STUDIES IN HUMAN INHERITANCE. IX.

The Inheritance of Taste Deficiency in Man.

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The establishment of linkage in man has long been one of the objectives in the writer's laboratory. To this end any unit character in man which occurs with reasonable frequency in the general population must be carefully analyzed and its unit-character nature established or disproven beyond question.

Among the most recently discovered of the unit characters in man is the so-called "taste blindness" or taste deficiency. The hereditary nature of this trait was established in 1931 by Snyder with 100 families, and by Blakeslee and Salmon with 47 families, following Fox's original discovery that taste deficiency actually existed. The final proof of the unit-character nature of any human hereditary factor, however, must lie in the mathematical analysis of the data, since we are unable to distinguish accurately between heterozygous and homozygous dominants in man. We are therefore unable in this particular instance to predict directly the ratios of tasters and non-tasters among the offspring of various matings.

Such predictions can be made, however, on a frequency basis. Since in our linkage studies it is essential for us to be certain of the unit-character nature of the taste deficiency, there is presented here the statistical analysis of the inheritance of taste deficiency among 800 families which have been studied at the Genetics Laboratories of the Ohio State University.

To Dr. Fox, of the DuPont Laboratories, we owe the accidental discovery that a small crystal of para-ethoxy-phenyl-thio-carbamide placed on the back of the tongue may produce one of two characteristic reactions. To some persons it will give an extremely bitter sensation, somewhat like quinine. To others no bitter taste at all will be apparent. The reaction is clear and distinct, and practically no doubtful cases are encountered. Since phenyl-thio-carbamide reacts the same as para-ethoxy-phenyl-thio-carbamide, we have used the former substance as being more readily available to us.

The results of our study of 800 families are given in Table I. It will be noted that the taste deficiency appears to be a simple recessive character. Where neither parent tastes the compound, practically none of the children do. . The small fraction of a percent exceptions may be due to illegitimacies, adoptions, errors in technic resulting from the fact that the phenomenon is a subjective one entirely, or to the possible taste-suppressing effect of some environmental agent of which we know nothing at present. We do know that acidity or alkalinity of the mouth, age, sex, and other tested variables apparently have no effect upon this taste deficiency.

TABLE I.

SUMMARY OF 800 FAMILIES STUDIED FOR INHERITANCE OF TASTE DEFICIENCY FOR PHENYL-THIO-CARBAMIDE, SHOWING OBSERVED AND CALCULATED PROPORTIONS OF TASTERS AND NON-TASTERS IN THE OFFSPRING OF THE VARIOUS TYPES OF MATINGS. TOTAL FOR 3,643 PARENTS AND CHILDREN: TASTERS, 70.2%; NON-TASTERS, 29.8%.

MATINGS	CHILDREN	
	TASTERS	NON-TASTERS
Taste × Taste 425	929 obs. 0.877 ± .007 calc. 0.876 ± .001 dev. 0.001 ± .007	130 0.123 ± .007 0.124 ± .001 0.001 ± .007
Taste × Taste deficient 289	483 obs. 0.634 ± .012 calc. 0.646 ± .002 dev. 0.012 ± .012	278 0.366 ± .012 0.354 ± .002 0.012 ± .012
Taste deficient × Taste deficient 86	5 obs. 0.021 calc. 0.000 dev. 0.021	218 0.979 1.000 0.021

Where both parents taste, the ratio of tasters to non-tasters in the offspring is about 7:1. This of course varies from the familiar 3:1 because a certain proportion of the tasting parents will be homozygous, producing all tasting children. The expected ratio of tasters and non-tasters among the offspring can only be calculated by first determining the frequencies of the allelomorphic factors in the general population. The same applies to families in which only one parent tastes, in which the familiar back-cross ratio of 1:1 will be changed due to the fact that some of the tasters will be homozygous.

The determination of the frequencies of the genes, the expected proportions of tasting and non-tasting children in various matings, and the consequent proof of the unit-character nature of the deficiency are given below.

Let us assume the taste deficiency to be a simple recessive character, designating the two allelomorphs as T and t, respectively.

Let p = frequency of T
and q = frequency of t.
Then p + q = 1. It is readily seen that

$$p^2 + 2\,pq = \text{tasters (A)}$$
$$q^2 = \text{non-tasters (B)}$$
$$q = \sqrt{B}$$
$$p = 1 - \sqrt{B}$$

In this case p = .445, q = .545

Since p^2 = homozygous tasters
and $2pq$ = heterozygous tasters,

$$\frac{p^2}{p^2 + 2\,pq} = \text{proportion of tasters which are homozygous}$$

$$\frac{2\,pq}{p^2 + 2\,pq} = \text{proportion of tasters which are heterozygous.}$$

From this it is easy to calculate the relative frequencies of matings of homozygous with homozygous, homozygous with heterozygous, and heterozygous with heterozygous, and consequently the proportion of recessive, non-tasting children to be expected from such matings. Since the only recessive children so produced will be one quarter of the offspring of heterozygous with heterozygous, a formula for this is readily derived. Similarly the calculation can be made for matings of tasters with non-tasters, where the recessive children will be one half of the offspring of matings of heterozygous with recessive. These formulae may be derived as follows:

Let R = proportion of recessive offspring to be expected from matings of dominant with dominant, and

S = proportion of recessive offspring to be expected from matings of dominant with recessive.

$$\text{Then } R = 1/4 \left(\frac{2\,pq}{p^2 + 2\,pq}\right)^2 = \left(\frac{q}{p + 2\,q}\right)^2$$

$$\text{and } S = 1/2 \left(\frac{2\,pq}{p^2 + 2\,pq}\right) = \frac{q}{p + 2\,q}$$

Since the frequencies p and q will vary for different samplings, the figures obtained from these formulae will of course vary, not only for other mutations occurring with different frequencies, but even for the same mutation in different races or populations. The frequencies of the allelomorphs must therefore be determined anew for each mutation of each new race.

By referring to Table I it can be seen that the deviations of the observed proportions from the expected proportions are well within their probable errors. The unit-character nature of the taste deficiency is thus amply proven.

The inheritance of taste deficiencies for still other compounds has been investigated in our laboratory and the results of these studies will soon be in press.

The probable errors of the observed and calculated proportions as given in Table I were obtained as follows:

$$\text{For the observed values, P. E.} = .6745 \sqrt{\frac{ab}{N}}$$

Where a = observed proportion of tasting children, b = observed proportion of non-tasting children, and N = number of offspring, for each type of mating.

For the calculated values, the probable error must be specifically derived. The complete derivation of these formulae is being given in a paper on the epistatic relationships of two types of taste deficiency, which we are now preparing for publication in "Genetics." For the present merely the resultant formulae are given. These are as follows:

$$\text{P. E.}\left(\frac{q}{p+2q}\right)^2 = \frac{.6745\ (1-\sqrt{b})}{4\ N\ (1+\sqrt{b})^2} \sqrt{\frac{16\ Nb}{1-b} - 1 - \frac{(1-2\sqrt{b})^2}{(1+\sqrt{b})^2} + \frac{2\ (1-2\sqrt{b})}{1+\sqrt{b}}}$$

$$\text{P. E.}\ \frac{q}{p+2q} = \frac{.6745}{8N\ (1+\sqrt{b})} \sqrt{\frac{16N\ (1-\sqrt{b})}{1+\sqrt{b}} - \frac{(1-\sqrt{b})^2}{b} + \frac{4\ (1-\sqrt{b})^2}{(1+\sqrt{b})\sqrt{b}} - \frac{4\ (1-\sqrt{b})^2}{(1+\sqrt{b})^2}}$$

Where b = the true value of the proportion of non-tasters in the population, which in practise must be taken as B, the observed value from the complete sample of individuals tested. N = total number of individuals tested.

A word may be added as to the inheritance of taste deficiency to di-ortho-tolyl-thio-carbamide, another compound investigated. Approximately 35% of the individuals tested could taste both compounds, an equal number tasted only phenyl-thio-carbamide, and about 30% could not taste either compound. Moreover, in many families where neither parent tasted the second compound, some of the offspring did. This indicates an epistatic relationship of the two factors concerned. The analysis of this phenomenon, as well as the derivation of all formulae concerned, will be given in the previously mentioned forthcoming publication.

BIBLIOGRAPHY.

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Fox, A. L. Science 73, suppl.: 14, 1931.
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An Introduction to Physical Science.

The title of this book, "Introduction to Physical Science," suggests that it might give a unified approach to the study of both physics and chemistry. Such, however, is not the case unless one concedes that physics is to be regarded as prerequisite to the study of chemistry and in that sense becomes an introduction to the study of chemistry. The intent of the book, however, is to introduce the student to the methods of scientific thinking as found in classical and modern physics and to acquaint him with some of the results of modern research in physics. The author recognizes in the preface the difficulty of compressing into such a limited space the necessary fundamental training for an appreciation of the developments which have characterized the last quarter of a century of physics and he is in my opinion correct in supposing that an introductory course in physics must include a survey of these newer developments as well as a consideration of the principles of classical physics.

In the selection and arrangement of the subject matter the author has been quite independent of the traditional order of presentation as found in most text-books of physics and has undertaken to present the essential principles of mechanics, heat, sound, light and classical electricity in sufficient detail to make it possible to understand selected topics from modern physics. Such topics as cathode rays, x-rays and positive rays, radioactivity, electric oscillations, relativity and wave mechanics are considered in somewhat greater detail than in most college text-books of physics. There is also an interesting chapter on cosmic physics. The chapter on wave mechanics and also the chapter on relativity seem to me to be too difficult for the type of student for whom the book was intended. The book seems clearly written, but many students and instructors will miss those more concrete illustrations and applications of physical principles which tend to make physical reasoning intimate and vital.

This book should serve as an excellent introduction to more advanced work in physics.—ALPHEUS W. SMITH.

Introduction to Physical Science, by Carl W. Miller. New York, John Wiley and Sons, Inc., 1932. $3.00.