

**Heredity of skin pigmentation in man / Gertrude C. Davenport and Charles B. Davenport.**

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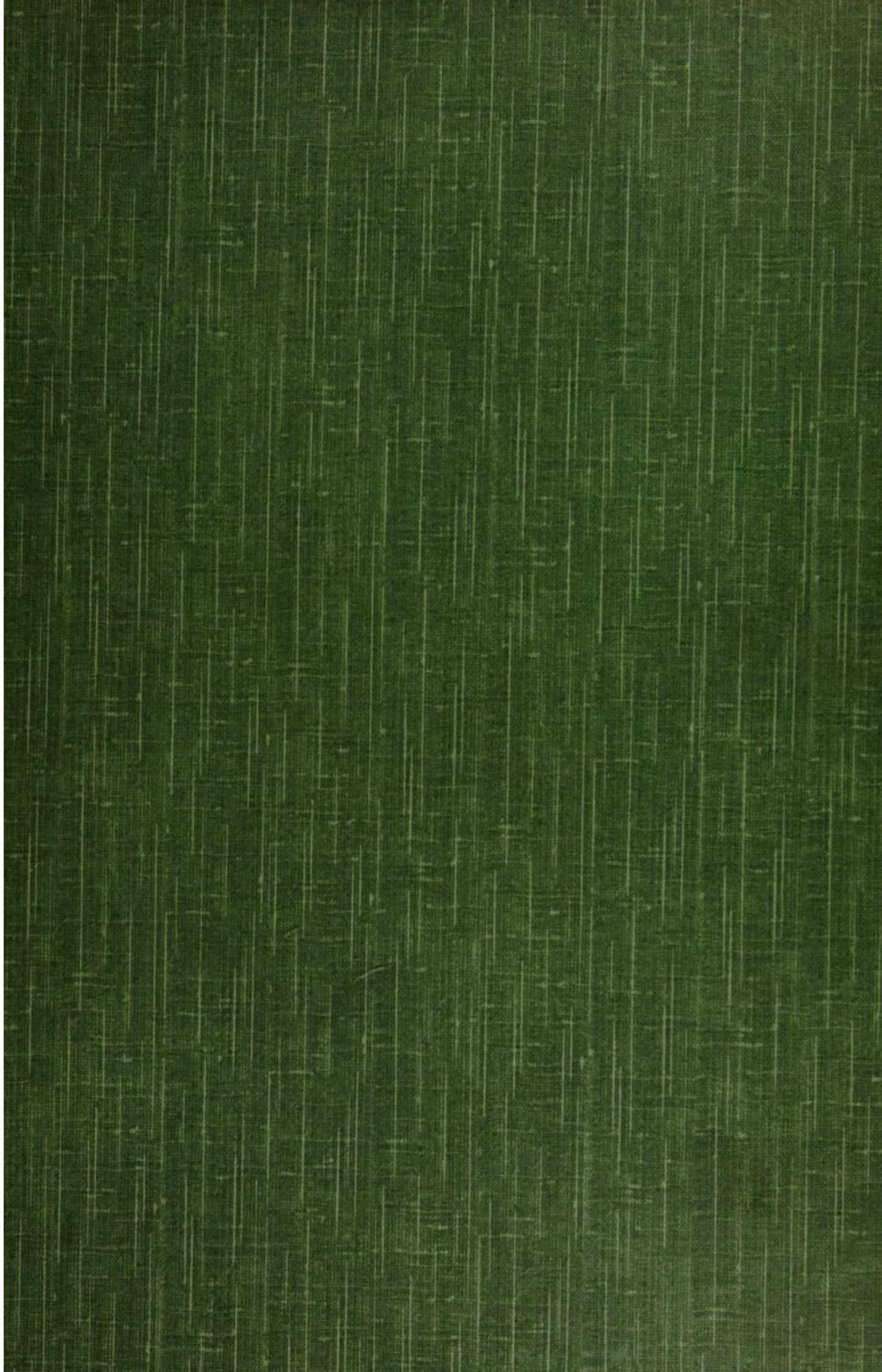
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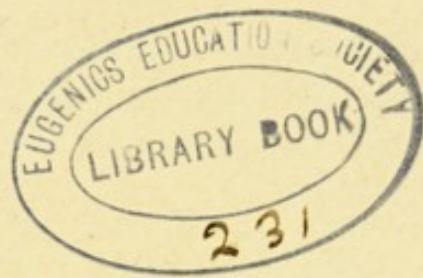
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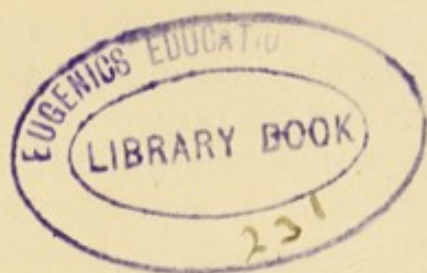
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## HEREDITY OF SKIN PIGMENTATION IN MAN

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## A. INTRODUCTION

IN the modern discussions on heredity there are those who, without undertaking experiments themselves, assume an attitude of hostility to the work of the experimental investigators of heredity and have taken a last stand in the phenomena of inheritance of human skin color. Pearson (1909), who has urged that the collection of extensive statistics is a prerequisite of deductions in the field of heredity, has actually published the non-quantitative impressions of a medical correspondent in the West Indies concerning the method of inheritance of skin color in negro  $\times$  white crosses and concludes that "in view of the opinion" cited "the suggestion that skin color 'mendelizes' should not be vaguely made." He thinks his correspondent's "views" establish "the main point" "that the segregation in the second generation to pure white or black skins does not occur." On the other hand, a writer in the *Mendel Journal*, No. 1, has also a correspondent in the zone of intermingling whose observations indicate partial, if not complete, segregation. Altogether the subject seems to deserve a more extended, less biased treatment.

## B. ANATOMICAL RELATIONS AND KINDS OF SKIN PIGMENT

The pigment of the skin, at least the melanic pigment which alone concerns us here, has its basis in the fine granules lying in the deeper layers of the stratum mucosum of the skin. The granules themselves are of mesodermal origin and the pigment cells—melanoblasts—seem to penetrate from below into the mucosa. Ehrmann (1896, Taf. XI, Fig. 24; Taf. IX, Fig. 19) has figured these melanoblasts in sections of the skin, both of brunets and of negroes. They are much the more abundant in negroes. The anatomical facts are that black skin pigment is made up of many discontinuous elements—the pigment granules. But the mosaic is so fine that, to the naked eye, the color is apparently uniform and a

unit. The anatomical differences between the skin of a brunet and a blond suggest that the grades of color may be due to more or fewer of the elements of the mosaic, and that would seem to be a discontinuous variation; but, on the other hand, since these granules increase in size and number during melanogenesis the difference in skin color between a negro, a mulatto, a brunet and a blond may be merely a difference in the point at which the essential melanogenetic process is stopped.

Besides the melanic pigment a yellow-red pigment is often present in skins of all races. This pigment is commonly considered a lipochrome and, in hair at least, is quite different in structure from melanic pigment.

### C. HEREDITY OF SKIN PIGMENT IN TYPICAL CAUCASIANS

The data for the study of inheritance in ordinary skin pigment of whites were obtained from two sets of inquiries. The first set was supplied chiefly by school children on cards 127 mm. by 203 mm., which called also for data on the form and color of hair and the color of eyes. The second set was derived from the Family Records filled out for over 300 families, largely by adult persons, including many men in professional life, genealogists and students, as well as farmers and men of affairs.

The directions as to use of terms were necessarily brief. In the first set they ran as follows: "4. Natural complexion or skin color. Use terms as follows: blond, brunet, intermediate, yellowish-white, olive-yellow, dark yellow-brown (dark olive), copper colored, chocolate, sooty black, full black, three fourths black, one half black, one fourth black." I willingly grant that terms are poor means of expressing degrees and quality of skin pigment. Nevertheless, blond and brunet are understood widely in the same sense and it was hoped that "intermediate" would be freely used in doubtful cases. This expectation was not fully justified, since of 1,275 offspring recorded only 513, or 40 per cent. of all, were re-



corded as of "intermediate" color, while 460, or 36 per cent., were given as blond and 302, or 24 per cent., as brunet. In the "Family Records" the nomenclature suggested was: "Complexion or skin color: *f* (fair), *i* (intermediate), *br* (brunet), *d.br* (dark brown)," etc. The returns in the family records are for 1,098 children, of whom 326, or about 29.5 per cent., are given as of "intermediate" color; 635, or 58 per cent., as fair, and 137, or about 12.5 per cent., as brunet. Evidently "blond" is used in a more restricted sense than "fair" by the population who filled out the blanks in question. All records together are of 2,394 children. Of these there are 843 intermediates, or 35.2 per cent., 1,129 "blond" or "fair," or 47.2 per cent.; and 422 "brunet," or 17.6 per cent. We thus see that only a little over one third of the children are recorded as having an intermediate skin color, while to nearly half are assigned the term "blond" or "fair." The "brunets" are a relatively small proportion of all children in the families under consideration. "Blond" and "fair" have certainly been used too broadly and this must affect somewhat the clearness of our results. However, taking the returns as they come, we shall be able to deduce certain conclusions of importance.

In the following tables we have entered the grandparental data as given. We have, however, not used in the statistics the grandparents as parents, not only because in that case only a single child of the family is known, but especially, because the order of accuracy of the grandparental data is, on the whole, inferior to that of the parents and children. By and large, the grandparental data are highly suggestive, but exceptional cases must be lightly weighted.

(a) *Blond* × *Blond* (Tables IA, IB).—From two "blond" or "fair" parents 526 children were altogether recorded, of which 472, or 89.7 per cent., were "blond," 40, or 7.6 per cent., were "intermediate," and 14, or 2.7 per cent., were "brunet." Owing to the fact that the number of brunets given is very small and because it

TABLE IA  
COMPLEXION: BLOND X BLOND

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Blond.	Inter.	Brun.						
Bry.	3		1	bl	bl	bl	br	bl	bl
Bug.	2			bl	bl	bl	bl	i	bl
Cal.	4			bl	bl	—	—	—	—
Cap.	1	1		bl	bl	i	i	i	i
Car.	3	2		bl	bl	bl	—	br	—
Cla.	1			bl	bl	bl	bl	i	bl
Deg.]	2			bl	bl	—	i	br	bl
Edw.	2	1		bl	bl	—	—	—	—
Eli.	1			bl	bl	br	bl	br	bl
Fay.	2			bl	bl	bl	bl	br	bl
Fir.	4			bl	bl	i	bl	bl	i
Fou.	1			bl	bl	i	i	bl	i
Fue.	3			bl	bl	bl	bl	bl	bl
Gra.	1	1		bl	bl	bl	i	i	bl
Hal.—A	2	2		bl	bl	br	i	bl	bl
Hed.—D	6			bl	bl	bl	bl	bl	bl
How.—C	6	1		bl	bl	bl	bl	bl	bl
Ker.	3	1		bl	bl	bl	bl	i	bl
Klo.	4			bl	bl	bl	bl	—	bl
Koo.	1		1	bl	bl	bl	bl	bl	bl
Kra.	3			bl	bl	bl	bl	bl	bl
Lav.	3			bl	bl	bl	bl	bl	bl
Len.	6			bl	bl	br	br	br	br
Lit.—B.	3			bl	bl	bl	bl	bl	i
McC.	2			bl	bl	bl	—	bl	bl
McG.	7		1	bl	bl	bl	bl	bl	bl
Mye.	4			bl	bl	bl	bl	bl	bl
Pad.	5			bl	bl	i	bl	—	—
Pla.	6			bl	bl	bl	bl	bl	bl
Reg.	6			bl	bl	bl	i	bl	bl
Sha.	6			bl	bl	bl	bl	i	bl
Sim.	3		1	bl	bl	bl	bl	bl	—
Ste.—F	2			bl	bl	bl	bl	bl	bl
Ste.—G	1	1		bl	bl	br	bl	br	—
Sto.—D	2			bl	bl	bl	bl	i	br
Sto.—E	3			bl	bl	i	i	i	i
Str.—A	5			bl	bl	i	bl	bl	i
Str.—E	2			bl	bl	bl	bl	bl	i
Totals (135)	121	10	4						

38 families.

seemed likely that the rule established for hair color would hold here (namely, that two light parents have no dark children), I asked for further details from all families returning dark children of two blond parents. Only two replies were received. In the case of a family returning two brunets and four blonds from two blond parents the new record gave the father as brunet instead of blond. In the case of the second family said to con-

TABLE IB  
COMPLEXION: FAIR X FAIR

Family Name.	Children			M.	F.	MM.	MF.	FM.	FF.
	Fair.	Inter.	Brun.						
Bar—4	4			f	f	f	f	f	f
Bel.—1	2	2		f	f	f	f	f	br
Bet.—1	6	1		f	f	—	f	i	f
Bio.—1	6			f	f	f	f	f	f
Bli.—1	6			f	f	f	f	f	f
Bra.—3	7			f	f	f?	f	f	dk
Bre.—2	3			f	f	f	f	f	f
Bro.—2	3			f	f	—	i	—	—
Bro.—8	3			f	f	—	—	—	—
Bro.—10	5	1		f	f	i	f	f	f
Bur.—1	4			f	f	f	f	f	f
Bus.—1	5			f	f	—	—	—	—
Che.—1	2			f	f	f	f	f	f
Coc.—1	2	3		f	f	f	f	f	f
Cog.—2	4		1	f	f	f	i	f	f
Com.	4			f	f	i	—	i	—
Con.	6			f	f	f	f	i	f
Cro.—1	5			f	f	f	f	f	f
Dol.—2	4			f	f	f	f	br	f
Elk.—1	4			f	f	f	f	br	f
Gie.	6			f	f	—	—	—	—
God.	5			f	f	br	f	f	i
Goo.	5			f	f	br	i	f	f
Had.—2	2	1		f	f	f	f	f	i
Hit.	4			f	f	f	f	f	f
Hit.	4	1		f	f	f	f	f	f
How.—1	6			f	f	f	f	f	f
How.—2	2			f	f	f	i	i	i
Jac.—2	3			f	f	f	f	f	f
Joh.—1	5	1		f	f	f	f	f	br
Jon.—2	2	1		f	f	f	i	br	f
Key.—1	4			f	f	f	f	f	f
Kir.—1	11			f	f	f	f	f	f
Klo.	4			f	f	f	f	—	f
Kor.	4	1		f	f	f	—	—	—
Kra.	3			f	f	i	f	f	f
Lan.	3			f	f	—	i	i	f
Lar.	9			f	f	f	f	f	f
Len.	6			f	f	br	i	f	f
Lit.	7			f	f	f	f	f	f
Mar.	5			f	f	f	f	f	f
Mar.	2			f	f	f	br	br	f
McC	10			f	f	f	f	f	f
Mey.—3	3			f	f	br	f	f	f
Obi.	10			f	f	f	f	f	f
Ord.—1	3			f	f	i	f	i	f
Par.	2			f	f	f	br	f	br
Pec.	3			f	f	f	f	f	f
Per.	4			f	f	f	i	f	i
Pic.—1	1	1		f	f	f	i	br	f
Ran.	2		1	f	f	—	—	f	br
Ran	2	1	1	f	f	br	f	f	f
Rec.	3	1		f	f	br	f	—	—
Rid.	3			f	f	—	br	i	f
Roe	3	1		f	f	f	f	f	i

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Fair.	Inter.	Brun.						
Row.	8			f	f	i	i	f	f
Rud.	9			f	f	br	f	f	f
Sch.	10			f	f	f	f	f	f
Sco.—2	6			f	f	br	f	f	f
She.—2	3			f	f	f	f	f	f
Shi.—1	2			f	f	f	i	f	i
Sim.	4			f	f	br	f	f	f
Smi.—1	2	1		f	f	i	i	—	i
Spa.	2	4	1	f	f	br	f	f	—
Str.—2	4	2		f	f	i	f	f	i
Sve.	6			f	f	br	f	f	f
Tau.—2	3	1		f	f	f	—	i	i
Tud.—1	3			f	f	f	f	f	f
Vel.	9	1		f	f	f	f	i	f
Ver.	5			f	f	f	f	f	f
Wan.	3			f	f	i	f	f	i
War.—1	3		1	f	f	br	f	br	br
Wes.	4			f	f	br	f	f	f
Wha.—1	9			f	f	f	f	f	f
Whi.—1	3			f	f	f	f	f	f
Win.	7			f	f	f	f	—	—
Wof.	7			f	f	f	f	f	f
Totals (378)	348	25	5						

77 families.

sist of two blond, one intermediate and one brunet offspring, the new record gave the mother as intermediate instead of blond, and the brunet child as light brunet or intermediate, but somewhat darker than the mother. These two families and a third (which is inaccessible) comprising five blonds and four brunets, were therefore struck out from the blond  $\times$  blond table, leaving only four brunets, or about 3 per cent., among the 135 offspring, recorded in Table IA. Tables IA and IB give 9 brunets among 513 children, or 1.75 per cent. Keeping in mind the probability of occasional blunders on the part of the recorders, it seems doubtful if these nine cases are properly included. The conclusion seems justified that *when both parents have blond complexion or fair skin all of their children will have a similar fair skin.*

(b) *Brunet  $\times$  Blond (fair)* (Table II).—The offspring of dark by light skin color is of importance because it should throw additional light on the question of dominance, if any. The families of two such parents are

TABLE II  
COMPLEXION: BLOND X BRUNET

Family Name.	Blond.	Inter.	Brun.	M.	F.	MM.	MF.	FM	FF.	Blond	Inter.	Brun.
And.	10			br	bl	br	lt. blo	bl	bl			
Bex.—1	2		2	br	f	f	f	f	i			
Bin.—1	1	1	1	f	br	br	f	br	br			
Boh.—2	2		1	br	f	f	f	br	i			
Boy.—1	4	2	1	f	br	br	f	f	f			
Bra.—3	5		3	br	bl	br	br	br	br			
Bro.—C	3	1	3	br	bl	br	br	br	i			
Bro.—5	3	2		br	f	—	—	—	—			
Bul.				br	bl	bl	br	bl	bl		2	
Bur.—2	3	1		f	br	f	f	br	br			
Byn.—1	1		1	br	f	br	f	f	f			
Car.—B				br	bl	br	i	bl	i		1	4
Car.—1	2	2		br	f	i	br	f	f			
Cas.	2			br	bl	bl	br	bl	br			
Cla.—1				br	f	br	i	f	i		2	
Clo.	1			bl	br	i	i	br	br			
Cor.	4	2	2	br	f	br	i	f	f			
Coz.	4	1		br	bl	i	br	br	br			
Cro.	3			br	bl	i	i	i	bl			
Cur.				br	bl	bl	br	bl	i			4
Cuw.	1	1	1	bl	br	i	bl	br	br			
Dig.—A	2	2	1	br	bl	—	—	—	—			
Doo.				bl	br	i	br	br	bl		1	4
Dra.	1	1		br	bl	br	i	i	i			
Dye.	2	2	1	bl	br	bl	i	br	br			
Edw.	3		2	br	f	i	f	f	f			
Edw.	4	2	2	f	br	f	i	y	br			
Eld.	3		1	f	br	f	f	br	br			
Eve.	4		1	f	br	f	f	f	i			
Fal.	5	1	1	bl	br	bl	bl	bl	bl			
Gla.	1		2	br	f	br	br	br	f			
Gla.—B	3	1	3	br	bl	bl	br	bl	i			
Goe.	1	1		f	br	br	br	br	br			
Gre.—E	1		2	bl	br	br	br	br	br			
Gri.	5	1	1	br	bl	bl	i	bl	br			
Hag.				br	f	f	br	—	—		4	
Hal.—E				br	bl	br	br	br	bl			5
Han.—1				br	f	br	br	f	f			2
Har.—D	1		1	bl	br	bl	br	br	br			
Hof.	4	1		bl	br	bl	br	br	br			
Hom.—B	4		2	bl	br	bl	bl	—	—			
Hur.	2		2	br	f	br	f	f	f			
Hyd.—1	4	1	1	br	f	f	br	f	br			
Jal.	1		4	br	f	f	br	f	f			
Jem.				br	bl	bl	br	br	bl		2	1
Jen.	1	2	2	br	f	i	br	f	—			
Jon.—B	3		3	bl	br	bl	bl	br	bl			
Jon.—1	2	1		d.br	f	i	i	br	f			
Jon.—3				f	d.br	f	f	br	br		3	1
Koc.—1	1	3	8	br	f	br	i	f	f			
Koc.—2				bl	br	bl	i	i	br		4	1
Lot.—A	3		2	br	bl	br	br	br	br			
Lym.—1				br	bl	br	br	br	bl			3
Lym.—2	3			f	br	i	f	i	i			
Mai	4	3	1	f	br	i	f	br	f			

Family Name.	Blond.	Inter.	Brun.	M.	F.	MM.	MF.	FM.	FF.	Blond.	Inter.	Brun.
Mat.	2			bl	br	br	br	bl	br			
McC.	5			br	f	br	br	f	br			
Mil.	3	2		br	bl	bl	—	bl	i			
Mil.—B	2		4	bl	br	bl	bl	br	br			2
Moo.				br	bl	i	br	i	i		2	
Owe.—1				br	f	f	—	—	—		2	
Par.	2	2	2	f	br	i	f	f	br			
Pat.				br	bl	br	i	br	br		1	3
Pre.	3	2	1	br	bl	i	br	bl	br			
Red.	2			br	bl	br	i	bl	bl			
Rei.—1	2	2	2	br	f	i	f	d.br	f			
Rel.	1		2	br	bl	—	—	—	—			
Ril.	3	1	2	bl	br	i	bl	i	i			
Sca.	3		1	bl	br	bl	bl	bl	br			
Smi.—E				br	bl	bl	—	—	—		4	
Spr.	2		2	bl	br	—	—	—	dark			
Ste.—C	2		3	bl	br	i	bl	br	i			
Ste.—2	2			br	f	f	f	f	f			
Str.—D	2			bl	br	i	br	br	bl			
Syk.	6	1	1	bl	br	—	—	br	br			
Tat.	5		1	br	bl	br	br	bl	bl		2	1
Van.—1				br	f	f	br	f	i			
Ven.—1	4	1		f	br	i	i	br	br			
Vos.	1	2		bl	br	i	i	br	br			
War.—A	1		1	br	bl	br	i	i	i			
Wen.	4	2	2	br	f	f	—	i	f			
Whi.				f	v.br	f	v.br	f	v.br		2	
Whi.	2	4	4	f	br	f	f	br	f			
Whi.—3	3	2	2	f	br	f	i	f	br			
Wil.	2		2	bl	br	i	bl	br	br			
Wol.	2	1	1	f	br	f	d.br	i	f			
Wor.	3	1		bl	br	bl	br	—	—			
Wyb.	4			br	f	i	i	f	f			
Total (342)	193	58	91						(60)	0	30	31

Total: 88 families. 70 families. *v.br*, very brown. 18 families.

given in Table II, and are divided into two classes, viz., those containing blond offspring, on the left side of the table, and those containing none, on the right side. The division is made in accordance with the hypothesis that "brunet" is dominant to "blond" and that the brunets may be of two sorts, either duplex or simplex, in respect to the pigmentation character. If the pigmentation factor of the dark parent is duplex no blonds are to be expected, but if the dark parent is simplex in pigmentation half of the children will have little or no black skin-pigment. By hypothesis the simplex parents should be about twice as numerous as the duplex. In Table II there are 70 families with blond children to 18 without

blonds. Some of the latter are doubtless without blonds *by chance*, owing to the small number in the family, just as there are 30 families in the entire 88 without brunet offspring or 39 without intermediates. That *all* of the families without blonds are not so by chance is probable from the following considerations: (*a*) blonds are almost (11:12.8) as numerous as the other two classes together yet the latter are *both* absent in the offspring of only eleven families; (*b*) there are more large families that are blondless than that are without brunets and intermediates, and when a large family is without offspring of a particular class the result is less probably due to chance. Finally, owing to the fact that the development of potential pigment is frequently retarded, some of the families with "blond" offspring would later be without blonds. We may conclude, then, that some of the blondless fraternities are so because all of their members have the determiner for skin pigmentation and, consequently, in the brunet  $\times$  blond matings some of the brunet parents are duplex in skin pigment. But the offspring of these duplex parents are not all alike; half of them are "intermediate" and the remainder "brunet." This result suggests that brunets may carry the "intermediate" grade of skin pigmentation as a hidden—hypostatic—factor.

In the families containing blond offspring, expectation, on the hypothesis of segregation, is that half of the offspring shall be blond and half pigmented in full or intermediate grade. Actually blonds are to non-blonds as 193:149 or as 1.3:1. The excess of blonds suggests that some of them are immature and potentially pigmented, the families really belonging to the right hand side of the table.

(*c*) *Brunet*  $\times$  *Brunet* (Table III).—When both parents are brunets there may, on the segregation theory, be two classes of families, namely, a class in which both parents produce germ-cells without the pigment determiner and a class in which at least one parent produces no such germ-cells. In the former case only are blond

TABLE III  
COMPLEXION: BRUNET × BRUNET

Family Name.	Blond.	Inter.	Brun.	M.	F.	MM.	MF.	FM.	FF.	Blond.	Inter.	Brun.
Ait.—1	3		1	br	br	f	br	f	f			
Alt.	1		4	br	br	bl	bl	br	—			
Arn.—2				br	br	br	i	br	i	2		1
Bal.—3	1		4	br	br	f	br	i	br			
Ban.	1	1	1	br	br	i	br	br	br			
Bay.				br	br	br	i	br	br	1		4
Blo.—1				br	br	—	br	br	—	3		2
Bro.—B	2		1	br	br	br	br	br	i			
Bu.	1		1	br	br	br	bl	—	br			
Can.				br	br	br	br	br	bl	2		
Cla.—D	2	1	4	br	br	br	br	lt	lt			
Col.—D	2		2	br	br	i	br	i	br			
Eni.				br	br	i	br	br	br			3
Fie.	3	1	1	br	br	i	br	br	i			3
Fis.				br	br	br	br	br	—			
Gim	1		2	dk	dk	f	dk	dk	dk			
Gre.—C	1		4	br	br	br	—	i	—			
Hen.				br	br	br	br	br	br			3
Hen.				br	br	br	i	br	—	1		5
Jac.—1	2		1	br	br	br	f	i	f			
Jor.—2	1	1	1	br	br	—	—	br	br			
Kay.				br	br	br	br	i	br	2		2
Kel.	4		3	br	br	br	f	br	f			
Kil.	2	1		br	br	i	—	—	—			
Kub.				br	br	br	br	bl	br	1		2
Lan.	1	2		br?	br?	bl	bl	bl	bl			
Lan.	2		2	br	br	br	br	br	br			
McB.				br	br	br	br	br	br			5
McC.	2		1	br	br	bl	br	—	—			
Mel.	2		3	br	br	i	f	br	br			
Mor.—A				br	br	i	i	br	br			2
Par.—B				dk	dk	i	br	br	br	1		2
Pib.—1				br	br	br	br	br	br			7
Pil.—2				br	br	br	br	i	br			5
Pon.	2	1		br	br	br	bl	br	—			
Ram.				br	br	br	br	br	br			3
Rob.—B				br	br	i	i	br	br	1		3
Sin.—D				br	br	br	br	br	br	3		1
Was.				br	br	i	br	i	br	2		3
Wri.	3	2	2	br	br	br	br	bl	i			
Wro.—B				br	br	br	bl	br	bl			2
You.	2	1	1	br	br	bl	i	bl	br			
Zin.	1		4	br	br	—	bl	—	—			
Total (96)	42	11	43						(77)	0	19	58

Total: 43 families. 23 families.

20 families.

offspring to be expected. Among the 43 families of Table III, 20 produced no blonds, although some of them comprise four to seven children. Consequently it is highly probable that some brunets are duplex in skin pigmentation. In the families that produce blonds there are



only 54 children out of a total of 96 that are either brunet or intermediate, or about 56 per cent. of all. With simple segregation and dominance 75 per cent. of dark offspring are to be expected; the deficiency is, I suspect, partly due to the exclusion from the left side of the table of some families with both parents simplex merely because they failed (in their small families) to produce blonds, although they were *potential* blond producers.

(d) *Intermediate*  $\times$  *Intermediate* (Table IV).—The intermediate class serves to include those whose skin has not the clear, transparent, pink quality of the typical blond, on the one hand, nor the rich dark shade of the brunet. It was intended to include a considerable range of color from 10 per cent. to 18 per cent. of black in the color wheel. As already stated, however, collaborators assigned less than a third of the offspring to this class.

The distribution of skin color in the offspring of two intermediates offers, it must be freely admitted, great difficulties. There are several possibilities. It might be that the "brunet" type of skin color is typical for skin pigment. Accordingly, the intermediate condition may be conceived as having been stopped part way in color development. This stoppage may be due to the fact that the units essential to the later phases of color development are lacking, or to the fact that the stimulus to full pigmentation is weak. The first alternative assumes many units for pigmentation; the second, one unit that fluctuates widely. Again the intermediate condition might be the consequence merely of its simplex or heterozygous nature. If the latter were the case two intermediates should produce light and dark offspring again in nearly equal proportions as well as intermediates. But if either of the two first-named hypotheses is correct, in accordance with results found by us in hair color, the offspring should not exceed in pigmentation the more pigmented parent; in the same way that in the offspring of two blond parents the parental color is not exceeded.

Table IV gives the data precisely as reported. As in

TABLE IV  
INTERMEDIATE × INTERMEDIATE

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Fair.	Inter.	Brun.						
Ave.—1		5		i	i	br	i	i	i
Bal.—A		6		i	i	i	i	—	—
Bal.—B	1	1		i	i	i	i	—	—
Bar.—2	3	4	2	i	i	i	f	i	f
Bar.—A	2	4		i	i	f	i	i	f
Bar.—3	2	2		i	i	i	f	i	i
Bat.—B	1		2	i	i	i	br	i	br
Bec.		5		i	i	i	i	br	i
Bec.—B		2		i	i	i	i	i	—
Bed.		2		i	i	i	i	i	i
Bre.—1		2		i	i	i	i	i	i
Bel.—1	1	1	2	i	i	br	f	br	i
Ber.	2	3		i	i	i	i	i	i
Bis.	3	3	1	i	i	i	br	i	i
Bla.	2	2	1	i	i	i	bl	bl	i
Bra.—4	3			i	i	i	br	i	br
Bra.—D	1	4	1	i	i	bl	i	i	i
Bro.—9		3		i	i	f	i	i	—
Bur.	2	2		i	i	br	i	i	i
Bur.—3		3		i	i	i	i	—	—
Cad.—2		5		i	i	?	f	i	i
Cal.—1		3		i	i	i	br	i	i
Cap.	2	2		i	i	i	i	bl	—
Cas.	1	9		i	i	i	br	i	i
Cha.		2	1	i	i	i	i	i	br
Cla.—2	1	3		i	i	i	i	i	i
Col.		4		i	i	i	i	—	—
Con.		5		i	i	i	i	i	i
Con.	1	1	1	i	i	br	bl	br	i
Con.—D		3		i	i	i	i	i	i
Con.—E		2	2	i	i	i	i	br	bl
Cox.	1	4		i	i	i	i	—	—
Dar.—B		2		i	i	i	i	br	i
Dar.—D		4		i	i	i	i	i	i
Dav.—1		2		i	i	i	i	br	i
Dav.—E	1	6		i	i	i	i	i	i
Dol.—1		13		i	i	i	i	i	i
Don.—1		8		i	i	i	i	i	br
Ear.	1	1		i	i	i	bl	i	bl
Eck.—1	3	1	2	i	i	i	f	f	i
Fer.		2		i	i	—	—	—	—
Gan.		2		i	i	i	bl	br	i
Gar.	1	4	2	i	i	i	i	i	i
Gen.	2	2		i	i	—	—	—	—
Goo.—2	2	1		i	i	br	f	f	i
Gra.—A	2	2		i	i	br	i	bl	br
Gro.—A		3		i	i	i	—	i	—
Gue.	6	2	2	i	i	i	i	i	br
Had.—B		3		i	i	dk	bl	i	br
Hal.	1	1		i	i	i	bl	i	i
Har.—A	4	3	3	i	i	bl	bl	bl	br
Har.—1		3		i	i	i	i	i	i
Har.—2	1	7		i	i	i	i	i	i
Haw.		3		i	i	—	—	i	i
Hay.	1	2	1	i	i	br	i	br	i

Family Name.	Children.			M	F.	MM.	MF.	FM.	FF.
	Fair.	Inter.	Brun.						
Hil.	1	1		i	i	i	i	i	i
Hog.—B	1	1	1	i	i	bl	br	—	—
Hoh.		6		i	i	i	i	i	i
Hol.	2	3		i	i	f	—	f	i
Hoy.		4		i	i	i	i	i	i
Hub.		4		i	i	i	i	i	i
Huf.	1	2		i	i	i	i	i	i
Irw.		2		i	i	i	i	i	i
Jam.	1	1	1	i	i	br	i	f	i
Keh.		2	3	i	i	i	br	br	i
Kei.		3		i	i	i	f	i	f
Kun.		1	1	i	i	i	i	i	br
Lay.		5		i	i	i	i	i	i
Lea.		3		i	i	i	i	i	i
Lit.—C	4		2	i	i	i	bl	i	i
Loc.—A	2	2	1	i	i	i	i	i	i
Loc.—B	1	1		i	i	bl	i	i	i
Loc.		4		i	i	bl	br	bl	bl
Loh.		3	2	i	i	—	—	—	—
Los.		4		i	i	i	br	i	i
Lum.	1	5		i	i	i	i	i	i
Mac.	2	1		i	i	bl	i	br	i
Mag.		5		i	i	i	i	i	i
Mar.—B		3		i	i	i	i	i	i
Max.		2		i	i	i	i	i	i
McC.—2			2	i	i	br	i	i	i
McD.	1	3		i	i	bl	i	i	i
McM.	3	3		i	i	i	i	i	i
Mea.		2	2	i	i	i	br	i	i
Mel.	1	5		i	i	i	br	br	i
Mer.		4		i	i	i	i	f	i
Mil—G	3	1		i	i	i	i	i	i
Mit.—C.		2		i	i	i	br	i	br
New.	1	5	1	i	i	i	i	i	i
New.	1	3	1	i	i	br	i	i	i
Nic.—2		3		i	i	f	br	i	i
Nor.	4	1		i	i	i	i	i	bl
Nur.		4		i	i	i	i	i	i
Pal.		1	1	i	i	br	bl	i	br
Pat.—A.	2	8		i	i	i	i	i	i
Pla.		2	1	i	i	i	i	—	i
Ran.—B		9		i	i	i	i	i	i
Rau.	1	1		i	i	bl	i	i	bl
Ree.		9		i	i	i	f	olive	i
Rem.	1	1		i	i	i	i	i	i
Ric.—C	2	1	2	i	i	br	i	br	br
Rin.	2	1	1	i	i	f	f	br	i
Rit.	1	3		i	i	i	i	i	i
Rob.	1	1	3	i	i	i	br	br	i
Rog.		4		i	i	i	i	br	i
Ros.		5		i	i	i	i	i	i
Rud.		3		i	i	i	i	i	i
Rus.	2	4		i	i	—	—	—	—
Sam.—C	2	2	1	i	i	i	i	i	i
Sam.—B	1	4		i	i	i	i	i	i

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Fair.	Inter.	Brun.						
Sam.—A	1		1	i	i	i	br	bl	br
Say.		2		i	i	i	i	i	br
Sea.	1	1		i	i	f	i	i	i
Sil.—B		3		i	i	br	i	i	br
Sil.—C		2	1	i	i	i	i	bl	i
Sin.		2		i	i	i	i	i	i
Smi.—3	4			i	i	i	i	i	i
Sml.		3		i	i	i	i	i	i
Sne.		2		i	i	i	i	i	br
Sob.	1	2		i	i	br	bl	bl	i
Squ.		5		i	i	i	i	br	i
Ste.—1		2	2	i	i	i	i	br	br
Sti.—1	2			i	i	i	i	i	i
Sto.—C		1	1	i	i	i	i	i	i
Str.—C.	2			i	i	br	i	bl	i
Str.	2			i	i	i	bl	i	bl
Str.		2		i	i	—	—	—	—
Sny.		4		i	i	i	i	i	i
Tay.—D		3		i	i	i	i	i	i
Tho.	2	2		i	i	bl	br	br	i
Tre.		4		i	i	i	i	i	i
Tru.	2	2		i	i	i	bl	i	i
Wal.	4	1		i	i	i	i	i	i
Wal.—2		7		i	i	i	i	i	i
Wan.		3		i	i	i	i	i	i
Wan.—B	1		1	i	i	—	i	i	i
War.—C.		2		i	i	f	f	dk	dk
Wes.	2	1		i	i	br	bl	bl	i
Whe.—D	1	1		i	i	bl	i	i	i
Wil.		3		i	i	i	bl	br	i
Wil.	1	3	1	i	i	—	—	br	i
Wil.—B	1		2	i	i	i	dk	br	i
Win.	1	2		i	i	i	i	i	i
Wol.	1	1	2	i	i	br	br	bl	i
Totals (591)	128	403	60						

the case of the other tables, a certain allowance has to be made for errors in reporting due to vague and incorrect recollection and to other mental lapses. In such families as Keh., McC.—2 and Rob. the color of one of the parents is probably incorrectly reported. Sometimes the probability of the record can be tested by considering the associated hair color, since there is a fairly high correlation between the two. Thus in the case of the Keh. family both "intermediate" parents have "black" hair, while all but one of the "brunet" children have hair that is recorded as of some shade lighter than black. In the McC.—2 and Rob. families both parents and children have "dark brown" hair, but, in both families, the skin

TABLE V  
INTERMEDIATE × BLOND

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Blond.	Inter.	Brun.						
Ave.	4	1		i	bl	i	i	i	bl
Bal.	3	1	1	bl	i	bl	br	—	—
Bar.	2			i	bl	i	br	bl	i
Bon.	4			i	bl	i	i	bl	bl
Bow.	3	2		i	bl	i	i	—	i
Col.—C.	2	3		bl	i	bl	br	i	bl
Dav.—C	2	2		bl	i	—	—	br	i
Dru.	2			i	bl	i	br	br	—
Ege.	2			bl	i	bl	—	bl	—
Ewa.	2			bl	i	i	i	i	i
Fin.	1	1		i	bl	i	br	i	i
Fra.	3	1	2	i	bl	—	—	—	—
Fra.—D	2			i	bl	—	—	—	—
Fri.—B	1	2		i	bl	i	i	i	bl
Gen.	3			bl	i	i	i	i	i
Gil.—B	3	1		i	bl	i	br	bl	i
Gor.—A	2	7	2	bl	i	bl	i	i	i
Gsc.	2		1	i	bl	br	bl	bl	bl
Hal.—B	4			bl	i	br	bl	i	br
Hal.—D	1	1		bl	i	i	bl	i	i
How.—D	3			bl	i	i	bl	i	i
Hur.	1	3		bl	i	i	i	i	i
Kel.	1	1		bl	i	bl	i	i	bl
Kir.	1	1		bl	i	i	i	i	i
Lat.—B.	3			bl	i	bl	i	i	i
Ma.	1	1	1	bl	i	bl	bl	bl	i
Mil.—D	2			bl	i	br	i	br	bl
Mos.	2	3		i	bl	i	i	i	bl
Pie.		2		i	bl	i	i	br	i
Pla.—C		1		i	bl	br	bl	i	bl
Pra.	4	4		bl	i	bl	i	dk	dk
Ras.—B	1	4		i	bl	bl	br	—	—
Rob.	3	4		i	bl	i	i	bl	i
Seco.	3	2	1	bl	i	bl	br	bl	br
Seco.—B	2			bl	i	bl	bl	i	i
Sha.	2			bl	i	i	i	bl	i
Str.	4	2		bl	i	bl	bl	bl	—
Suo.		7		i	bl	br	bl	—	bl
Tw.	3	1		bl	i	bl	bl	—	—
Vos.	2	1		bl	i	br	bl	i	i
Wal.		4		bl	i	i	bl	bl	bl
Web.	6	1		bl	i	bl	br	br	br
Wri.	3			i	bl	fair	i	bl	i
Wro.—C	1	1		i	bl	i	br	bl	bl
Totals: (179)	96	75	8						

44 families.

color of the parents is given as "intermediate," while that of all or most of the children is given as "brunet." It seems probable that in applying the *terms* that were available the difference in skin color between parents and children has been unconsciously exaggerated.

## INTERMEDIATE × FAIR

Family Name.	Children.			M.	F.	MM.	MF.	FM.	FF.
	Fair	Inter.	Brun.						
Ba.	4	1	2	f	i	f	i	br	br
Bec.—1	4	2		f	i	f	—	f	i
Beh.	6	1	1	i	f	f	i	i	f
Ben.—3		2		i	f	br	f	f	f
Bet.—2	2		1	i	f	f	br	i	i
Boh.—1	7	2		i	f	—	—	—	—
Bon.	4			i	f	—	i	i	f
Boo.—1	1	3		i	f	f	br	f	i
Boy.	7	2		i	f	f	f	f	f
Bro.—4	3	3		i	f	f	i	f	i
Bye.—1		2		f	i	—	—	i	br
Cah.—1	7	1		i	f	i	f	f	f
Cam.—1	1	3		f	i	i	f	f	br
Can.	5	3		f	i	br	f	br	i
Cha.—3	4	2		f	i	i	f	—	i
Cl.	6	2		f	i	f	f	f	i
Clo.—1	3	5		f	i	f	f	br	i
Coi.—1	1	3		i	f	i	br	f	f
Cra.—1	1	1		i	f	i	i	i	i
Cro.—2	5	2		f	i	i	f	i	i
Cuo.	4			i	f	f	f	f	f
Dar.—1		1	3 <sup>1</sup>	f	i <sup>2</sup>	f	i	br	f
Dow.—2	1	2	1	f	i	i	i	br	—
Fox.—1	2			f	i	f	f	i	—
Gar.—1		2		f	i	—	—	—	i
Glo.	6	1	1	i	f	—	—	—	f
Gor.—1	8	1		i	f	—	—	—	—
Has.	3		1	f	i	f	f	—	—
Kas.	3	3		i	f	i	f	—	—
May.	1	2		f	i	i	i	f	i
Mor.—3		1	1	f	i	f	f	f	i
Mun.	1	5	1	f	i	br	f	br	f
Nip	2	1	2	f	i	i	i	i	i
Obi.	4			f	i	br	f	i	i
Ogd.	1	2		f	i	f	f	f	f
Ori.—1	2	2		i	f	i	i	i	f
Owe.—2	5			f	i	f	f	f	f
Ram.	2	2		f	i	i	i	i	f
Rec.	1	3		f	i	—	—	—	f
She.—1	3	3		i	f	i	f	f	i
Sti.—2	1		1	i	f	f	f	i	f
Str.		3		f	i	—	—	i	f
Tit.	4	1		f	i	i	i	i	i
Wal.—1		4	1	f	i	i	i	i	i
Way.	3	1	2	f	i	br	f	f	i
Zop.		3		i	f	f	f	f	f
Total (229)	128	83	18						

46 families.

<sup>1</sup> Medium brown to dark brown hair.<sup>2</sup> "Black" hair, hazel eyes.

Applying no correction at all, however, practically 90 per cent. of the offspring agree with the rule that they are not darker than their darker parents. Nevertheless, the hypothesis that intermediate skin color is sometimes due to the imperfect dominance of the simplex determiner must be admitted as plausible.

(e) *Intermediate*  $\times$  *Blond*.—The results of this mating are given in Table V, showing the distribution of skin color in the offspring. If all intermediates were simplex in skin pigmentation we should expect blonds and intermediates in equal numbers. Also on the hypothesis that the higher grade of pigmentation is epistatic we should expect blonds and intermediates, but no brunets. The actual distribution agrees nearly with expectation on either hypothesis: where the term "blond" is used 54 per cent. of the offspring are blonds; and among the "fairs" 56 per cent. are fair. Most of the remainder are "intermediate," the exceptions constituting only about 6 per cent. of all offspring. In some of the most aberrant families, like Dar.—1, one finds in the hair color reason for doubting if classification was always made with judgment. It seems probable that when the parentage really falls into this class brunet offspring rarely, if ever, occur.

(f) *Intermediate*  $\times$  *Brunet* (Table VI).—If intermediate skin color is simplex then brunet is duplex and expectation is that half of the offspring shall be brunet, half intermediate and there shall be no blonds. But if intermediate and brunet represent two different stages of pigmentation either of which may be epistatic to blond, then a certain proportion (sometimes less than 25 per cent.) of the offspring should be blonds. Actually there are many blonds (about 24 per cent. of all offspring) and consequently the second hypothesis is favored again.

Of the 80 families 39 have no blond offspring; we may inquire if the ancestry of such families differs in the proportions of the blonds from those that produce blond offspring. We find that in the families with blond off-

TABLE VI  
 BRUNET × INTERMEDIATE

Family Name.	Blond or Fair.	Inter.	Brun.	M.	F.	MM.	MF.	FM	FF.
Bea.	3	2	5	br	i	i	bl	bl	i
Bis.—2	1		1	i	br	i	br	i	br
Boh.—3	5	1	3	br	i	—	—	—	—
Boy.—2		1	4	i	br	—	—	bl	—
Bro.—7	2		1	i	br	f	i	br	br
But.		1	2	i	br	br	br	br	br
Clu.—A		3		i	br	—	—	—	—
Clu.—B	1	1	1	i	br	i	—	—	—
Con.	3	2	2	br	i	bl	i	bl	bl
Cur.—A		1	1	br	i	bl	bl	bl	i
Cur.—1		4	2	i	br	f	i	i	br
Dav.—A.	1	4	2	i	br	—	—	—	—
Dep.		2		i	br	i	—	i	br
Dev.		2		i	br	bl	br	—	bl
Dey.—A	2	1		br	i	br	br	i	br
Don.	1	1	5	br	i	bl	bl	bl	i
Don.—B.	1		3	i	br	i	bl	bl	br
Dow.—1	5			br	i	f	br	f	f
Dru.—B	2	1		br	i	—	—	—	—
Eas.	2			i	br	br	i	f	br
Fyt.		2	3	i	br	—	—	i	br
Gar.—A	2		3	i	br	br	i	br	i
Gar.—1	2	3	1	br	i	i	br	i	f
Gan.	3	3		br	i	i	i	i	f
Get.		3	2	i	br	i	i	i	i
Gil.		2	2	br	i	br	f	i	f
Gla.—A		6	2	i	br	i	bl	br	br
Gra.—D		3	2	br	i	i	br	i	i
Gre		2		i	br	br	br	i	i
Had.	2			br	i	i	br	br	i
Han.			2	br	i	bl	br	bl	i
Har.			2	br	i	br	i	i	i
Hay			2	br	i	—	br	br	f
Hen.—A		2	1	i	br	br	i	br	bl
Hew.	3	2	3	br	i	i	—	bl	br
Hir.	1	1		br	i	br	br	i	i
Hit.		2		i	br	i	i	i	br
Hop.		1	1	br	i	i	i	i	br
Jor.—1		2	1	br	i	i	br	i	i
Ker.	1		1	br	i	i	i	i	i
Kro.—1	1	2	1	br	i	br	f	br	i
Leo.		2	1	br	i	bl	br	br	i
Lon.—C		1	2	br	i	br	i	i	i
Lue	1	2	1	br	i	br	br	i	br
McG.	2	1		br	i	i	i	br	i
McK.		2		br	i	f	i	br	i
McL.		2	3	i	br	i	br	br	—
McG.		1	2	br	i	i	i	i	i
Mar.	1	2		br	i	i	f	i	i
Mil.—A.	1	1	1	br	i	i	br	br	i
Mit.—C.		3		i	br	i	br	bl	br
Nic.—A	1	1	3	i	br	i	br	br	bl
Nic.—1		2	3	i	br	i	br	br	i
Oe.		5		i	br	i	i	br	br
Pal	1		1	br	i	f	br	f	br
Poe.		2	1	br	i	br	br	i	i



Family Name.	Blond or Fair.	Inter.	Brun.	M.	F.	MM.	MF.	FM.	FF.
Pyn.	1	3	1	i	br	i	br	i	br
Ric.—3	2		2	br	i	f	br	br	i
Roc.	3	2		i	br	i	i	br	br
Rol.		5	1	br	i	br	br	i	i
Say.	1		1	br	i	br	i	bl	dk
Sch.	1	2		br	i	br	f	f	f
Sec.—1	2	1		br	i	i	i	i	i
Sel.		1	3	i	br	i	br	i	br
Ser.			2	br	i	br	bl	br	br
Sho.		1	2	br	i	i	bl	br	i
Ski.	2	1	2	i	br	i	br	br	br
Smi.	2	1		br	i	f	i	i	i
Spi.	1	3		br	i	i	f	i	i
Ste.—D		2	5	br	i	br	i	i	—
Sto.—B		1	1	i	br	i	i	br	br
Tho.		3		i	br	i	br	i	i
Tre.		2	1	br	i	br	br	i	—
Tuc.	2			br	i	i	bl	bl	br
Tyd.—1		2		i	br	i	i	i	br
Ver.		1	1	br	i	i	bl	i	br
Way.	2	1	1	i	br	—	—	i	i
Web.	1		1	i	br	i	bl	i	i
Wei.	1	1	1	br	i	bl	br	bl	br
Woo.		6	1	i	br	i	br	i	br
Totals (307)	73	129	105						

80 families. Certain grandparental terms are printed in italics to indicate our doubt as to their correctness.

spring 24 per cent. of the known grandparents are recorded as blond or fair, whereas in families without blond offspring only 13 per cent. of the known grandparents are blond or fair. In families with blond offspring 9 of the 34 complete sets of grandparents (or 26.5 per cent.) show blondness on both the paternal and maternal side, whereas in families without blond offspring, of the 36 complete sets of grandparents only 4, or 11 per cent., show blondness on both sides, and the size of the families in these four cases is small, viz., 2, 2, 2, 4, so that there is a large chance that the families are potentially blond producing and really belong in with the blond producing families. It appears, then, that both the intermediate and brunet parents may contain hypostatic blondness, and where they do they will have blond offspring, but not otherwise.

If the brunet parent is, in any case, duplex-brunet and contains no hypostatic intermediate or blond then ex-

pectation is that all of its offspring shall be brunet. This condition is apparently not realized even in the 29 families that yield no blonds. Only in seven cases are both [grand] parents of the brown parent "brunet," but there is no evidence that they were not simplex. At any rate, in all these seven cases some "intermediate" offspring were produced.

(g) *Comparisons.*—The relations of the foregoing facts are better brought out by the compact table where the results of the various matings can be compared.

TABLE VII  
THE NUMBER AND DISTRIBUTION OF THE OFFSPRING OF VARIOUS MATINGS

Nature of Mating.	Frequency.				Proportions.		
	Total.	Blond.	Inter.	Brun.	Blond.	Inter.	Brun.
Blond × blond . . . . .	513	469	35	9	91.4	6.8	1.8
Blond × intermediate . . . . .	408	224	158	26	54.9	38.7	6.4
Blond × brunet . . . . .	403	193	88	122	47.9	21.8	30.3
Intermediate × intermediate . . . . .	591	128	403	60	21.8	68.5	9.7
Intermediate × brunet . . . . .	307	73	129	105	23.8	42.0	34.2
Brunet × brunet . . . . .	173	42	30	101	24.3	17.3	58.4
Totals . . . . .	2,394	1,129	843	423			

Considering alone the proportions of blonds in the families of the various matings, some striking figures are obtained. Three classes appear:

I. Class comprising about 90 per cent. blonds approaching 100 per cent.—blond × blond (91.4 per cent.).

II. Classes in which the blonds constitute approximately 50 per cent.—blond × intermediate (54.9 per cent.), blond × brunet (48 per cent.).

III. Classes in which the blonds constitute approximately 25 per cent.—brunet × brunet (24.3 per cent.), brunet × intermediate (23.8 per cent.), intermediate × intermediate (21.8 per cent.).

In the first class neither parent shows skin pigment; in the second class one parent only shows such pigment; in the third class both parents show skin pigment. The proportions of blonds in the first class are those expected from Mendelian crosses of  $R \times R$ ; of the second class those expected from  $R \times DR$  crosses, and of the

third class those expected from DR  $\times$  DR matings. Shall it therefore be concluded that all brunets as well as intermediates are simplex in skin pigment? This does not follow; but it does seem to be a fact that duplex "brunet" and "intermediate" are not common;<sup>1</sup> indeed so uncommon as not to alter materially the proportions that would be given on the hypothesis that they are always simplex.

The principle of the non-transgressibility of the upper limit to which we have called attention elsewhere<sup>2</sup> seems to hold for skin pigment also although the result is less clear-cut, probably because the terms were less accurately assigned. To see how closely the law holds Table VIII has been constructed. The three cases: (a) darker parent blond; (b) darker parent intermediate; (c) darker parent brunet—are chosen and the distribution of offspring in each case indicated at the right.

TABLE VIII  
SHOWING THE DISTRIBUTION OF THE DIFFERENT CLASSES OF SKIN COLOR IN  
THE THREE CASES WHEN THE DARKER PARENT IS BLOND,  
INTERMEDIATE AND BRUNET

Grade of Darker Parent.	Offspring.				Proportions.		
	Frequency.						
	Totals.	Blond.	Inter.	Brun.	Blond.	Inter.	Brun.
Blond.....	513	469	35	9	91.4	6.8	1.8
Intermediate.....	996	352	561	83	35.3	56.3	8.3
Brunet.....	883	308	247	328	34.9	28.0	37.1

Table VIII shows that exceptions to the rule of delimitation are, considering the vagueness of terms,<sup>3</sup> relatively rare, only about 8 per cent., and, consequently, the rule seems verified.

The significance of the intermediate grades of skin color is a question of prime importance. There is some evidence, for example in Table IV, families Har. A, Keh.

<sup>1</sup> For examples of probably duplex "brunet" see Table III, Eni, Hen, McB, Ram. Of duplex intermediates there seem to be examples in Table IV, Bal.—A, Dol.—1, Don.—1, Ran.—B, and Ree; and in Table V, Suo.

<sup>2</sup> G. C. and C. B. Davenport, 1909, p. 208.

<sup>3</sup> The proportion would be substantially reduced were returns that show intrinsic evidence of error eliminated.

and Rob., that the intermediate condition is sometimes a simplex or heterozygous condition. But, in most cases the evidence is clear that the "intermediate" grade (or grades) is simply epistatic to blond and hypostatic to brunet and that intermediate may carry, and usually does carry, hypostatic "blond," while brunet may carry, and usually does carry, either or both hypostatic blond or hypostatic intermediate. There is nothing unprecedented in the conception that a given condition may be in some cases simplex and in others act as a unit. Some cases of barring in the plumage color of poultry belong to the one category and others to the other.

The meaning of the case of skin pigmentation, like that of hair pigmentation, is not perfectly clear. There is a possibility that pigmentation stops at certain well-defined points, each of which is determined by an hereditary unit; on the other hand, it seems even more probable that there is a continuous gradation in depth of pigmentation and that the strong internal conditions that lead to deeper pigmentation dominate over the weaker conditions. In the one case the varying characteristic is composed of a series of steps; in the other of an inclined plane. But a series of steps can not be distinguished from an inclined plane if the steps be taken small enough.

#### D. HEREDITY OF SKIN PIGMENTATION IN CROSSES BETWEEN WHITES AND NEGROES

The behavior in inheritance of the very dark skin pigmentation characteristic of negro races now deserves consideration. It is remarkable that despite the abundance of material available the facts of the inheritance of pigmentation in such crosses should have remained so long in dispute. To settle the question whether segregation occurs, two essential conditions must be met. First, the parentage of the children must be unquestioned and, second, the degree of pigmentation must be quantitatively expressed. Through the kind coopera-

tion of correspondents in the south and above all of Professor H. E. Jordan, of the University of Virginia, who furnished all of the quantitative data, I am able to meet these conditions.

The quantitative data were obtained by means of the Bradley color top, using the standard colors of the Milton Bradley Company, of Springfield, Mass. The numbers given are percentages of the entire area of the disc occupied by the corresponding colors on the revolving disc. All color determinations were made of the dorsal aspect of the forearm slightly above the wrist. The determinations by the color top indicate that human skin color is obtained by mixing black (N), yellow (Y), red (R) and white (W). The first constituent is the melanic pigment, the second probably is due to a lipochrome pigment so wide-spread in animals and found in the human hair and iris, the red is chiefly that of hæmoglobin; and the white is reflected from the opaque skin. The color formula of the skin of the wrist of a slightly tanned "white" skin—the writer's—is as follows:

N	Y	R	W
8	9	50	33

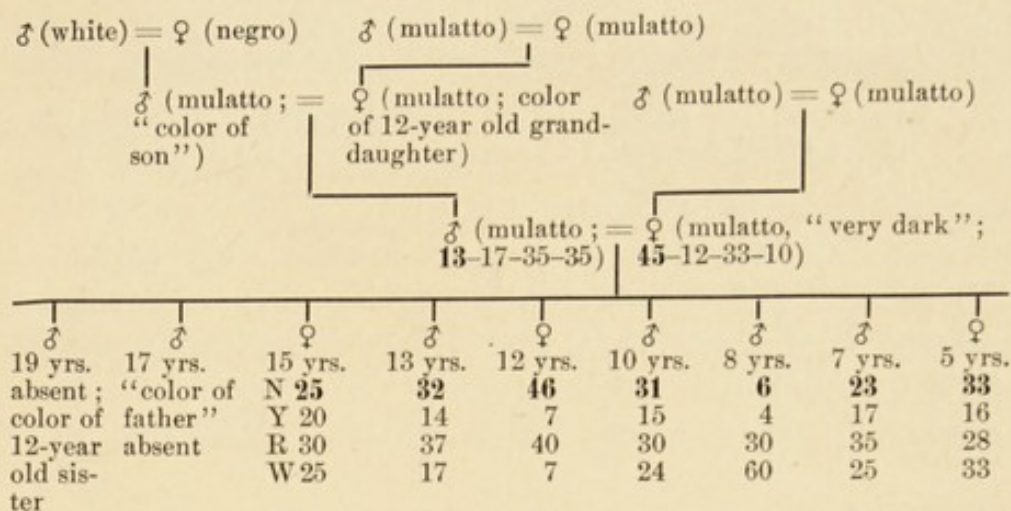
The determinations by the color top are fairly delicate. The formula 10-12-41-37 gives a decidedly different color from the foregoing and not red enough for any wrist-skin. The skin color of a very dark negro, about 18 years old, measured by Dr. Jordan gave: N 75, Y 3, R 20, W 2. Dr. Jordan thinks the skin color of this boy's face would be given by N 90, R 10. Another black negro is given by N 68, Y 2, R 26, W 4.

We may now consider the pedigrees of skin color collected by Dr. Jordan.

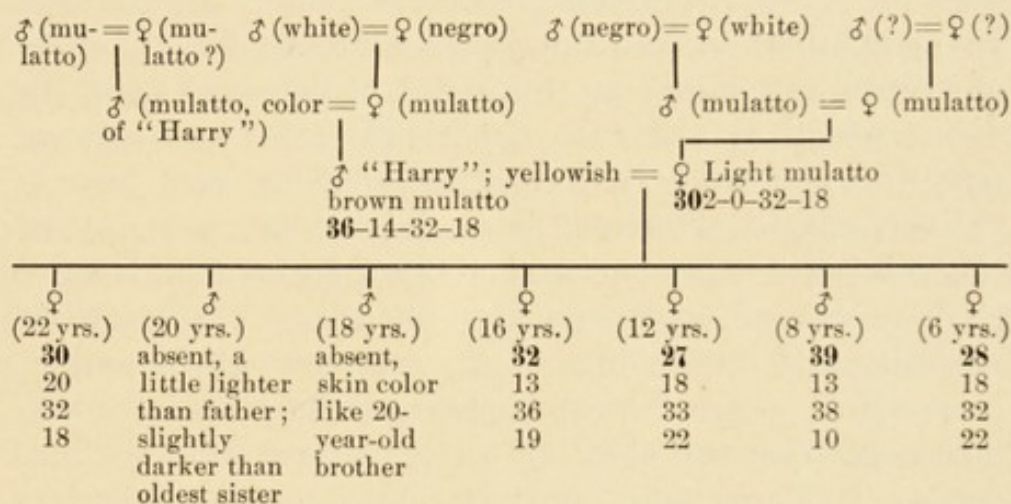
As to the question of legitimacy, Dr. Jordan writes: "There isn't the least doubt, I think, about the legitimacy of the children in the families of 'H.,' 'W.,' 'J.' and 'F.'"<sup>5</sup>

<sup>5</sup> The quantitative data on this family were not obtained, as the members were too inaccessible. The "C." family was obtained after Dr. Jordan's letter was written, and his remarks are doubtless applicable to that family also.

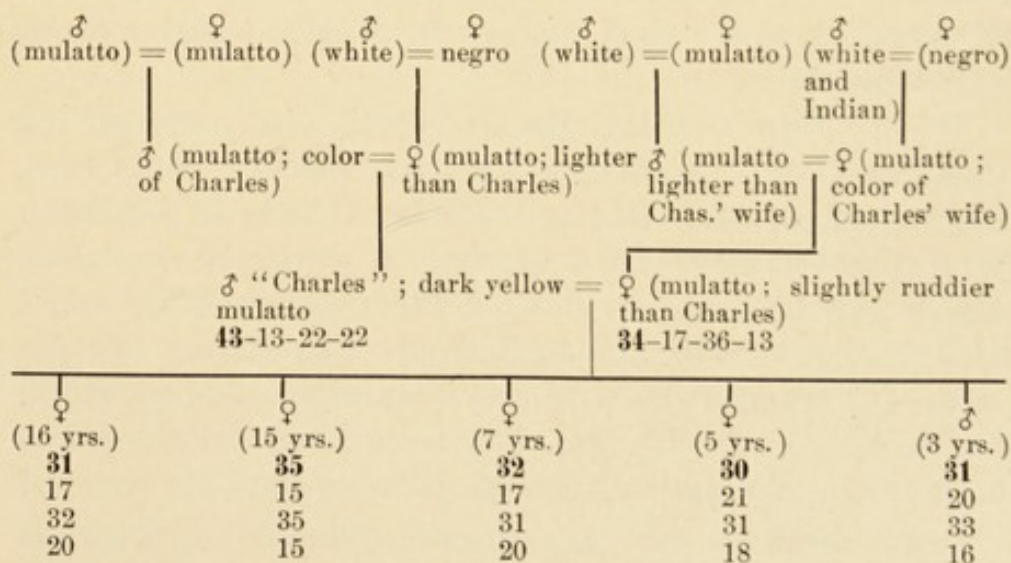
W. FAMILY

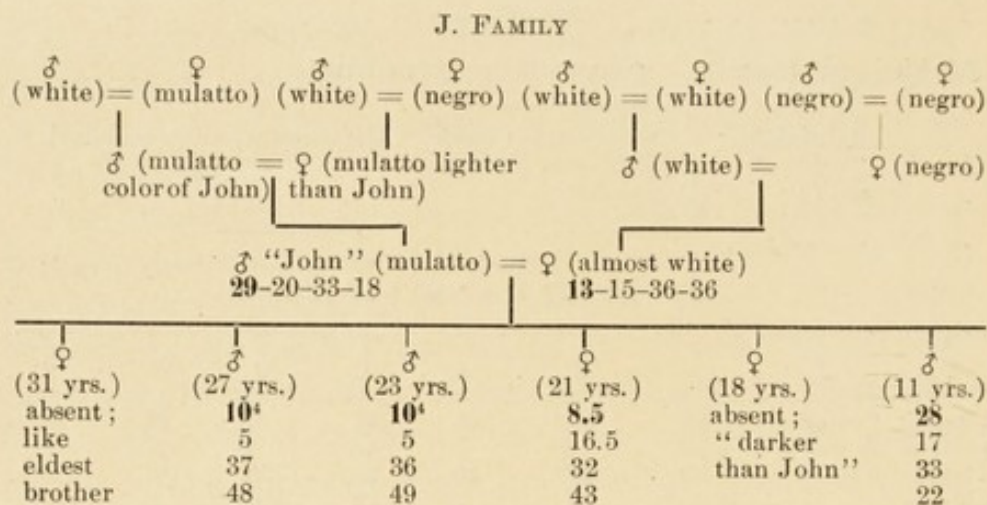


H. FAMILY



C. FAMILY





Dr. F—— for years a resident of this section, and health officer of C——, supports me in this belief. Moreover, I have explained to each family the necessity for my study of absolute certainty on this point, have asked them the direct question, and each about the other, and can get only the assurance that the family life in each case is entirely chaste. One man is a minister, one principal of the colored school, one a thriving merchant and one a barber, and all seem considerably above the grade of morality and intelligence of the ordinary stupid and irresponsible negro. I think you may be absolutely certain regarding the chastity of the several mothers concerned." Those who know Dr. Jordan will appreciate the better the great weight to be given his conclusion. It seems to us we may proceed to discuss these cases as experimental data.

Of the four families the W. family is, perhaps, the most striking. The father, the grandson of a white man, has himself a grade of pigmentation (black, 13 per cent.) no darker than that of a brunet. His wife is very dark (black, 45 per cent.). The children range from white (black, 6 per cent.) to as dark as the mother (46 per cent.). The entire series of percentages of black runs: 6, 23, 25, 31, 32, 33, 46. We have here 1 light intermediate; 5 of mulatto tint and 1 "very dark." None of

<sup>4</sup> These measurements were made an hour apart, after shifting of the color discs and the later without recalling the earlier measurement.

the children show a significantly greater pigmentation than the darker parent, and one is lighter than the lighter parent. There is clear evidence of segregation of the skin pigmentation.

The J. family is important because of the mating of an "almost white" first generation mulatto with a male mulatto who is more than twice as dark. Of the four children measured three are nearly white, whiter than the mother, and one is as dark as the father. The series runs: 8.5, 10, 10, 28. A segregation of practically white and half dark (grandparental colors) takes place here also.

The H. family has also several points of interest. A lighter and darker mulatto parent (black, 30 per cent. and 36 per cent., respectively) from four mulatto grandparents have children ranging in amount of black pigment from 27 to 39; these extremes being somewhat lighter and somewhat darker, respectively, than the parents. No white appears. This result is like that obtained in many Caucasian families with "intermediate" skin color; where two "intermediate" parents (that apparently do not have hypostatic "blond") breed true. They behave like "pure dominants."

The C. family gives much the same result. Two second generation mulattoes of rather dark type have children of this dark type only. None of them exceed the darker parent; some of them run lighter than the less pigmented parent. These parents also seem "pure dominants," or, better, contain no hypostatic white.

The significance of the data of these four families is perfectly clear in view of the studies that we have made on the inheritance of hair and skin color in "Caucasians." There are many grades of pigmentation—more or less definite stopping points, perhaps, in a continuous pigmentation process. A tendency to proceed far in the pigmentation process is dominant over the less progressive condition, but imperfectly so. Consequently, first-generation mulattoes are not as dark as the negro parent. Whether in the offspring of two such mulattoes



the "extracted dominants" would ever return to the original pigmentation of the dark negro parent is doubtful; first, because neither "white" nor black is a single unit. Only in rare instances will the "extracted" blacks be free of some white unit. We are dealing in this case not with two unit characters only but perhaps with a myriad of them. A chance combination of a lot of lower grades will give "white" skin; a combination of "dark units" free of any "white units" would give a dark skin, but most of the offspring will show the various intermediate grades due to diverse combinations of the black and white units. As a rule, even in the first hybrid generation, the darkest grade that is potential in the protoplasm tends to show in the offspring; and so, as a general rule, offspring are rarely darker than the darker parent.

To the foregoing quantitative data may be added some qualitative evidence concerning inheritance of skin color in black  $\times$  white crosses. This testimony is all that I have been able to collect of a definite nature and it has all come from persons possessed of negro blood.

Professor W. E. DuBois, of Atlanta University, Georgia, writes:

Strictly speaking a mulatto is a child of a white person and a full-blooded negro. . . . [Their] children are liable to vary greatly. . . . They might be light in color or dark in color . . . or freckled, with red curly hair.

Maj. R. R. Moton, of the Hampton (Va.) Normal and Agricultural Institute, writes:

Mulatto parents very often have children that are practically white so far as external appearances are concerned, and the same parents may have children that are black or very dark brown. This is very common. Indeed, I think it is more often that the children vary than not.

He cites three examples, all of families whose fathers hold positions of trust in Hampton; two in the institute. A. "is a mulatto and so is his wife. Their first child was a girl . . . a distinct blond in hair and complexion.

The second child was very dark, darker than either father or mother." B. "is a mulatto and his first wife was a mulatto. Their first child, a girl, was . . . just the complexion of the father and mother. The second child, a boy, was very dark." C. "is a mulatto, and his wife is also a mulatto. Their first child, a girl, is darker than either mother or father; not black, however. The second, a boy, is much lighter than either mother or father; almost white. The third, a girl, is a distinct blond with Saxon eyes and complexion."

Professor T. B. Williams, of Hampton Institute, writes:

I know two large families in which both parents in each family are practically white. All of the children are like the parents, practically white. In fact some of them have left home and are "passing for white" in other sections.

These cases are important as indicating that the lower grades of pigmentation do not produce the higher grades (except that some mulatto tints produce darker children by extraction of the white). Professor Williams continues:

In another family the mother is practically white, the father, a mulatto, is darker. They have six girls. Five of them are practically white; one is a very light yellow. In another family the father and mother are as nearly pure mulattoes as are commonly found. One parent is in each case, I am pretty sure, white, and the other in each case is a pure or nearly pure negro. The children of this couple vary from the parents both ways. The older child is fairer than the parents and even has blue eyes, while theirs are dark. The younger child is darker than the parents, though not "black, or nearly so." I could multiply these illustrations many times. There are, too, settlements of mulatto people who for some generations have taken pains not to marry among darker colored people but have gone on intermarrying yet I have never seen a black person as a result of these unions.

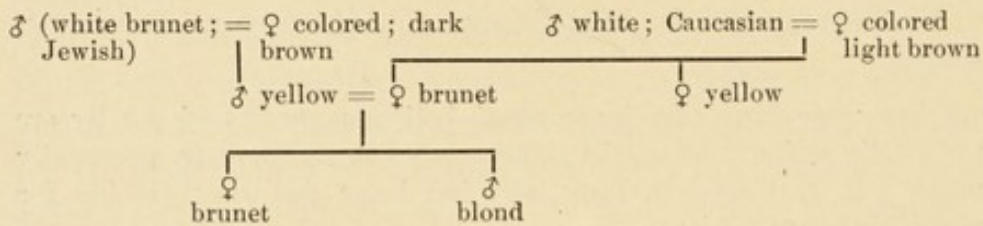
In addition to these data from colored people we have the following from Professor H. V. Wilson, of the University of North Carolina. The family was reported to him by a physician.

Parents, fairly light mulattoes. Woman virtuous. Several children. All children but one, the ordinary type of mulatto; characteristics inter-

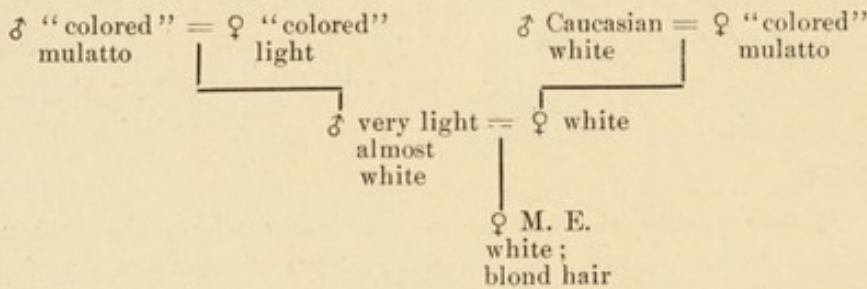
mediate between negro and white. One child shows segregated characters, has blue eyes and other characters close to those of white race.

Finally we give sundry fragments of pedigrees furnished by two reliable and highly intelligent colored persons. Owing to the slight social sentiment among most colored persons against unchastity, they have little motive to hide from one another the facts of parentage of children. Consequently the facts as given below are probably correct.

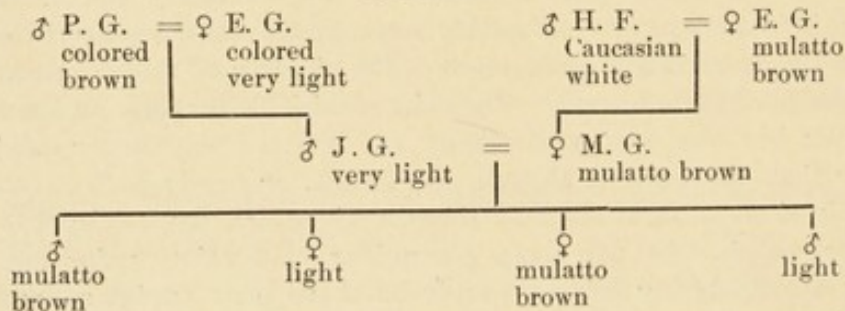
B. FAMILY



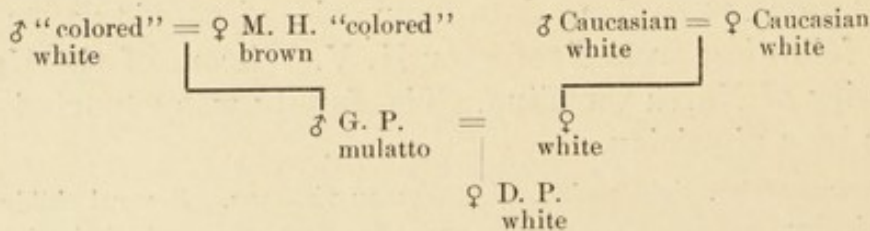
E. FAMILY



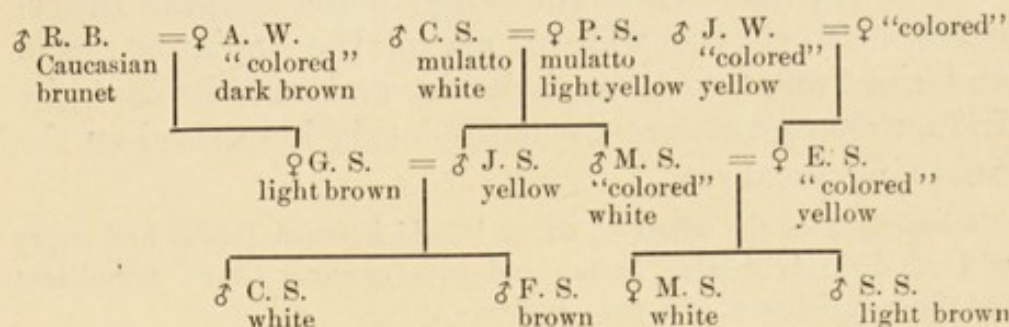
G. FAMILY



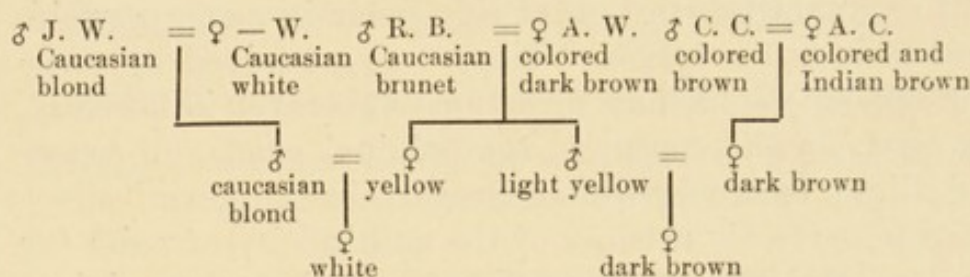
P. FAMILY



S. FAMILY

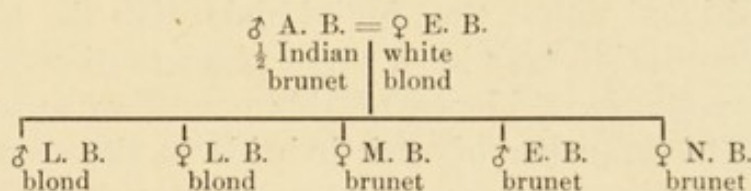


W. FAMILY

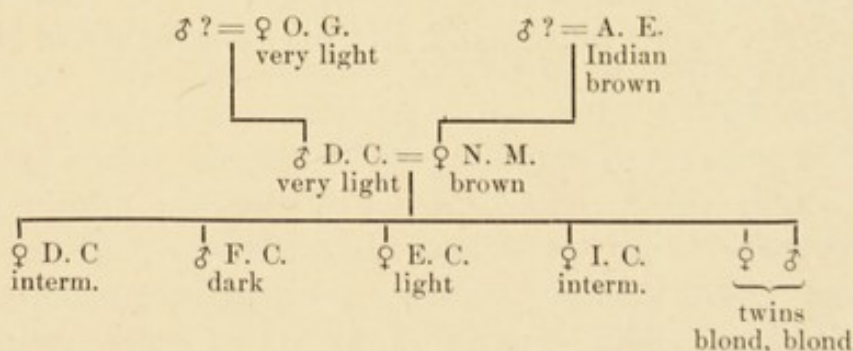


The following families are the product of North American Indian and white crosses.

BES. FAMILY



COO. FAMILY



In some of these families segregation is apparent, notably, in B., G. and S., and Bes and Coo.

Finally, we may refer to an observation made by Louis Agassiz (1891, p. 532) in Brazil which bears upon the matter of segregation, both of skin color and other

characteristics. After referring to the striking differences between the white  $\times$  negro, the Indian  $\times$  negro and the Indian  $\times$  white hybrids, and stating that the Indian characters are the more deeply impressed on the offspring, he says:

I have known the offspring of an hybrid between Indian and negro with an hybrid between Indian and white resume almost completely the characteristics of the pure Indian.

The conclusion from these various data, qualitative as well as quantitative, is that skin color in negro  $\times$  white crosses is not a typical "blend" as conceived by those who oppose the modern direction of research in heredity, but that, on the contrary, the original grades of heavy and slight melanogenesis segregate in the germ cells—often imperfectly because of the multiplicity of units (or grades) for skin pigmentation—and thus the original color characters are more or less perfectly restored. All studies indicate that blonds lack one or more units that brunets possess; that the negro skin possesses still additional units; that individuals with the heavier skin pigmentation may have slight pigmentation covered over—hypostatic, evidence of this condition appearing in the light offspring of such hybrids in the second or third generation; and that first-generation hybrids frequently show, somatically, a color grade less than that which they carry potentially and may segregate in their germ cells.

## HEREDITY OF SKIN PIGMENT IN MAN. II

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EVOLUTION, COLD SPRING HARBOR, N. Y.

### E. INHERITANCE OF ALBINISM

Albinism is the absence of pigmentation through lack of either, or both, the chromogen and the oxidizing ferment. The condition occurs widespread among animals and plants. In man it is rather rare, probably not occurring (if one may hazard a mere guess) in the population of the United States, as a whole, in more than in one case in 10,000 people.

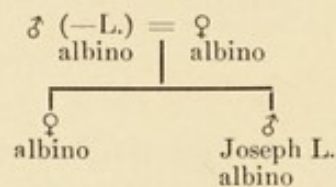
Of true albinism in man there are all degrees. Aside from the piebald condition occasionally found in colored persons there are various grades of uniform depigmentation—hair color varying from light yellow to pure white; irides varying from pale blue to absence of blue, and pupils varying in the intensity of the pink color. Indeed, there is abundant testimony that persons born as albinos may acquire a slight pigmentation. Such a case was cited by Dr. H. B. Young (1905) from Illinois. Albino cats also vary in the pinkish glow of the retina.

Despite variations in the completeness of depigmentation albinism can usually be clearly distinguished, at least in its more marked grades, and so we can study its inheritance. The cases given below were mostly col-

lected by ourselves alone, or with the aid of a medically trained assistant, Dr. Sumner Everingham, and many of the albinos were seen by us.

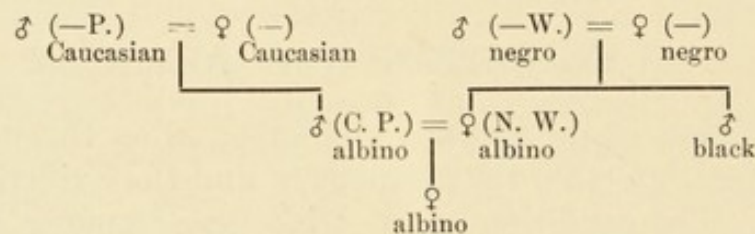
### I. BOTH PARENTS ARE ALBINOS

#### 1. LUC. FAMILY



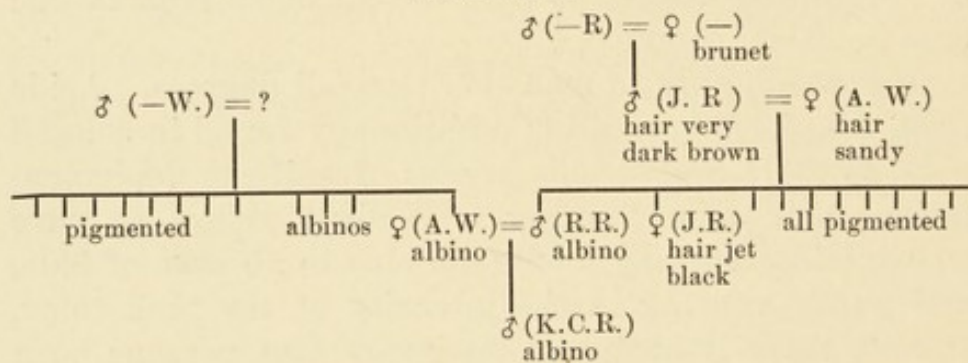
*Note.*—This case is on the authority of Mr. Rob Roy, an albino who seems entirely trustworthy, and has met many albinos in the "show" business.

#### 2. PRI. FAMILY



*Note.*—This case also on the authority of Rob Roy.

#### 3. R. FAMILY

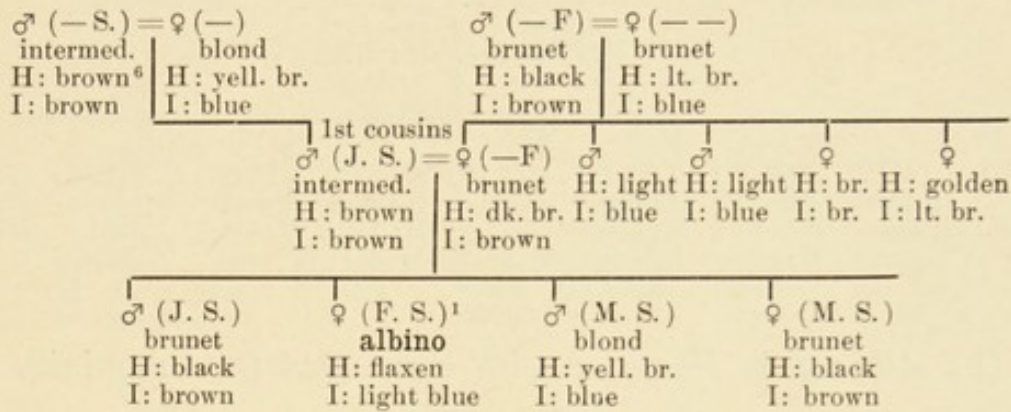


*Note.*—R. R. seen by me.

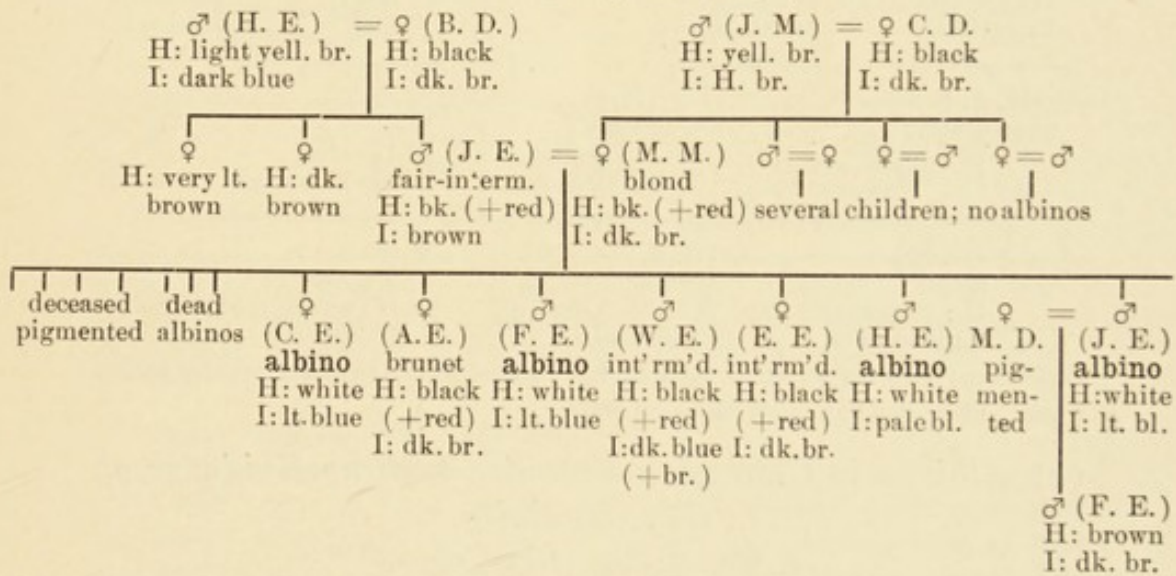
II. NEITHER PARENT ALBINIC

(a) *Albinos in Caucasian Families with Admitted Consanguinity*

4. SHE. FAMILY



5. ENN. FAMILY (IRISH ORIGIN)



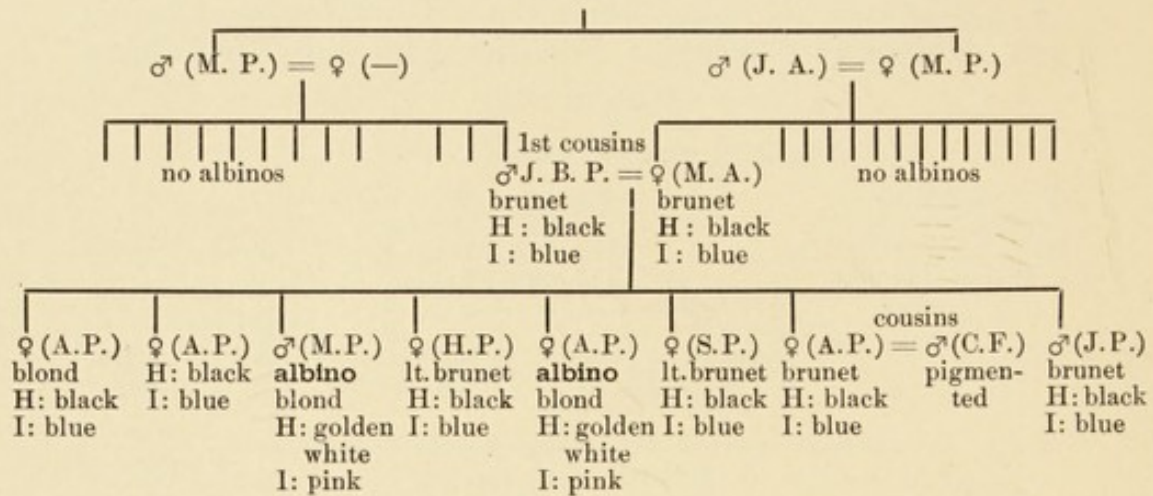
*Note.*—Three generations known; no other albinos. The father and mother, JE and MM, are distant cousins (not first); and father's mother and mother's mother bear the same surname and come from the same place in Ireland. The youngest son (JE) married a distant cousin having the same surname as both his grandmothers. Seen by C. B. D.

<sup>6</sup> In the pedigree tables H indicates hair color; I iris color.

<sup>7</sup> Hair faintly yellowish; irides pale blue; retina, medium pinkish glow; nystagmus moderate; congenital myopia; school work satisfactory; father and mother first cousins. Seen by S. E.

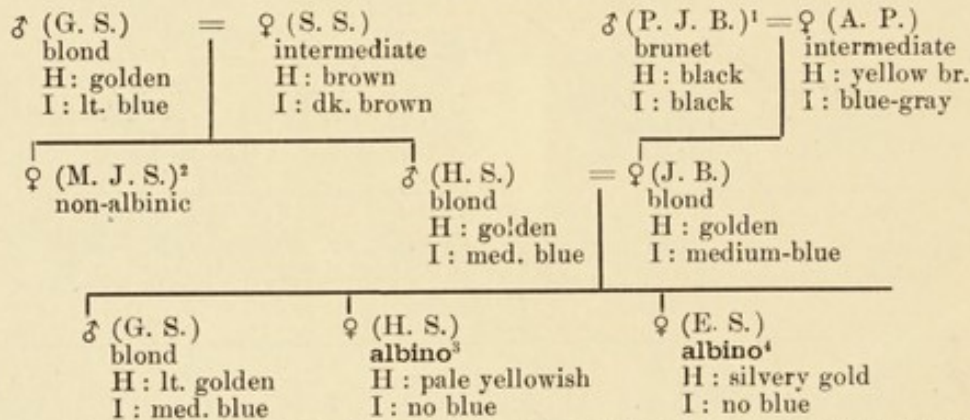


6. PAR. FAMILY



(b) Albinos in Families with Suspected Consanguinity

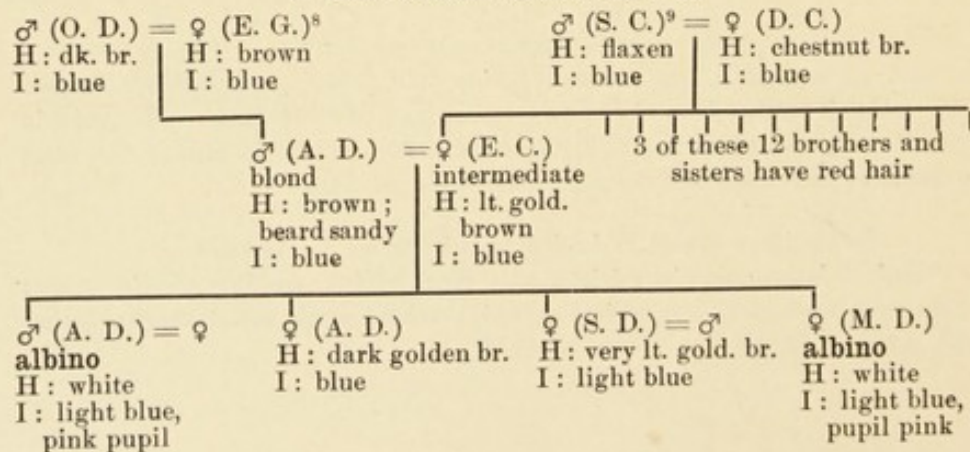
7. SAC. FAMILY



Note.—Seen by C. B. D. and S. E. ¹ and ² have the same middle name. ³ and ⁴ show reddish glow through pupil.

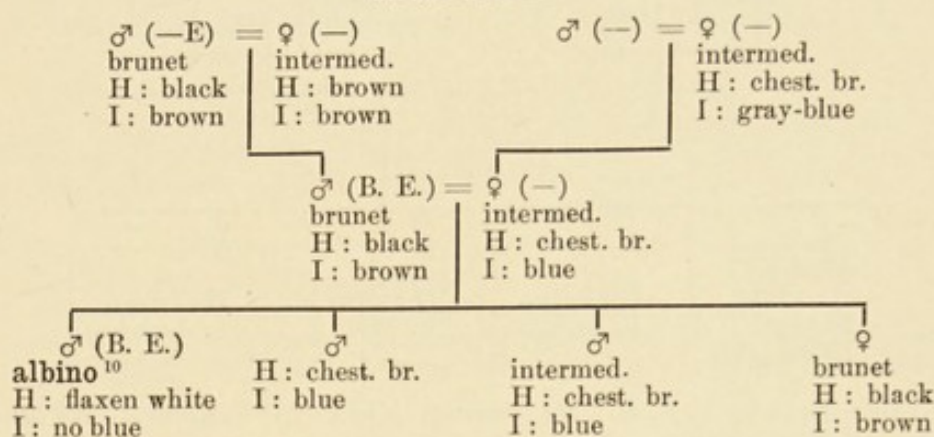
(c) Albinos in Caucasian Families with no Evidence of Consanguinity

8. DON. FAMILY (IRISH ORIGIN)



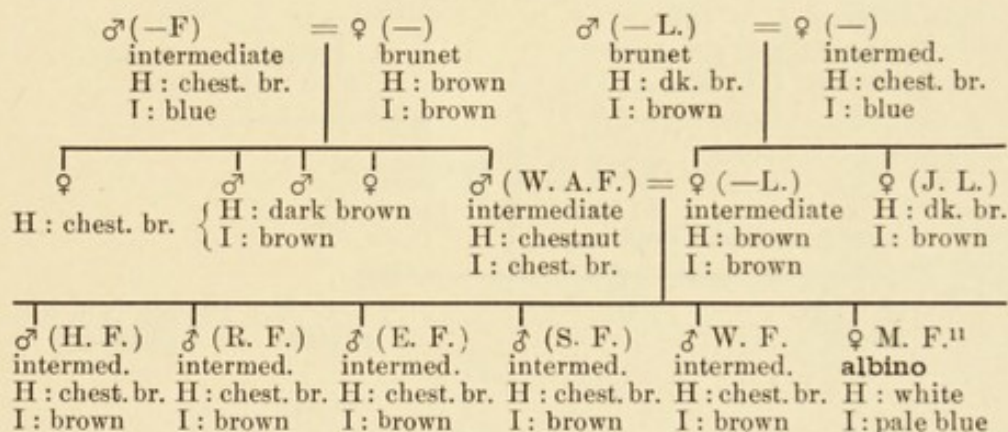
Note.—Seen by C. B. D. No relative on either side known to be an albino.

## 9. ED. FAMILY



Note.—Seen by S. E.

## 10. FAR. FAMILY



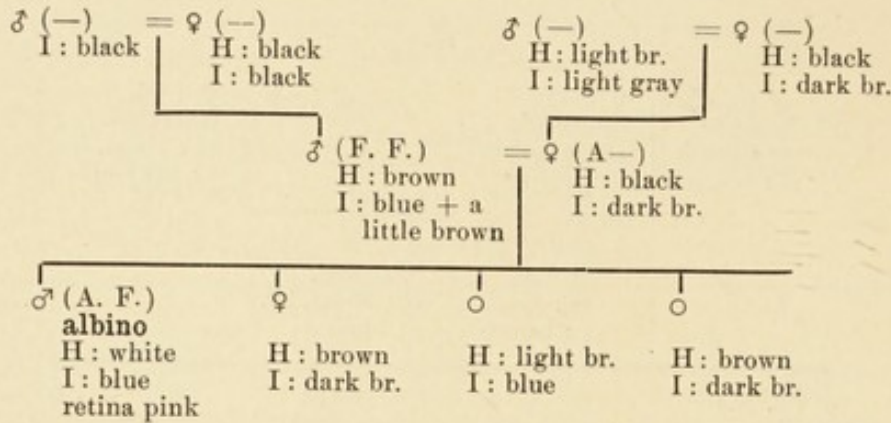
<sup>8</sup> Some relatives with sandy hair.

<sup>9</sup> Many of his relatives have red hair.

<sup>10</sup> Hair white as snow; retina with bright pinkish glow; nystagmus moderate; shortsighted; can read 9 pt. Modern (Roman) type at three inches from eyes; school work middling. Red hair in ancestry, three generations back.

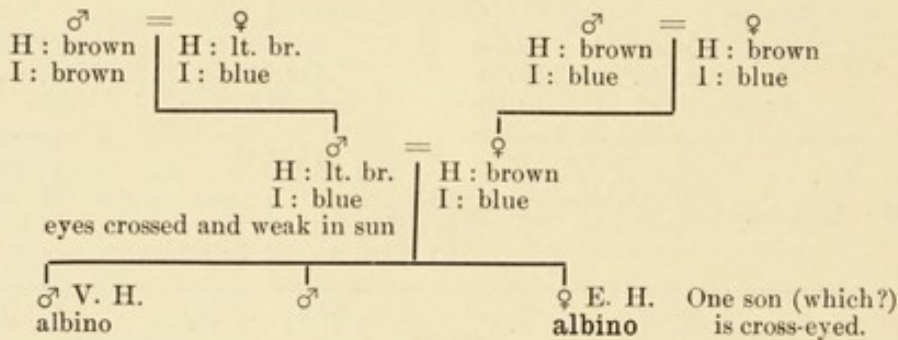
<sup>11</sup> Seen by S. E. Retina, medium pinkish glow; nystagmus slight; reads, No. 9 Modern (Roman) print at nine inches; school work satisfactory. No consanguinity known.

11. FER. FAMILY (ITALIAN)

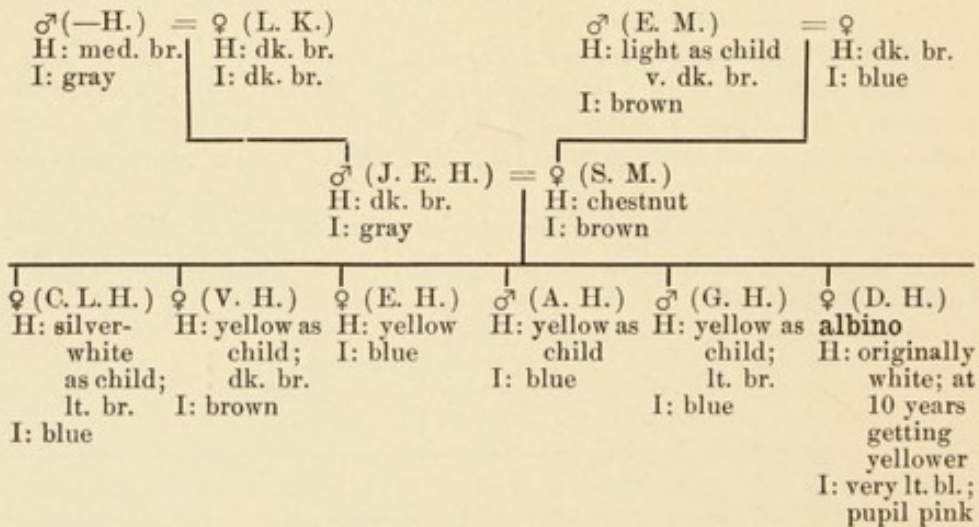


Note.—Seen by C. B. D. No consanguinity so far as known. No other albino relatives recalled.

11a. HLO. FAMILY (BOHEMIAN)

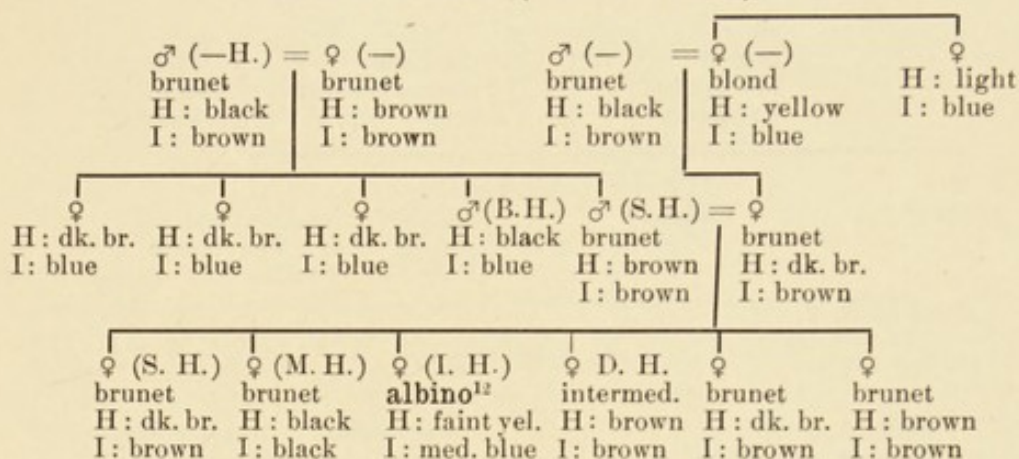


12. HOR. FAMILY



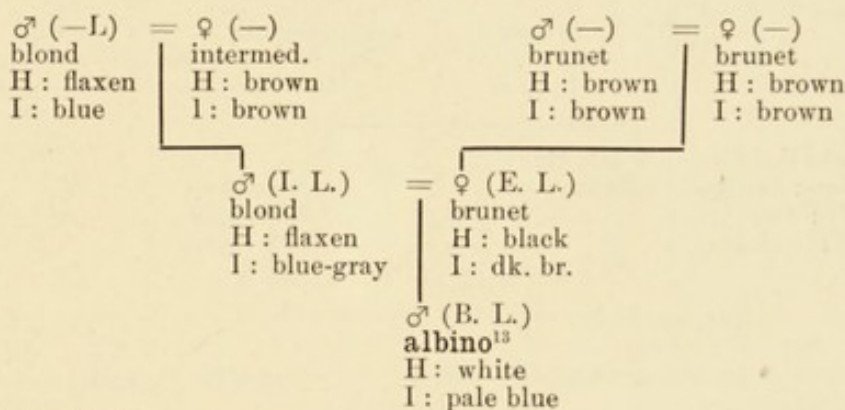
Seen by C. B. D. Nystagmus present.

13. HUF. FAMILY (GERMAN ORIGIN)



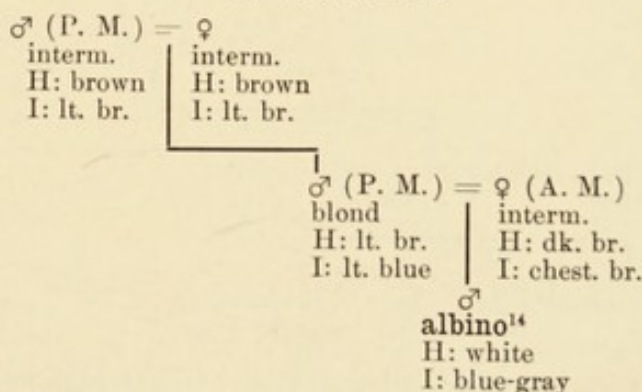
Seen by S. E.

14. LIE. FAMILY



Seen by S. E.

15. MCG. FAMILY



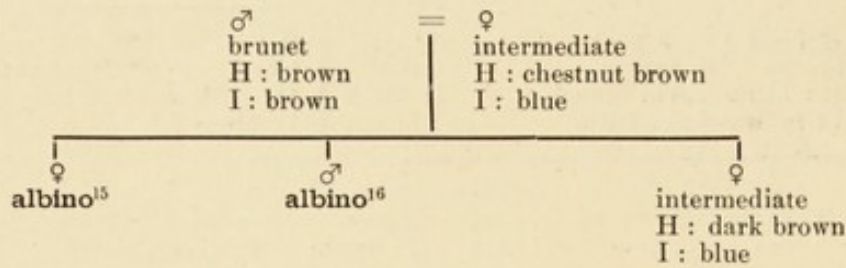
Seen by S. E.

<sup>12</sup> Retina with slight pinkish glow; nystagmus present in moderate degree; congenital hypermetropia.

<sup>13</sup> Retina pigmented; nystagmus present; nearsighted.

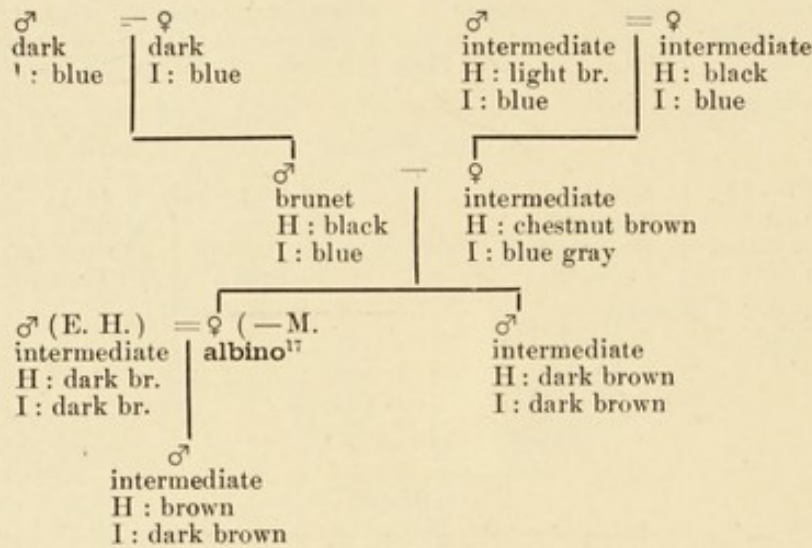
<sup>14</sup> Retina pinkish; nystagmus present; very slight internal strabismus; general intelligence; average at school work, reads readily; sight good except in bright light.

## 16. MCK. FAMILY



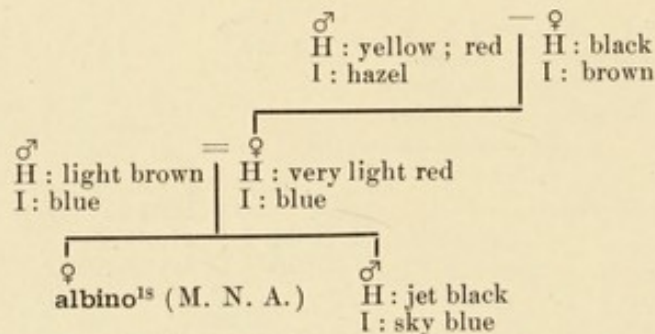
Seen by S. E.

## 17. MOO. FAMILY



Seen by S. E.

## 18. NEA. FAMILY



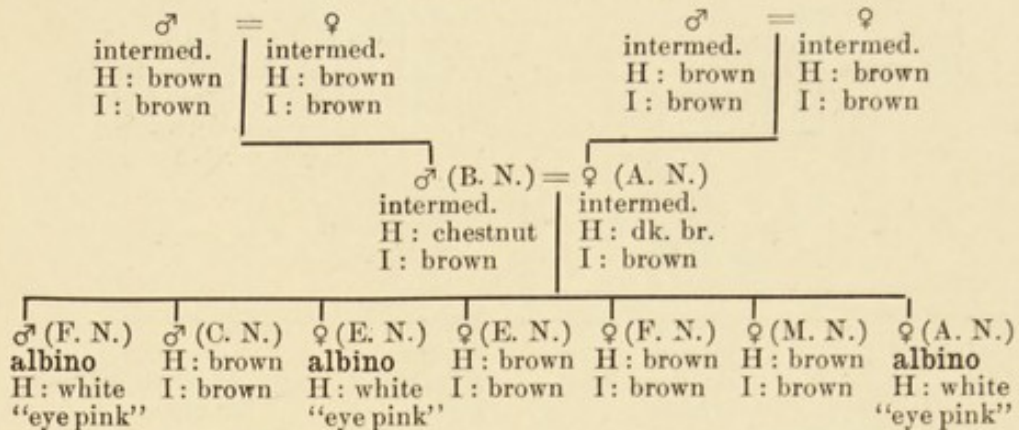
<sup>15</sup> Hair white; iris pale blue; retina pinkish as seen through pupil; nystagmus present; slight internal strabismus; work at school very difficult, sight growing weaker.

<sup>16</sup> Details as above. Eyes stronger, can read No. 9 point at 18 inches.

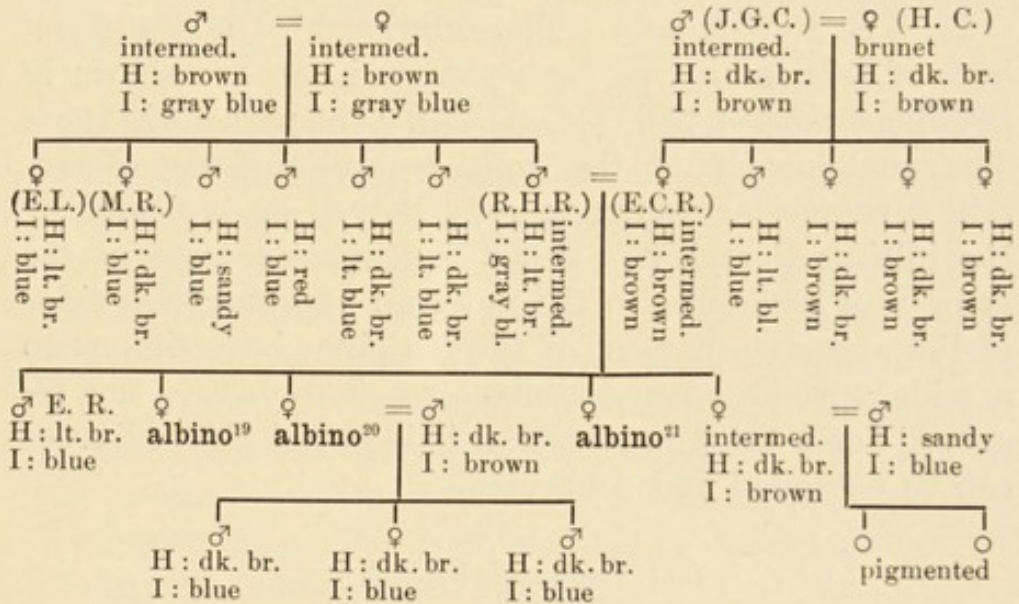
<sup>17</sup> Hair white; iris light blue, retina dark (almost black), nystagmus present, has congenital high degree of myopia. Fairly good at school, can see to sew at night, bright in conversation.

<sup>18</sup> Complexion very fair, hair white, iris clear blue.

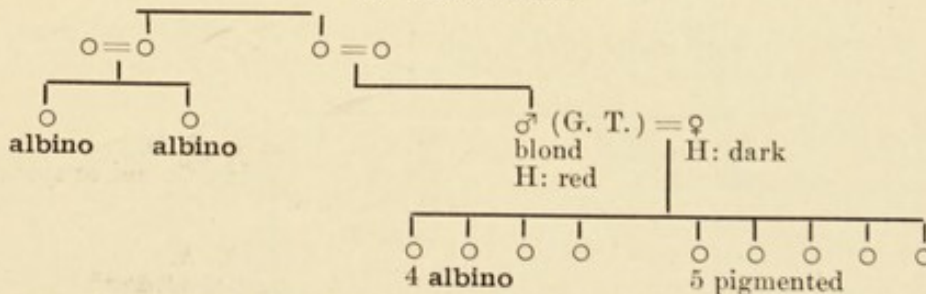
19. NOG. FAMILY (ITALIAN)



20. RID. FAMILY



21. THO. FAMILY

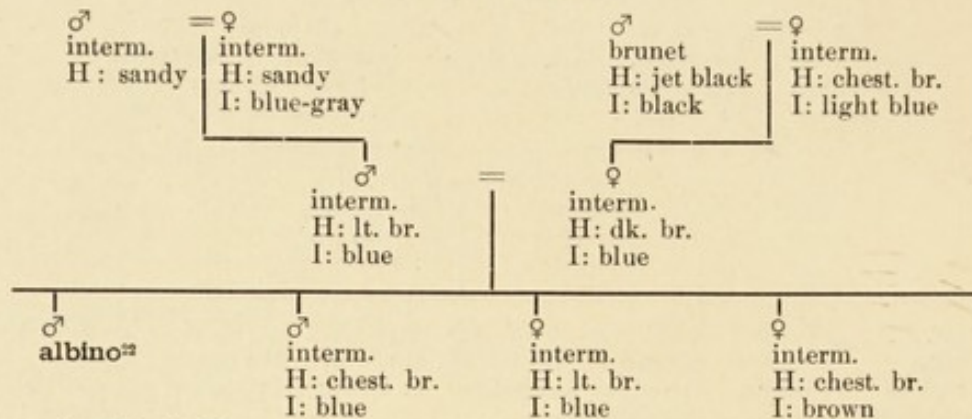


<sup>19</sup> Hair, faintly yellowish; iris, devoid of blue; retina with medium pinkish glow; nystagmus moderate; myopia, school work satisfactory; read a good deal; sparetime spent in weaving seats of cane chairs.

<sup>20</sup> Hair faintly yellowish; iris devoid of blue; retina with medium pinkish glow; nystagmus moderate; myopia; school work middling.

<sup>21</sup> Hair faintly yellowish; iris pale blue; retina with medium pinkish glow; nystagmus moderate; myopia; school work middling.

## 22. WIL. FAMILY

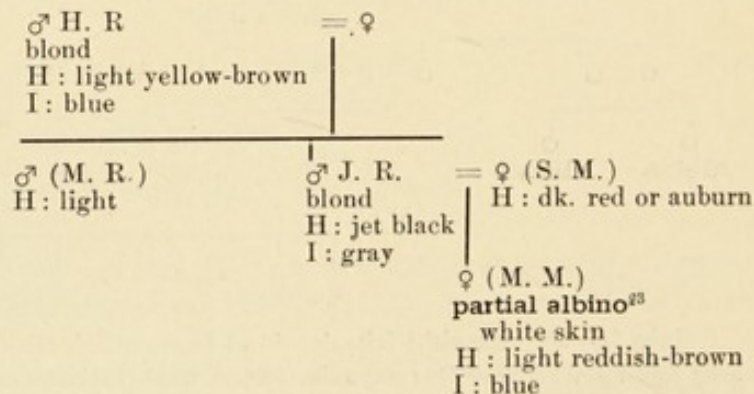


Seen by S. E.

23. The P-W family. The relationships of the members of this family, so far as worked out, are shown in the diagrams 23a, 23b, 23c and 23d. The persons in these diagrams come from the same general region and several surnames are common, especially those indicated by the initials P and W. The frequent recurrence of the same four surnames in the paternal and maternal sides of the ancestry of most of these albinos is testimony to a wide spread consanguinity. Further details are reserved for a later paper when it is hoped the pedigrees can be extended and connected.

## (d) Colored Families

## 24. MER. FAMILY



<sup>22</sup> Hair white; iris pale blue; retina bright pink; nystagmus marked; eyes sensitive to bright light, sees better in half light. "Kept up with the rest in school."

<sup>23</sup> Seen by C. B. D. Retina not pink. Slight nystagmus.





TABLE B

GIVING THE NUMBER OF NORMAL AND OF ALBINIC OFFSPRING OF AN ALBINIC INDIVIDUAL MARRIED TO A NORMAL.

N, normal; A, albinic, D, the dominant character; R, the recessive.

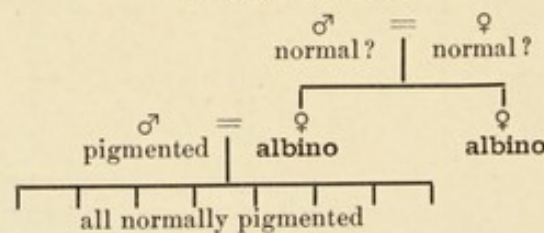
D	R	DR (=N)	RR (=A)
N ♀	A 4 ♂ <sup>25</sup>	0	0
N ♂	A 7 ♀	0	0
N ♂	A 9 ♀	1	0
N ♀	A 11 ♂	1	0
		2	0

If we consider *both* parents of the fourteen albinos listed in Table A as simplex in pigment, *i. e.*, as having not only normal but also albinic germ-cells, they were "DR's." When two such simplex (DR) individuals are mated, we expect 25 per cent. of the offspring to be duplex (DD), 50 per cent. simplex (DR or RD), and 25 per cent. without pigment (RR). Only the last will be albinic, 75 per cent. will be of normal color. We actually find that with fourteen albinos there are associated in their fraternities 37 + or 38 + normal individuals, expectation being 42. The deficiency would doubtless be accounted for by the unincorporated normal children. Since the proportion of albinic offspring in the given fraternities accords with expectation on the assumption that albinism is recessive that assumption is justified.

Second, if albinism is recessive, it should not appear in offspring of albinos with normal consorts. Unfortunately the sterility of the cross makes it difficult to get the desired data, but so far as they go, they are not in disaccord with hypothesis.

### III. ONE PARENT ALBINIC

#### 26. EDD. FAMILY



<sup>25</sup> These numbers refer to the serial numbers of the cases as given in Table A.



## IV. THE D. G. V. FAMILY (see Plate)

This remarkable family comprises a great mixture of white, negro and even Indian blood, as well as many consanguineous marriages. The MAN family comes from the same rural community, but its connections with the D. G. V. family have not yet been established. It will be observed that every albino has the blood of all three families D., G. and V., so it can not be said, at present, from which family albinism originally came. It will be noted, also, that both of the youngest family (whose history is best known) arise from cousin marriages. Considering only those families in which albinism actually occurs there are 8 albinos in 22 children, which is a greater proportion than the expected 25 per cent. (5 or 6 albinic offspring). It is clear, however, that it may well be that there is potential albinism in one or more of the families with 3 to 5 children, in which by chance it fails to appear—the 22 children are merely a minimum.

Details about some of the persons in this family follow:

V.<sup>1</sup> 7, Yellowish complexion, brown hair and iris.

V. 8, Yellowish complexion, light brown hair, blue iris.

V. 9, An almost white mulatto, very light brown hair, blue iris.

V. 10, An almost white mulatto, brown hair, blue iris.

VI. 4, Intermediate complexion, light brown hair, gray iris.

VI. 5, Yellowish complexion, light brown hair, blue iris.

VII. 1, T. V., aged 3, albino, hair white, iris colorless, retina with pinkish glow, nystagmus present, intellectually bright and well developed.

VII. 2, F. V., aged 4, intermediate complexion, hair and iris dark brown.

VII. 3, M. V., aged 1, brunet, hair and iris black.

V. 20, J. V. (Indian, French and negro blood), yellow skin, very light brown hair, yellow iris.

<sup>20a</sup> The Roman numeral refers to the generation; the Arabic to the individual.

TABLE IX

SHOWING THE HAIR AND EYE COLOR OF PARENTS AND GRANDPARENTS OF ALBINOS ARISING FROM PIGMENTED PARENTS

No.	Name.	Father.		Mother.		F.F.		F.M.		M.F.		M.M.	
		Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye.	Hair.	Eye.
4.	She.	br	br	dk.br	br	br	br	yell.br	bl	N	br	lt.br	bl.
5.	Enn.	N+R	br	N(+R)	dk.br	dk.bl	dk.bl	N	dk.br	yell.br	lt.br	N	dk.br
7.	Sac.	gold	bl	gold	bl	lt.bl	lt.bl	br	dk.br	N	N	N	bl.gr
7a.	Bro.-7	dk.br	N	dk.br	bl.	—	—	—	—	—	—	—	—
8.	Don	br+R	bl	lt.goldbr.	bl	bl	bl	br	br	flax	bl	bl	bl
9.	Ed.	N	br	chest.br	bl	bl	chest.br	br	br	dk.br	br	chest.br	gray bl
10.	Far.	chest	chest.br	br	br	—	—	N	N	lt.br	lt.gray	chest.br	bl
11.	Fer.	br	bl	N	dk.br	lt.br	lt.br	br	br	br	bl	N	dk.br
11a.	Hlo.	br	bl	br	br	gray	gray	dk.br	dk.br	lt. to dr.br	br	dk.br	bl
12.	Hor.	dk.br	gray	chest	br	br	br	br	br	N	br	yell.	bl
13.	Hut.	br	br	dk.br	br	br	br	br	br	br	br	br	br
14.	Lie.	flax	bl.gray	N	dk.br	bl	bl	—	—	—	—	—	—
15.	Meg.	lt.br	lt.bl	dk.br	chest.br	lt.br	lt.br	br	lt.br	—	—	—	—
16.	Mek.	br	br	chest.br	bl	—	—	—	—	—	—	—	—
17.	Moo.	N	bl	chest.br	bl.gray	bl	bl	—	bl	lt.br	bl	N	bl
18.	Nea.	lt.br	bl	v. lt. red	bl	—	—	br	—	yell.red	hazel	N	br
19.	Nog.	chest	br	dk.br	br	br	br	br	—	br	br	br	br
19a.	Pit.	N	N	dk.br	bl	blue	blue	N	N	light	bl	N	br
20.	Rid.	lt.br	gray bl	br	br	gray bl	gray bl	br	gray bl	dk.br	br	dk.br	br
21.	Tho.	red	—	dark	—	—	—	—	—	—	—	—	—
22.	Wil.	lt.br	bl	dk.br	bl	—	—	sandy	bl.gray	N	N	chest.br	lt.bl

V. 21, M. (Irish origin), brunet, black hair, blue iris.

VI. 10, J. V., Brunet, brown hair, blue iris.

VI. 11, S. G., Intermediate complexion, brown hair and iris.

VII. 15, A. V., Aged 18, albino, white hair, colorless iris, retina pinkish, nystagmus present, mentally quick.

VII. 18, L. V., Aged 24, albino, white hair, colorless iris.

#### V. THE CONDITION OF HAIR AND EYE COLOR IN THE PIGMENTED PARENTS OF ALBINOS

Assuming all pigmented parents of albinos to be simplex in pigment we may inquire if such simplex parents differ from the population at large in their hair and eye color. To get an answer to this inquiry Table IX has been drawn up.

This table is summarized in Table X, so as to bring out the relative frequency of the different types.

TABLE X

THE RELATIVE FREQUENCY OF THE DIFFERENT TYPES OF HAIR AND EYE COLOR IN THE PARENTAGE OF ALBINOS

Hair Color.								Eye Color.							
Types.	F.	M.	FF.	FM.	MF.	MM.	Total.	Types.	F.	M.	FF.	FM.	MF.	MM.	Total.
N (black)	3	2	3	3	3	5	19	N (black)	2			2	2		6
dk. br.	2	8	1	1	2	2	16	dk. br.		3		3		2	8
br.	5	3	6	10	4	3	31	br.	6	6	4	5	7	5	32
lt. br.	4				2	1	7	lt. br.			2	1	1		4
golden	1	2	2	1	1	1	8	chest. br.	1	1					2
yellow						1	1	hazel					1		1
flaxen	1		1		1		3	gray	1		1		1		3
red+N	1	1					2	blue-gray	2	1	1	2		2	8
red+dk.br.	1						1	blue	7	9	6	4	4	7	37
chestnut	2	4	1			3	10	lt. blue	1		1			1	3
red	1	1			1		3								
Total	21	21	14	15	14	16	101	Total	20	20	15	17	16	17	105

If Table X be compared with the proportional distribution of the different types of hair color in the population at large, certain differences are seen. Thus while black, dark brown and brown hair constitute in a random

population (Holmes and Loomis, 1909, p. 55) 695 out of 853 persons, or 81.5 per cent., in Table X, they constitute only 65 per cent. On the other hand, while, according to Holmes and Loomis (1909, Table III), red and auburn constitute only about 5.5 per cent. of their population, the various forms of red constitute 16 per cent. of the population of Table X, or three times the typical proportion. It appears then that, on the whole, the pigmented ancestry of albinos shows an excess of red and the weaker grades of melanic pigment.

The distribution of eye color, on the other hand, shows little that is abnormal. The "blacks" are somewhat deficient, about 70 per cent. as abundant as in the population as a whole, the browns are in excess, and the blues occur in nearly normal proportions. The last result was hardly anticipated as it might have been expected that the pale blue iris of the albino would be specially apt to proceed from blue-eyed parents, but this is not so. As a matter of fact, dark brown eyes are quite compatible with recessive albinism as Table XI shows. The general teaching of Table XI is that the heterozygous or simplex pigmentation of the offspring is not always clearly less than that of the darker parent. But, on the whole, blue iris predominates slightly and the hair tends to run

TABLE XI

SHOWING THE HAIR AND IRIS COLOR OF THE OFFSPRING OF AN ALBINO AND A PIGMENTED PARENT

Family.	Parents.			Offspring.	
	Albino.	Pigmented Parent.		Hair Color.	Iris Color.
		Hair Color.	Iris Color.		
Enn.	♂	N	dk. br.	br.	dk. br.
Moo.	♀	dk. br.	dk. br.	br.	dk. br.
Nea	♀	pigmented	pigmented	lt. br.	lt. br.
				br.	blue
				blond	blue
				jet black	—
Rid.	♀	dk. br.	br.	dk. br.	blue
				dk. br.	blue
				dk. br.	blue

lighter than, or at least not to exceed, that of the darker parent.

#### VI. THE ORIGIN AND "CAUSE" OF ALBINISM

The question remains to be discussed: What is the origin and "cause" of these albinos. The general conclusion seems justified, as in other mammals so in man, albinism is due to the fortuitous union of two germ-cells lacking this factor so that it is absent in the zygote whence the albino proceeds.

The objections to this view are three: (1) The usual absence of any history of albinism in the family; (2) the improbability of so frequent unions of two persons bearing albinism recessive; (3) the lack of statistical accord of the results of human breeding with those of animals.

The first objection is not valid for any one who has done experimental breeding, because he knows full well how the recessive condition may be carried unexpressed in the germ-cells for many generations awaiting that chance conjugant that also carries the recessive condition. Absence of any history of albinism in a family has the less significance in a country like ours where a large proportion of the population can not tell the names of their grandparents and know little of their cousins, who may, indeed, live one to three thousand miles away.

The improbability of so frequent unions of two or three persons having albinism recessive has been referred to by Pearson. With a mathematical showing, he tells the story of an albino who married successively two pigmented (?) husbands and had some albino children by each. "All three stocks, according to Mendelian hypothesis, ought to have albinism in a recessive form. You can calculate the chances against that because an albino occurs in Italy about 1 in 30,000, in Norway, about 1 every 20,000 of the population, in Scotland, 1 in 24,000. What are the chances that a woman of albinotic stock should marry two stocks affected with albinism and not related either to her or to each other?" The inference

seems to be that Pearson would be content with "calculating the chances" and, because the ratio was small, insisting that the three stocks could not all have albinism recessive. Such a method of procedure is, I fear, all too characteristic of the "careful work" which alone, according to its editor, is admitted to the pages of *Biometrika*.<sup>26</sup> Of course the facts are that we have here no data for calculating the required chances. In the first place, the term "not related" has only a relative significance in the statistics of human qualities; it usually means not first cousin or nearer relative, more rarely extends to second cousin, or at the outside, to third cousin. And yet two persons of the grade of tenth cousin may easily carry recessive an albinic condition derived from a common source. A fairer question would be, what are the chances that a woman shall marry in succession two men related between the grades of third and tenth cousin, supposing, further, all three come from the same rural district, long settled and relatively stable? I think the conditions that Pearson does not cite might easily render the chances several million to one in favor of the three persons being less distantly related than tenth cousin. An actual illustration of this condition of affairs is shown in the D. G. V. and P. W. families. The three family names represented by D., G. and V. occur again and again in this family, as the pedigree table shows. Some of the consorts are recognized as "first cousins"; but in most other cases they are stated to be "unrelated." If the inquiry is pressed the admission is made "were perhaps *distantly*." One may "calculate the chances" that in the same mountain community, of perhaps 300 inhabitants, who are all segregated by color from the surrounding population; two persons of the same name (uncommon outside the community) are absolutely *unrelated*, or unrelated outside the degree of seventh cousin. But even in a flat

<sup>26</sup>In justice it should be added that the remark was not made in *Biometrika*.



country, penetrated by a railroad, we find, as in the P. W. family, a large proportion of consanguineous marriages. The argument against the probability of unions with recessive albinism has not yet been presented with any force.

The third point—the lack of statistical accord between the results of human breeding and those of animals—has been often remarked upon. Bateson (1909, p. 28, footnote) believes the descent of albinism in man to be complicated by some unascertained disturbance. A careful consideration and analysis of the statistics indicates, I think, that this disturbance is to be found in the method of collecting the statistics. From the matings of two persons that are simplex in pigmentation, two sorts of families are to be expected, namely, those with albinos and those without. Since in the long run, from such parents, only one albino is produced in four offspring, it is clear that the chances are that in all families of one,

TABLE XII

GIVING ALL FAMILIES CONTAINING ALBINO OFFSPRING FROM TWO PIGMENTED CAUCASIAN PARENTS

Reference.	Offspring.				Reference.	Offspring.			
	Albinic.	Pigmented.	Total.	Per Cent. Albinic.		Albinic.	Pigmented.	Total.	Per Cent. Albinic.
She.	1	3	4	25	Tho.	4	4	9	60
Enn.	7	7	14	50	Wil.	1	3	4	25
Sac.	2	1	3	67	P-W.a.	1	11	12	8
Don.	2	2	4	50	P-W.a. III. 15	5	3	8	62
Ed.	1	3	4	25	P-W.b. II. 2	2	7	9	22
Far.	1	5	6	17	P-W.b. IV. 3	1	2	3	33
Fer.	1	3	4	25	P-W.c. I. 1	1	0	1	—
Hlo.	2	1	3	67	P-W. VI. 1	1	3	4	25
Hor.	1	5	6	17	P-Wd. III. 11	1	0	1	—
Huf.	1	5	6	17	P-W. IV. 1	1	12	13	7
Lie.	1	0	1	—	D.G.V. II. 1	4	1	5	80
McG.	1	0	1	—	D.G.V. IV. 5	1	2	3	33
McK.	2	1	3	67	D.G.V. VI. 10	2	8	10	20
Moo.	1	1	2	50	D.G.V. V. 24	1	3	4	25
Nea.	1	1	2	50	Men.	1	0	1	—
Nog.	3	4	7	42	Man.	6	3	9	67
Ria.	3	2	5	60					
					Totals.	64	107	171	374

two or three children albinism will not appear. Even in families of four or more the possible case of albinism may fail to occur. All such cases of an actual low ratio of albinism are omitted from any calculation of proportions; chiefly the accidentally high ratios are brought under consideration. The actual proportions of albinos to all offspring of two pigmented parents are given for each family in Table XII.

These 33 families together with two not plotted in the diagrams are summarized in Table XII.

TABLE XIII

THE PROPORTION OF ALBINOS IN ALBINIC FAMILIES OF DIFFERENT SIZES,  
WHEN NEITHER PARENT IS ALBINIC

No of Children in Family.	No. Albinic.	Per Cent. Albinism.	Families.	Total Number of Families.
1	1	100	Lie., Mcg., P.W. (bis)	4
2	1	50	Moo., Nea.	2
3	2	67	Sac., Mck.	2
3	1	33	Vin., D.G.V., P.W.	3
4	2	50	Don.	1
4	1	25	She., Ed., Fer., Gur., Wil., D.G.V., P.W.	7
5	4	80	D.G.V.	1
5	3	60	Ria.	1
6	2	33	Wes.A.	1
6	1	17	For., Hor., Huf.	3
7	1	14	P.W. (not platted)	1
7	3	42	Nog.	1
8	5	63	P.W.	1
9	6	67	Man.	1
9	4	44	Tho.	1
9	2	22	P.W.	1
10	2	20	D.G.V.	1
12	1	8	P.W.	1
13	7	54	Enn.	1
13	1	8	P.W.	1
				35

Taking Table XIII in its entirety there is an average of 44 per cent. albinos to a family where expectation is 25. If we consider only the families with four or more children we find the average proportion of albinos to be 34 per cent. If we take families with six or more children the average proportion of albinos falls to 32 per

cent.; with 10 or more children to 23 per cent. On the average, with the larger families the proportion of albinos tends to approach expectation.

A second source of error is not to be neglected. When the attention of the parent or acquaintance is focused by the questioner upon albinos the albinic children are all recalled, while some normal children (such as were still-born or died in infancy) are more apt to be forgotten. I have repeatedly had the experience of bringing to mind by further questioning children that had not been at first mentioned, and they were always normal children. The records of families with only one child and that an albino are frequently due to the fact that the peculiar child is the only one recalled. Considering the high frequency of infant mortality the omission of normal children forms an important factor tending to raise the proportion of albinos.

A third possible source of error lies in imperfection of dominance, *i. e.*, the occasional failure of the pigment to show itself in the young children who have it simplex. Of this imperfection there are all degrees. Thus the albinos in the LIE (No. 14) and Moo (No. 17) families have a dark retina with white hair, washed-out blue iris and nystagmus. In other cases, such as the RID family (No. 20) and P-W,<sub>A</sub> (XII, 24, 25), the hair is yellowish, while the retina is pink, or the pinkish retinal glow and nystagmus may be slight. Another fact that favors the view of frequent failure of the simplex determiner to activate fully is the progressive increase in pigmentation shown by some albinos. This is a common phenomenon. Seligsohn in Eulenburg's "Real Encyclopädie," 1880, p. 162, states: "Bei einem vngesunden Eltern mit allen Merkmalen einer Albino geborenen Kinde schwand die rothe Farbe der Iris von Jahr zu Jahr." This increase in development of a simplex character has been observed by Lang in snails, by one of us in poultry and by others.

In concluding this discussion of the causes of the aberration in the proportion of albinos I wish to urge that

what is needed in these studies is not so much a vaster number of families as more families that have been completely and accurately studied. Human pedigrees, like breeding records, are full of imperfect statements. The whole truth is to be gained only by visiting the families and carefully cross questioning them.

## VII. CONCLUSIONS

What conclusions can be drawn from a study of the foregoing study of albinos?

1. Two albinic parents have only albinic offspring. This holds for the families Nos. 1-3, comprising four children altogether. These cases were all given us by Mr. R. R., an intelligent and reliable albino. He married an albino and had one son still, or until recently, living; albinic like his parents. These cases are, so far as I know, the first that have been published.

Dr. R. A. Gortner tells us that he formerly knew of a family of two albino parents and five albino children near his home in Nebraska, but attempts to trace this family have proved unsuccessful. The probability that this rule will hold generally is enhanced from experiments on animals where two albinos always yield only albino offspring.

2. Even when neither parent of albinos is an albino they are apt to be related. In 33 such families 11 are almost certainly from consanguineous matings. This is 33 per cent., a proportion that is certainly vastly greater than that of the population at large.<sup>27</sup> The fact that consanguinity even when present must frequently be unknown heightens the probability that parents of albinos are usually related. The importance of this conclusion is that it tends to bring these cases under the general rule that a recessive condition appears only when both parents carry the same defect; and the probability that both carry the same defect is heightened when both belong to the same strain.

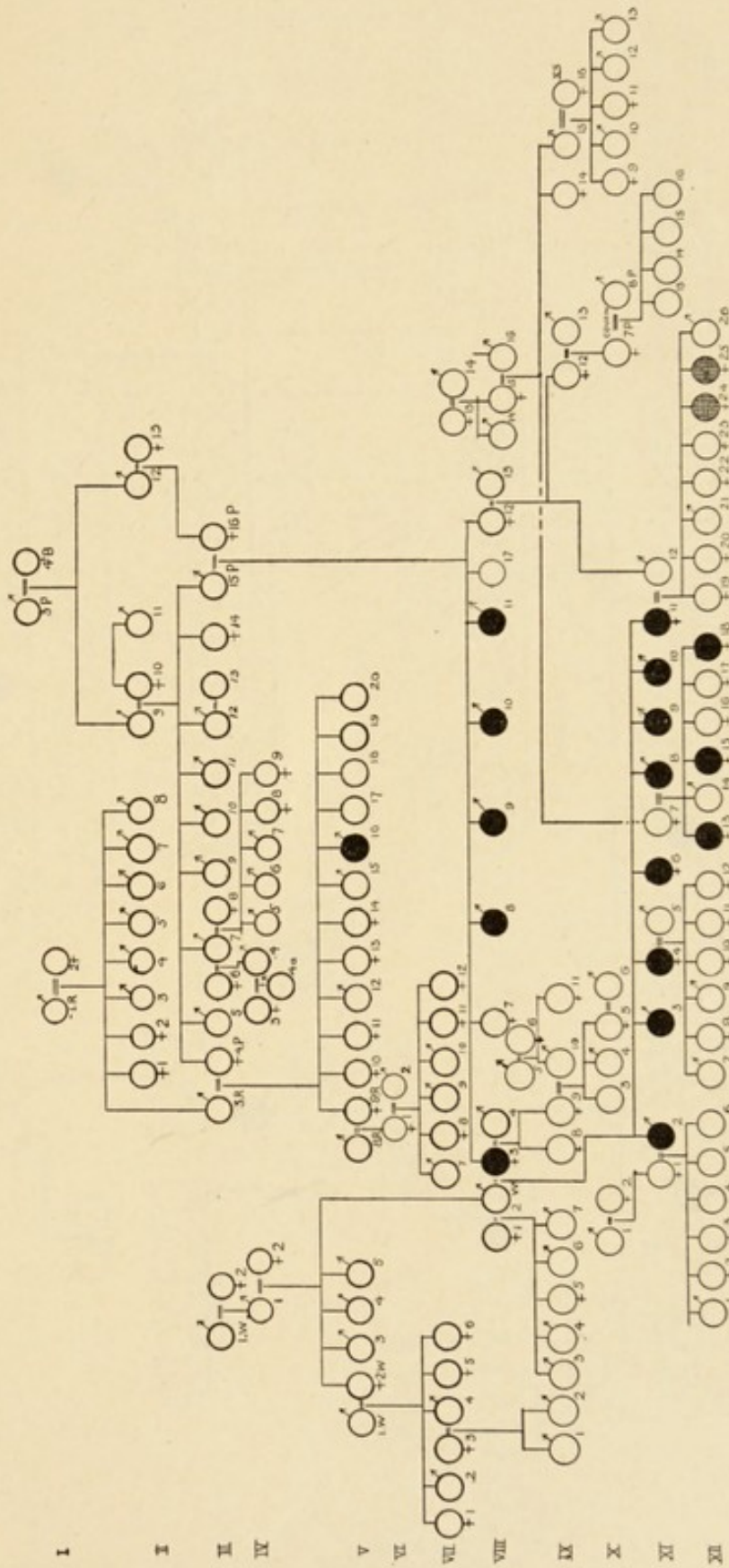
<sup>27</sup> Lagleyze (1907) finds in 48 families of albinos consanguinity in 10, with collateral antecedents in 7, non-consanguinity in 26, and unknown 5.

3. The proportion of albinos in any family probably accords in the long run with Mendelian expectation, as in other mammals. From two non-albinic parents the proportion for families of four or more children is 34 per cent. albinos instead of the expected 25 per cent. But various causes result in an omission of normal individuals and tend to swell the proportion of the abnormal. When one parent is albinic and albino offspring occur at all we get (RID and 4 cases in P. W.), a total of 16 albinos and 15 pigmented, which accords with expectation.

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September 8, 1910.

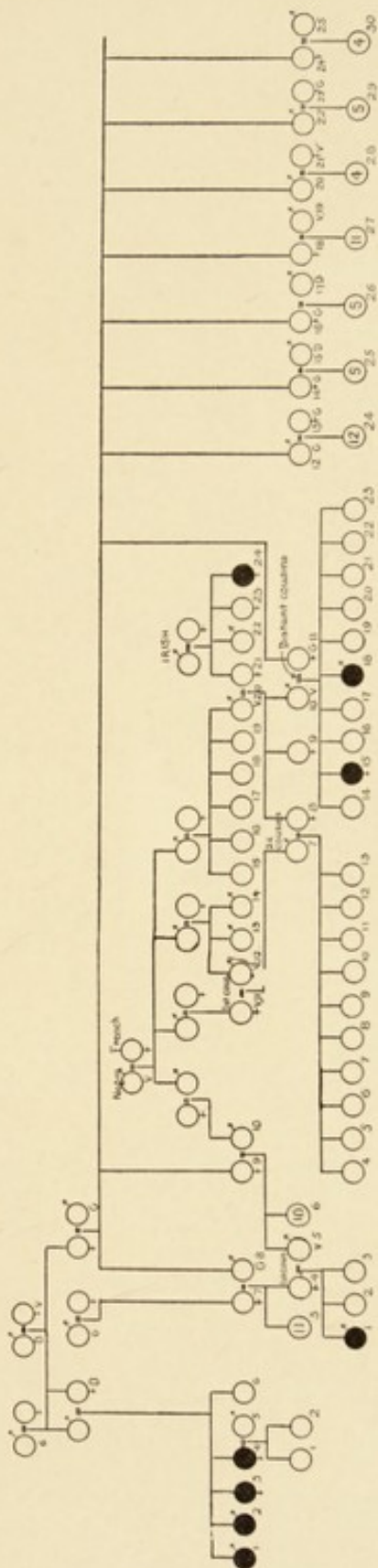
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23a Family.





D. G. V. Family













