Interesting conclusions follow from these observations. The interblink periods of each subject when awake and when in the resting condition were sensibly identical, whereas in sleep bilateral lid movements ceased entirely. There was no indication in either case of any slowing down of the blink-rate with the approach of sleep; indeed, on one occasion the female subject ceased blinking immediately after three lid movements each separated in time by less than one second. It appears that the time taken for the transition from consciousness to unconsciousness under natural conditions is not more than one or two seconds. There was no clear indication that the degree of closure of the eyes during sleep was greater than when the eyes were closed voluntarily during resting periods.

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¹ "Text-Book of Ophthalmology", 1, 644 (Henry Kimpton, London, W.C.1, 1942).

Three Pedigrees for Colour Blindness

THREE pedigrees have been found which are of interest in relation to the two-locus theory of the inheritance of red-green blindness formulated by Waaler¹ and Franceschetti², and summarized by Gates³. The present hypothesis suggests two series of alleles with near loci on the X-chromosome, N , r , r' , p and N' , g , d' , d , in which N and N' stand for the normal genes, r for red anomaly, r' for red anomaly with darkened red⁴, p for protanopia, g for green anomaly, d' for deviant or anomalous deuteranopia⁵, and d for ordinary deuteranopia. The orders of dominance are believed to be as shown above, N and N' being the most dominant. The two-locus theory is supported by the observation that certain women carrying genes from both series are of normal phenotype^{4,5,6,7}, and the discovery all over the world of fewer women defectives⁸ than would be expected on the single-locus theory by the calculation given by Ford⁸.

In Pedigree I there are two green anomalous sisters whose brother (deceased) was believed to be normal. These sisters married men who were believed to have normal colour vision because they were employed on the railway. One, who was tested by me, was normal; the other (deceased) had not been suspected of any defect. The first sister had four children: a normal daughter, one deuteranope son, one green and one red anomalous, all tested by me. The other sister had two sons, one a deuteranope, exactly like his cousin in every detail of colour vision, married to a normal woman and having two sons believed normal

but too young to test. The other (deceased) was believed to have been a deuteranope.

In order to explain this pedigree, we may assume that the two sisters were both double heterozygotes of genotype rg/Nd , and their brother $NN'/-$, using the system of notation suggested by Ford⁸, in which the oblique line separates genes on different chromosomes. Their deuteranope sons would be $Nd/-$, while the green and red anomalous sons would be produced by crossing-over, the green anomalous being $Ng/-$ and the red anomalous $rd/-$. The genotype of the red anomalous son is a conjecture based on the assumption that the gene which is more dominant in its own series would be more effective in this combination than the gene of lower dominance in the parallel series. Another conjecture would be that the genes r and d together would produce only that quality in the phenotype which they could share. The red anomalous colour match in the Rayleigh equation is a possible match for a deuteranope, whereas all other possible deuteranope matches would be impossible for red anomalous vision. The latter conjecture would apply only when the red end of the spectrum is not darkened in red anomalous vision, as in the present case.

The normal daughter might be of genotype rg/NN' , a double heterozygote in which the two defective genes in different loci have equal and opposite effects, and probably cancel each other out. De Vries has suggested that this combination is of normal phenotype⁶.

Pedigrees II and III illustrate the possibility that a man of normal phenotype may have a colour-blind or anomalous daughter and a normal son. In Pedigree II we may assume that the father was of genotype $pd/-$, and of normal phenotype, which has been suggested for this combination when it occurs in a woman in the form pd/NN' . If the mother was a normal heterozygote of genotype pN'/NN' , the daughter would be pN'/pd , a protanope homozygote and a deuteranope heterozygote together. The son, if normal as believed, would be $NN'/-$, or, if not normal, then a protanope, $pN'/-$.

In Pedigree III the father, believed to be normal, might be of genotype $rg/-$, and of normal phenotype because these genes produce equal and opposite effects, while the mother could be the normal red anomalous heterozygote, rN'/NN' . The daughter would be rN'/rg , a red anomalous homozygote and green anomalous heterozygote at the same time, and be of red anomalous phenotype, as found.

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¹ Waaler, G. H. M., *Z. für ind. Abs. und Ver.*, 45, 279 (1927).

² Franceschetti, A., *Schweiz. Med. Wochens.*, 58, 52, 1273 (1928).

³ Gates, R. R., "Human Genetics", chapter 6 (1946).

⁴ Pickford, R. W., *J. Psychol.*, 27, 153 (1949).

⁵ de Vries, H., *Physica*, 14, 367 (1948).

⁶ de Vries, H., *Genetica*, 24, 199 (1948).

⁷ Gray, R. C., *Nature*, 153, 657 (1944).

⁸ Ford, E. B., "Genetics for Medical Students" (2nd edit., 1946).

⁹ Pickford, R. W., *Nature*, 162, 684 (1948).