16 feet long was put up to hold back enough salt-water in the pond to make it possible to pump at any state of tide and to use in case of fire.

MAINTENANCE.

Pipes were reset in the greenhouse and the floor partly concreted; the wooden stable-floor was replaced by concrete, the hay-mow remodeled, sundry cases and trap-nests manufactured as required, and the lawns and paths maintained in fair order.

BIBLIOGRAPHY OF PUBLICATIONS RELATING TO WORK ACCOMPLISHED BY GRANTEES AND ASSOCIATES.

Under this heading it is sought to include the titles of all publications bearing upon work done under grants from the Carnegie Institution of Washington, exclusive of the regular publications. A list of the latter which have appeared during the year will be found in the President's Report (pp. 32–33). The following list has been made as complete as possible, and in some cases titles may be included which have only an indirect connection with grants from the Institution:

ACREE, S. F., and R. F. BRUNEL. On the salts of tautomeric compounds: Reactions of urazole salts with alkyl halides. (Amer. Chem. Jour., XLIII, pp. 505–553. June, 1910.)

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