With the improved techniques of field recording and of laboratory study it is of course desirable that in all future collecting only adequate and permanent recordings should be made. The limitations of transcription by hearing have been pointed out clearly by the phonophotographic analysis.

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# SPECIAL ARTICLES

## A LETHAL DWARF MUTATION IN THE RABBIT WITH STIGMATA OF ENDOCRINE ABNORMALITY

RECESSIVE dwarf mutations in the guinea pig and in the mouse have been described by Sollas[1] and by Snell,[2] respectively. Both of these mutants are viable, and carriers of the dwarf genes appear to be normal. The skeletal changes in the guinea pig suggest an achondroplastic dwarf, while according to Smith and MacDowell[3] the dwarf character in the mouse is due to a hereditary deficiency of the growth-promoting hormone of the pituitary.

Abnormally small or dwarf-like individuals are of frequent occurrence in the rabbit as familial characters but, as a rule, affected animals show no serious impairment of vitality or any other decided abnormality. A dwarf mutation has been encountered, however, among the progeny of a Polish rabbit which is of interest from the point of view of size inheritance, on the one hand, and the occurrence of pathological conditions in animals possessing the dwarf gene, on the other. This mutation appeared in the course of experiments which were being carried out for other purposes and the nature of the abnormality has not been determined with certainty, but the evidence obtained so far indicates that the condition is of endocrine and probably of pituitary origin.

The original male transmitting the dwarf gene has been mated with related and unrelated Polish females and with numerous unrelated females of various breeds. From the $F_1$ progeny thus obtained, $F_2$ and back-cross litters have been produced.

An analysis of birth weights shows that the $F_1$ progeny is divisible into a large and a small class of equal numbers (55 small, 56 large). The actual weights of these animals are influenced by the relative weights of parental stocks, but in general the ratio of the small to the large class is 4:5. In two instances, typical dwarfs occurred in $F_1$ litters. The $F_2$ progeny contains individuals of three classes with a birth weight ratio of approximately 1:2:3. The same result is obtained when certain $F_1$ females are back-crossed to the original male parent, while with other females the litters are of the $F_1$ type. The actual weights obtained for 56 young derived from parents both of which were known to produce dwarfs were 13.66, 31.55 and 46.86 grams. The number in each class was 15, 26 and 15, respectively. A slight excess in the weights for classes 2 and 3 may be attributed to the fact that animals of these classes are frequently fed before weights can be obtained, while those of class 1 are not. No correction is made in the values given.

Individuals of class 1 are non-viable dwarfs. As far as we have been able to determine by test matings, those of class 2 are transmitters of the dwarf gene, while those of class 3 are homozygous normals. The $F_1$ progeny is composed of animals corresponding genetically with those of classes 2 and 3.

The dwarfs of this stock are born alive and occasionally they are capable of nursing, but so far, none of them has lived longer than a few days. They are delicately formed and to outward appearance are fully developed except for the bones of the calvarium, which, as a rule, are incompletely calcified.

Other classes of young are apparently normal at birth, but they are subject to numerous abnormalities in early life and to a peculiar process of deterioration after full sexual maturity has been attained. The most evident of the early abnormalities is an affection of the bones, which is characterized by the resorption of calcium with the production of cranial defects, spontaneous fractures of the long bones and deformities due to bending, which indicate increased fragility, on the one hand, and softening or osteomalacia, on the other. This condition develops during the first few weeks of life. At the onset, animals of this type are well nourished, or even fat and pudgy, but in time growth is diminished or completely arrested and they are extremely sluggish. Death is apt to occur at this stage. Vitamin treatment is of little or no avail, but rapid improvement follows fostering and there is some recent evidence that irradiation with the Mazda CX lamp is beneficial. Animals that recover are active and vigorous, but they present a dwarfed or stunted appearance; they are, for a time, pot-bellied and their legs are deformed and shortened. After maturity has been reached, a secondary deterioration occurs in many animals which is characterized by loss of weight (20.0 to 30.0 per cent.), softening and erosion of the teeth and reproductive disorders.

These peculiarities appear to be limited to carriers of the dwarf gene or are more pronounced in animals of this class than in their normal litter mates, but the

[1] I. B. J. Sollas, *Rep. Evol. Com. Royal Soc.*, 5: 51, 1909.
[2] G. D. Snell, *Proc. Nat. Acad. Sci.*, 15: 733, 1929.
[3] P. E. Smith and E. C. MacDowell, *Anat. Rec.*, 50: 85, 1931.

connection, if any, between the dwarfing factors and those responsible for other abnormalities has not been determined. It will be necessary to observe, mark, rear and test large numbers of animals before these points can be settled.

The observations made on this group of animals point to an incomplete recessive mutation, which is characterized by a dwarfing effect and by functional disorders in both heterozygous and homozygous individuals. The reduction in size is of a measured order so that a unit size factor becomes operative in the determination of the weights of affected individuals in relation to the weights of normal members of the population. The unit factor is represented by a homozygous, lethal dwarf which is one third the weight of its normal sibs and one half the weight of its heterozygous sibs. It is possible that factors operating in this manner may be concerned in other types of size inheritance.

The combination of abnormalities presented suggests a primary pituitary disorder which affects both the acidophilic and the basophilic elements of the anterior pituitary with secondary disturbances of other endocrine glands.[4] This possibility is further supported by the occurrence in another group of rabbits of a hereditary condition which simulates over-function of the acromegalic type. This will be reported in another paper.

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[4] Harvey Cushing, *Harvey Lectures*, 28: 90, 1932–33.

## THE BIOLOGICAL AND CHEMICAL NOMENCLATURE FOR THE CAROTENOIDS

THE class of natural pigments known as carotenoids has attracted the attention of botanists, zoologists and chemists for nearly a century. The past decade has witnessed the nearly complete clarification of the chemical constitution and molecular configuration of almost all the known members of this class of substances. It is now definitely established that the true carotenoids, *i.e.*, those members which have the same number of carbon atoms as carotene are either hydrocarbons of definite configuration or alcohols or ketones of these same hydrocarbons. The hydrocarbons appear to fall into two groups, the carotenes, containing ionone rings and the lycopenes, aliphatic isomers of carotene. The existence of several isomeric carotenes has been established, but so far only one lycopene. The nomenclature now employed for the different carotenes, *i.e.*, α-, β-, etc., is fairly satisfactory both from a biological as well as a chemical standpoint. However, the nomenclature at present prevailing for the ketonic and alcoholic carotenoids is both unsatisfactory and also confusing.

According to the prevailing nomenclature for the alcoholic carotenoids it is necessary to choose between the following alternatives: (a) Retain the term xanthophyll as a term of historical value to designate the crystalline pigment mixture with the composition $C_{40}H_{56}O_2$, isolated by Willstätter[1] from green leaves; (b) employ the term xanthophyll in the future only in the plural, *i.e.*, xanthophylls, to designate the isomeric carotenoids having the composition $C_{40}H_{56}O_2$, analogous to the term carotenes for the isomeric carotenoids with the composition $C_{40}H_{56}$, and employ only specific names for various xanthophylls as isolated, as has already been done in the case of lutein and zeaxanthin, the two major and minor fractions so far isolated from the crystalline mixture from leaves, formerly called xanthophyll; new specific names could be given for any additional isomers which may be discovered in the future; (c) employ the old term xanthophyll for the major component of the crystalline mixture from green leaves, and give new names to the various isomers as isolated or discovered, as has been done in the case of the carotenoid zeaxanthin; this alternative would require the abandonment of the term lutein, the name given by Kuhn to the major xanthophyll-like pigment of green leaves.

In the main the first and second alternatives are favored by Kuhn[2] and the third alternative by Karrer.[3] The situation is analogous to that which developed when it became definitely known that vitamin B is composed of more than one component. In view of the fact that the discovery of isomeric forms of carotene was followed by the adoption of the more logical scheme of designating them as α- β- γ- and δ-carotene, respectively, instead of giving them specific names, and furthermore in view of the fact that xanthophyll (lutein) appears to be structurally related to α-carotene and zeaxanthin to β-carotene (as pointed out by Karrer[4]), another, more logical alternative of the present systems of xanthophyll nomenclature would be as follows: Employ the term xanthophyll as a generic term for the $C_{40}H_{56}O_2$ carotenoids, analogous to the generic term carotene and designate the specific xanthophylls as α-, β-, etc., to indicate their structural relationship to the corresponding α-, β-, etc., carotenes as their structure is elucidated. The "lutein" of Kuhn and the "xantho-

[1] R. Willstätter and W. Mieg, *Liebigs Ann.*, 355: 1, 1907.

[2] R. Kuhn, A. Winterstein and E. Lederer, *Z. f. physiol. Chem.*, 197: 141, 1931.

[3] P. Karrer, H. Wehrli and A. Helfenstein, *Helv. chim. Acta*, 13: 268, 1930.

[4] P. Karrer and H. Wehrli, *Nova Acta Leopoldina*, n. s., 1: 175, 1933.