

Part First.



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ORIGINAL COMMUNICATIONS.

ARTICLE I.—*On the Prevalence of Chromato-Pseudopsis or Colour-Blindness ; its Evils, and the Means of Diminishing its Frequency.*  
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THE co-existence of perfect vision in other respects with an inability more or less complete to distinguish colours from each other, has within the last few years attracted considerable attention. Some very distinguished men, such as Dugald Stewart, M. Sismondi, and John Dalton, have been the subjects of this peculiarity of sight, and the last of them, by reporting his own case, has earned at the hands of the Continental philosophers the unwelcome distinction of giving his name to the peculiarity in question. It has been called Daltonism, and its subjects Daltonians. The countrymen of Dalton have protested against the immortalising of his name, in connection with a personal defect ; and the chemists of all countries might claim that the term Daltonian is needed by them to distinguish those who adopt the famous opinions of Dalton, concerning the atomic constitution of matter. Other terms, accordingly, have been devised for this affection of vision, chiefly of Greek origin, such as *chromato-pseudopsis*, *dyschromatopsis*, *dyschrosis*, *parachromatism*, and the like ; none of which are very euphonious, whilst most of them are far from explicit. The term *chromato-pseudopsis*, i.e., *false vision of colours*, has, upon the whole, been preferred by scientific men, and it very fairly represents the general character of the affection under notice, which more frequently shows itself as an abnormal perception of colours, than as a total inability to discern them. Yet there are cases on record (and I shall have to report one myself, occurring, too, in the person of a house-painter) where the perception of black and white, i.e., of degrees of illumination, was all that existed to represent the sense of colour, so that such a person might be justly said to be *blind to colours*. And in all the subjects of *chromato-pseudopsis*, there exists either inability to discern a single colour, such as red ; or inability to discern the difference between two colours, such as green and red ; so that they may be said, with sufficient propriety, to be blind to red, or blind to the difference between

green and red, *i.e.*, more explicitly, blind to one of two colours presented simultaneously to the eye. It seems, therefore, that the term Colour-Blindness, introduced by Sir David Brewster, may be fully justified as a scientific term; and even if it were less defensible than it is, its employment would be warranted by the necessity which exists for some expressive English name for an affection of vision which, from the evils entailed by it on its subjects and their neighbours, is an object of importance to the entire community. The English word, moreover, has the advantage over the Greek of permitting an adjective and noun to be readily formed from it, so that we can speak of those to whom it refers as colour-blind persons, or as *the* colour-blind; whereas the awkwardness of naming such parties *chromato-pseudopts* or *idiopts*, has been felt by all, and has doubtless been one of the chief causes why so objectionable a phrase as Daltonian has not long ago been discarded.<sup>1</sup>

The authors on colour-blindness have, many of them, been as famous as its subjects; but into the literature of the question it is not my intention to enter, as this has been ably and amply discussed by Professor Wartmann of Lausanne. A translation of his paper appeared in "Taylor's Scientific Memoirs" for 1846, accompanied by notes by the English editor. To this paper, and the works which are quoted in it, I refer those who wish to learn the present state of our knowledge concerning colour-blindness.

The object of the present communication is chiefly practical, and is mainly to direct the attention of the community, and especially of medical men, to the nature and prevalence of the affection under notice. In spite of the papers which have been published on the subject, the extent to which colour-blindness prevails has been so little credited, that more than one eye-surgeon of experience has never examined a case of it; yet, as will appear, cases abound in all ranks and professions throughout the country.

My own special attention was directed to the subject, from the blunders which I found my chemical pupils make, in reference to the colours of compounds. After making every allowance for imperfect exposition on my part, and insufficient attention on the part of my students, and after also making a large deduction from inaccurate answers, on the score of imperfect remembrance, and inability to name colours, I still found, both in the laboratory

<sup>1</sup> The word Daltonian appears to have been in use for fifty years in the Academy of Geneva, and to have been first employed in print in 1827, by Pierre Prevost (*Taylor's Scientific Memoirs*, 1846, p. 158). It was thus introduced into use during the lifetime of Dalton, whose case was published by himself in 1794 (*Mem. Lit. and Phil. Soc. Manchester*, Vol. V.). Whether he was aware of the use made of his name, I do not know, but he certainly would have acquitted the Genevese philosopher of any intention to mock him, by calling those who had the same peculiarity of vision as he possessed, Daltonians. In truth, Dalton seemed rather pleased than annoyed by his colour-blindness, and enjoyed the amusement which his mistakes regarding colours occasioned to others.

and lecture-room, that many a pupil was puzzled to describe the changes which occur when an acid or an alkali acts upon a vegetable colouring matter, although to a normal eye these changes are of the most marked character; and that in general I could count with little confidence upon accurate answers to questions regarding the colours of bodies. At intervals since studying Dalton's account of his colour-blindness, some years ago, the suspicion crossed my mind that some of my pupils must be colour-blind; but I set the notion aside as extravagant, till last winter, when the perplexities which an intelligent laboratory pupil constantly betrayed in deciding on the colours of precipitates, led me to investigate his case, and he soon proved to be a well-marked case of colour-blindness, as, indeed, he had not long before discovered for himself. Another well-marked case showed itself in the person of a middle-aged gentleman attending my lectures, who had become aware of his peculiarity of vision in boyhood. I had thus an opportunity, during several consecutive months, of examining two characteristic examples of colour-blindness, and as the subjects of it were educated intelligent men, who afforded me every facility for testing their sense of colour, I soon learned what were the points of most importance in examining such cases. I have since had the opportunity of examining many additional examples, which I shall report in full in the sequel; but I wish first to mention, that struck by the danger which attends the use of coloured signals on railways, if any of the signal-men are colour-blind, and satisfied from the published statistics of colour-blindness, that it must present itself in the army of railway servants spread over Europe and America, I brought this aspect of the subject before the Royal Scottish Society of Arts, and afterwards published a letter on it, in the *Athenæum* for April last. This letter contained a request for information regarding unpublished cases, which led to my receiving a number of interesting communications, the more important of which are embodied in what follows.

I bring the entire subject before my medical brethren, engaged in actual practice, as they have better opportunities than most other classes of the community, for ascertaining the extent to which colour-blindness prevails; an important point, on which our present information is exceedingly defective. It will presently appear, also, that apart from its interest in a scientific point of view to the physiologist and pathologist, there is no profession concerned with colour as a property of bodies, which has not an interest in lessening the severity and diminishing the frequency of colour-blindness.

I shall consider the subject under the following divisions:—

- I. Nature of Chromato-Pseudopsis or Colour-Blindness.
- II. Cases illustrative of the Degrees and Varieties of Colour-Blindness.
- III. General Conclusions concerning the Colours perceived with

most difficulty, or most liable to be confounded with each other by the Colour-Blind.

IV. Extent to which Colour-Blindness prevails in Males and Females.

V. Theories of Colour-Blindness.

VI. Advantages and Disadvantages of Colour-Blindness ; its Prevention and Cure.

I.—*Nature of Chromato-Pseudopsis or Colour-Blindness.*

Writing chiefly with a practical end in view, I shall be content to consider colour-blindness as it shows itself in eyes otherwise normal, as of three kinds.

1. Inability to discern any colour, properly so called, so that black and white, *i.e.*, light and shade, are the only variations of tint perceived.

2. Inability to discriminate between the nicer shades of the more composite colours, such as browns, greys, and neutral tints.

3. Inability to distinguish between the primary colours, red, blue, and yellow, or between these and the secondary and tertiary colours, such as green, purple, orange, and brown.

It is to this last variety of colour-blindness that I shall chiefly refer ; but a little must first be said concerning the other two kinds. It will be convenient also, in considering the first and rarest form of colour-blindness, to refer to certain difficulties which attend the examination of all cases of this affection of vision. These difficulties can best be referred to, as they present themselves in those in whom the perception of colour is at zero.

Total colour-blindness is very rare, but several well-marked cases of it are on record,<sup>1</sup> and it is remarkable that insensibility to colours is not only compatible with distinct vision in other respects, but appears frequently to be attended by a perception of objects very faintly illuminated, such as those sensible to colours do not possess. Perhaps, however, this is only what we should expect ; for a retina unfatigued by the impression of colour, will preserve a sensitiveness to faint light such as an ordinary eye, exhausted by the reception of tints of all kinds, cannot retain. In writing this, I do not wish to assert that perfect achromatism has certainly been found in any human organ of vision. None of the recorded cases of total colour-blindness have been examined physically with such care as to warrant us in saying that it was absolute. With the optical instruments now accessible to us, and especially with the means of producing the purest and most brilliant colours which the apparatus for polarising light secures, we should probably find no human eye otherwise perfect, absolutely insensitive to colour.

And even if it were altogether unimpressible by colour, it appears

<sup>1</sup> Taylor's Scientific Memoirs, 1846. Pp. 162, 163.

exceedingly doubtful whether we should be able to discover that it was. We have it not in our power to subject an eye simply to the influence of colour. Every luminous ray is (in the language of the Material Hypothesis of Light) a bundle of colour-giving, heat-giving, and chemical or actinic rays, mingled in unequal proportion. Each colour-ray, therefore, carries along with it to the retina, a different number of heat-rays and chemical rays. Thus, if for simplicity's sake, we assume only three colours to exist, red, blue, and yellow, then the red ray of the spectrum, which the painter metaphorically styles a warm colour, is in reality much hotter when tried by the thermometer, than the blue or yellow. The blue, which is the coldest and darkest of the three primary colours, greatly excels the red and yellow in the number of chemical rays which accompany it; whilst the yellow, which is totally destitute of such rays, and contains very few heat-rays, must necessarily consist almost entirely of colour-rays; and it further excels red and blue in luminosity. The retina, accordingly, in so far as it is influenced by heat, will be most affected by the red ray; in so far as it is susceptible of chemical change, by the blue ray; and in so far as it is influenced by luminosity, by the yellow ray; apart from the special impressions made upon it by each ray in virtue of its colour.

When, therefore, we ask any one to gaze at a rainbow (which I select as the great natural representation of many colours) and tell us what he sees in it, we ask him to report on a series of complex sensations, to the production of which the brightness, heat, colour, and chemical force, present in the light by which he sees it, all do, or at least may, contribute. Such a spectator, though absolutely blind to colours, might retain susceptibility to all the other influences of light, and would probably possess it in a higher degree than those who were not colour-blind. It is certain at least, as the sequel will show, that the colour-blind, of all degrees, often possess in perfection the power of distinguishing shades of the same colour; and that when they confound two colours, such as red and green, they assort together, with great nicety, the light and dark shades of the one with the similar shades of the other.

The most severe sufferer, accordingly, from colour-blindness, may be expected to see as large and as perfect a rainbow or spectrum as others do, although to him it is colourless. The different bands, such as the bright yellow, the dark blue, and the intermediate red, will affect his eye differently, in virtue of their different luminosity; and if he had been accustomed from early life to distinguish degrees of brightness by the terms yellow, red, and blue, we should never discover, by his description of the rainbow, that he was colour-blind at all.

It is true, that if difference in luminosity were all that distinguished one band of the rainbow from another in the eyes of the colour-blind, it should be possible to paint a spectrum in black and white, which would satisfy them as well as a coloured one; and in

that case we should have a certain proof that colour was, for them, non-existent. Probably, however, only a colour-blind artist could execute such a black and white spectrum as would satisfy a colour-blind eye; and it would appear very strange to normal eyes.

But, for the reasons already given, it seems certain that the unequal temperature and chemical energy of the several bands of the spectrum will be as acutely felt by colour-blind as by normal eyes, and therefore that no combination of light and shade would impress even an achromatic retina as a combination of colours does. A colour-blind person, therefore, would find something wanting in a black and white spectrum, and could never make us certain that that something was not colour.

What has been said of those who are totally colour-blind, applies in great part to those who are partially so; only investigations of the latter are much simplified by the fact, that in general they are cognisant of two of the primary colours, and are often also not altogether unconscious of the third. But all cases of colour-blindness agree in this, that to the extent of its occurrence in any one, it implies a condition of vision, in reference to which there is not a common experience, and therefore cannot be a common language between those conscious of colour and those unconscious of it. The information, accordingly, which they can convey to each other is almost solely of a negative kind. We cannot, for example, give to one who never saw green a positive conception of what we understand by it: we can at best make him aware that it is none of the colours he does see. And he, on his part, cannot make us understand what *positive* impression green makes upon his eye, although he may satisfy us that it is something different from that which blue or yellow makes.

It must therefore be remembered, that the report of every case of colour-blindness is rendered hopelessly imperfect, in a twofold way, viz., by the impossibility of subjecting the eye to the test of colour, unaccompanied by other agencies, and by the impossibility of procuring from the colour-blind a positive account of the peculiarities of their vision.

The cases of total colour-blindness collected by Wartmann have been imperfectly described by their original observers. One goes back to 1684, and is thus detailed:—"A young woman, 32 or 33 years old, came to consult Dr Dawbeney about her sight, which, though excellent in other respects, incapacitated her from appreciating any other colour than white and black, although she could often read for nearly a quarter of an hour in the greatest darkness." A family is referred to by Spurzheim, "all the members of which could only distinguish black and white." Three persons of one family, named Harris, are also referred to, "who distinguished in colours only tints of luminous intensity, calling all bright tints white, and all dull ones black."<sup>1</sup>

<sup>1</sup>The original authorities for these statements are given in Taylor's Scientific Memoirs, 1846. Pp. 162-163.

I have not myself met with a case corresponding to those, although I shall have occasion, further on, to refer to a physician who confounds all colours. One, however, has been reported to me by Mr Charles Inglis, of 48, Hanover Street, Edinburgh, who was well acquainted with the party. He has recently gone to Australia, so that he is for the present beyond the reach of inquiry. According to his own testimony, and the belief of my informant, "he could not distinguish any colours but black and white;" yet, strange as it may seem, he was a house-painter. The explanation of his prosecuting a calling, for which apparently he was so unfitted, is found in the fact, that he was an excellent draughtsman, with a good eye for form, and skilful in designing. He trusted to his wife to keep him right in selecting and mixing colours; but on one occasion, when she was out of the way, and workmen were scarce, he took a part himself in painting a public building in England, which he had been employed to put in order. He mixed the colours himself, and believed that he had produced a stone-tint, with which he proceeded to cover the walls; but after he had gone over some square yards, he was informed that he was painting the building *blue!* I regret that I can supply no farther particulars concerning this interesting case.

2. The second variety of colour-blindness, where the nicer shades of the more composite colours alone are mistaken, is *apparently* the rule rather than the exception in the majority of persons, at least of the male sex, in this country. But the sense of colour is so little cultivated amongst them, that the power of discriminating between tints is often dormant rather than absent; and the excessively scanty nomenclature of colours with which they are in general satisfied, does not furnish the means of distinguishing between colours and their shades, although that distinction may be perfectly well perceived. Even educated men hesitate to pronounce between scarlet and crimson, and are often content to call both, throughout all their shades, *Red*. Among the less educated, the reluctance to name colours is still greater; and if difficulty in naming were accepted as implying difficulty in distinguishing colours, we should be compelled to infer that the true perception of these was a very rare gift. In examining, for example, one by one, the Chemical Class of the Edinburgh Veterinary College, amounting to some sixty persons, I found the great majority decline to give names to any colours but red, blue, yellow, green, and brown. Purple and orange they would not name, although they described the relation of these to red, blue, and yellow, with sufficient accuracy. Without a little circumspection, accordingly, one might easily be misled into the belief that colour-blindness is much more common than it really is. But names of colours can quite well be dispensed with in examining cases of this affection. A safer method is, to request that a number of differently coloured squares of cloth, or paper, or glass, or skeins of worsted, be arranged so that all of the same colour and shade are placed together. When

this is done, it will frequently be found, that those who make no mistake in matching full tints of the primary and secondary colours, err in certain of the fainter shades of both, and in all the shades of some of the more mixed colours. Thus the difference between pink and pale blue is a puzzle to many who do not otherwise confound colours. Mr Crombie, dyer, Brown Square, Edinburgh, informs me of three persons known to him, connected with dyeing, to whom the tints in question were a constant occasion of mistake. Messrs Grieve and Company, South Bridge, Edinburgh, had in their employment a person who could match all colours but drabs. Professor S. is never certain, even by daylight, of the difference between blue and green; and many persons confound pink with pale yellow. No distinction, however, of any value in a scientific point of view, can be drawn between such cases and those which are chiefly discussed in this paper, for the difference between them is plainly one only of degree; but it is practically convenient to separate them, for whilst the milder forms of true colour-blindness are as incurable as the severer, they cannot always be distinguished, especially in the young, from an inability to discriminate certain colours, which education is quite competent to remove. In truth, we are all by birth colour-blind to some extent; and painters know how long it is before the most susceptible eye acquires its maximum sensibility to colour. It will be more convenient, however, to reserve the full consideration of what may be called curable colour-blindness for another part of the paper.

3. The third form of colour-blindness, in which red, blue, yellow, purple, orange, green, brown, etc., are respectively mistaken for other colours, or all confounded together, is the most important variety of this affection. In extreme cases, although colours are occasionally quite correctly named, there is no certainty as to any colour. In less severe cases, the majority of colours are seen accurately, but two at least (as red and green), and generally four (as red, green, olive, and brown), are not distinguished from each other. The examples adduced in the sequel will illustrate this and many other points, and I reserve the statement of those general conclusions which the present state of our knowledge on colour-blindness seems to warrant, till the cases in question have been considered. There are one or two points, however, which first require notice. Of the three primary colours, yellow is certainly that which gives least difficulty to those not absolutely unconscious of colour. The majority of the colour-blind see it perfectly, and no case, so far as I know, is on record where yellow was the colour most liable to be mistaken, or where it was confounded with its complementary purple. Blue, if pure and well illuminated, is readily recognised by the majority of those who are colour-blind, and a few describe it as the colour they see best. Yet, singularly enough, though blue and yellow are so well seen, their combination, green, is one of the great stumbling-blocks of those who confound colours. It is frequently

mistaken for blue, still more frequently for red, and occasionally for yellow.

Red is the primary colour most distracting to the subjects of colour-blindness. For some it has absolutely no existence, for many it is undistinguishable from its complementary green; and the most famous cases of colour-blindness, including that of Dalton, are connected with a confusion or identification of red with green. A rarer but not less interesting case, is the identification of red with black. Uncertainty as to red and green might be expected to imply a corresponding uncertainty in discriminating the more complex colours into which they enter, and to a great extent this is the case. Purple is confounded with blue, the red apparently not being visible. Orange is called yellow. Olive is confounded with brown or rather russet, the green in the one, and the red in the other, inducing the same confusion as they do when seen together in a state of purity.

The following cases, which have come under my notice during the last nine months, are, with one exception, published now for the first time. Several I have had the opportunity of examining myself. Several have been examined by others, who have reported them to me. Others rest upon the authority of the parties themselves who communicated them. The names of the parties have, at their own request, been omitted in the majority of cases; but as it is desirable, for the sake of statistics, to guard against the same case being described by two observers, and counting as two cases, I have placed a list of the names in the hands of the Editor of the "Monthly Medical Journal," so that those who encounter cases of colour-blindness may learn from him, or from me, whether they are described in this paper.

The letter of the alphabet, marking each case, is the ultimate, not the initial, letter of the party's name. I have been driven to this departure from the ordinary practice by the somewhat singular circumstance, that one alphabetical letter largely predominates in the surname-initials of my cases; so that on grounds as good as those on which statistical conclusions are often based, I might affirm, that persons whose surnames commence with a particular letter of the alphabet, are more liable than others to colour-blindness.<sup>1</sup>

<sup>1</sup> Some have thought that colour-blindness was accompanied by a peculiar colour of the iris; others by a peculiar appearance of the pupil; others by a peculiar expression of the eye; others by a prominence in the middle of the superciliary ridge (the phrenological organ of colour). Had the advocates of the importance of any one of those physical characters, as an index of colour-blindness, encountered as many examples of its occurrence, as I have encountered of a common initial in the surnames of the subjects of that peculiarity of vision, they would probably have considered their view as established; and yet these cases might be quite exceptional, and prove to be unimportant as soon as the investigation included a larger number of persons. It may illustrate the danger of induction from too few particulars to mention, that the obnoxious initial marked the surname of the *first* colour-blind person I encountered; that it characterises the four severest cases which have come before me; that it occurs in

## II.—Cases Illustrative of the Degrees and Varieties of Chromato-Pseudopsis, or Colour-Blindness.

The great majority of cases of colour-blindness occur in persons of the male sex. I shall therefore describe the male cases known to me first.

CASE I.—Mr D., a middle-aged gentleman, discovered in boyhood the peculiarity of his vision in reference to colours, from the disagreement between himself and others, as to the names to be given to the strands of a particoloured string with which he was flying a kite. He made known his case to me; and as he attended my lectures last winter, I had many opportunities of testing his vision. The following is his own account of matters, drawn up at my request:—

“As far as I can tell, the following expresses my experience as to colours. Yellow is the brightest colour; blue nearly as bright. These two are the only ones I see distinctly in the rainbow. Red I can distinguish when bright, but delicate shades I confound with stone colour or grey. Green I have no distinct conception of. According to its different shades, it appears black, brown, red, yellow, blue, and grey.

“I cannot distinguish at any distance the ripe cherries on a tree, or strawberries, from their leaves. The flowers of a scarlet geranium I cannot see distinctly at a distance by daylight; but by candlelight there is a marked contrast between them and the leaves.

“I have no conception of what is meant by complementary colours, or of the agreement of different colours when blended together, as for instance what kind of a carpet accords with red curtains in a room.

“With regard to my want of perception of green, it appears to me that the blue and the yellow rays neutralise each other, and, when in equal proportions, constitute what is really no colour, varying all the way from a very light drab or grey to a dingy black. When the blue rays predominate, it appears a blue drab; and when the yellow rays are in excess, it appears a yellow drab. When the blue and yellow are properly blended, a lady's green silk dress appears to me very similar, and no more glaring than a drab silk. The dry dirt of the street I could equally suppose to be green.

“I also confound red and brown frequently. I could not distinguish between treacle and blood spilt in a road by daylight, though I believe I could by candlelight.”

Mr D., it will be seen, like the majority of the colour-blind, sees only blue and yellow in the solar spectrum. He would be set down by many as *identifying* red with green; but in reality red when vivid, fully illuminated, and not far removed from the eye, is for him an actual colour; whilst green is not its equivalent, for it is not

one of the three female cases referred to in the sequel; that of seven medical men, colour-blind in different degrees, six answer to the said letter; and that, altogether, I have fifteen examples of the occurrence of this initial, whilst two of the most celebrated cases, described by other authors, rank under it also. This list does not include relatives; and only one surname occurs twice, there being sixteen separate surnames, whilst the most common name that occurs under this letter is not represented.

uniformly confounded with red or any other single colour, but simulates many, and frequently appears black, *i.e.*, makes no luminous impression upon the retina. Mr D., indeed, is certain that he often sees red quite distinctly, but he is not certain that he ever saw green; all colours, accordingly, on which he cannot at once pronounce, he sets aside as probably green.

This gentleman is an educated, highly intelligent person, and he allowed me to test his peculiarity of vision in as many ways as I pleased.

One of the modes which I adopted, was to ask him to assign names to the colour-diagrams in Mr D. R. Hay's "Nomenclature of Colours" (second edition). He has correctly distinguished the *yellows*, and has not mistaken other colours for them, either by daylight or candlelight. The *blues* are also rightly defined by daylight, but other colours are mistaken for them, as the purple of plate 2, which is called *dull blue*; the lilacs of plate 8, which are called *dingy blues*; and the blue-greens of plate 15, which are called *bluish-red*. By candlelight the green of plate 2 is called *blue*; the blue-greens of plate 5, *blue*; and the blue-greens of plate 11, *reddish-blue* and *blue*.

The bright reds are distinctly discriminated both by daylight and candlelight; but, as implied in the last paragraph, bluish-greens are mistaken for bluish-reds; and, as the sequel will show, certain shades of red and green appear identical.

Greens appear under all names. Thus the pure greens of Mr Hay's first and second plates are referred to as "reddish dark drab" and "light brown" by daylight, and as "reddish-blue" and "blue" by candlelight. The pale greens of plate 6 are pronounced to be "drabs" by daylight, and "drabs or greens" by candlelight. The *olives* of plates 5, 8, and 19 are styled, as seen by daylight, "browns;" and plate 23, which contains three shades of red and three of green, is regarded as displaying by daylight six shades of dark crimson, the greens being further described as rather browner than the reds. By candlelight the same colours were seen as three "reds" and three "dark drabs or greens." Plate 29, which contains three different shades of red and three of green, is described as showing, by daylight, six pale reds, and by candlelight three reds and three reddish-blues. In addition, the darker shades of purple are all styled black.

I also tried Mr D. with coloured papers, powders, vegetable infusions, and pieces of glass. Pure blues and yellows he did not mistake, nor bright reds when seen near; but dull or dark reds were confounded with green and sometimes with brown. Among the greens, however, every mixed colour found a place, so that all the paler shades of violet and red-purple, all the russets, yellowish-browns, greys, and neutral tints were arranged together, and along with the true greens, regarded as shades of one colour, which was by preference styled *drab*.

Mr D.'s vision, except in regard to colour, is perfect. His eyes, which were examined by my friend Mr Walker the eye-surgeon, are quite healthy. The iris is grey; the pupil does not show so deep a black as the majority of eyes do, in consequence, as Mr Walker thinks, of a deficiency of the *pigmentum nigrum* of the choroid. Mr D.'s father, two brothers, one sister and her son, have exhibited a similar peculiarity in the perception of colour, but it does not appear in his children.

CASE II.—Mr P., æt. 28, unexpectedly discovered his defect in the discernment of colours, in consequence of a piece of enamel which he had prepared, and believed to be pearl or milk-white, being pronounced by others to be decidedly green. He was with difficulty convinced of this; but he gradually became satisfied of his peculiarity of vision, which has betrayed him into many inconvenient mistakes. Last winter he worked for five months in my laboratory, and some time elapsed before I discovered his colour-blindness, which he was not ready to acknowledge, and could to a great extent conceal, by his sagacity in observing those properties of bodies which are not affected by colour. But as colour is frequently the only criterion by which chemical compounds can be distinguished from each other in the course of analysis, and as he was a thoroughly conscientious worker, he could not avoid frequently appealing to others for assurance regarding questionable tints; and it was in reply to a recommendation of mine, that he should train his own eye to appreciate colours, and not look to assistance from the eyes of others, that he made known to me his colour-blindness. The following is his own account of his case:—

“I have most difficulty in distinguishing greens, except when they are of a medium tint, and very pure. When dark they appear brown or black mixed with blue; and when light, where the yellow predominates, I distinguish nothing but yellow.

“In the spectrum and rainbow I only see two colours, blue and yellow. I am very uncertain about any colour, when either very dark or very light. Surface has a considerable influence in determining my judgment. I distinguish bright and transparent colours best.

“In going over the diagrams in Mr Hay's work (*“Nomenclature of Colours,”* second edition), I find that I give the same colour a different name on different occasions.

“Artificial light causes some green colours to appear blue, and does not assist me in distinguishing other colours.”

It will be seen from this account, in spite of its brevity, that Mr P.'s case is worse than Mr D.'s; and as both gentlemen examined colours together in my presence, I could fully compare their cases. I did not ask Mr P. to name many of Mr Hay's colour-diagrams; but here are a few, as determined by him. The green of plate 1 he distinguished rightly by daylight, but described by gaslight as “blue and brown.”

In plate 2d, as seen by gaslight, the hue called by Mr Hay *citrine* is described as green, and the true green is named *brown*; russet is described as *red*; and purple as *red and black*; olive as *blue and black*, and orange as *dark red*. In plate 11th, *myrtle green* is left unnamed by daylight, and a darker shade of blue-green is described as *red and blue*. Both are described by gaslight as *blue and grey*. In plate 13th, the lightest of three shades of yellow-green (pomona-green) is called "*orange*" by daylight; and the darker shades are described as "*red and brown*." By gaslight the first appeared "*grey and yellow*," the others "*grey and blue*."

From this account, it should seem that artificial light makes a greater difference in Mr P.'s apprehension of colours than would be inferred from his own account; but it must be remembered, on the other hand, that as he does not uniformly misname colours, it is difficult to be certain how far this element of uncertainty affects the results obtained with different lights.

I made many trials in other ways with Mr P. What struck me most in his case, although it seems likely that it is a general accompaniment of the extremest forms of colour-blindness, was the exhibition of a feeble hold upon colour, as a quality of bodies. Apart altogether from confounding one colour with another, Mr P. frequently hesitates to give any name whatever to bright secondary colours, such as purple and green, and if one is suddenly shown him, or if many colours of any degree are shown at once, he totally declines to venture upon names. Thus, on some occasions he has distinguished red and green liquids from each other, and on others has confounded them. Red lead he pronounced to be red, but he could give no name to the colour of vermilion. Small scales of copper-red tinsel, exhibiting a bright metallic lustre, he thought showed *every* colour. Red oxide of iron he recognised as reddish-brown, but he could not describe the colour of the nearly similar brown, or puce oxide of lead. The green oxide of chromium he pronounced on one occasion to be black, and on another to be brown. Grass appears to him sometimes green, but generally yellow, and he knows only a difference of shade between ripe and unripe corn.

Two other points in connection with Mr P.'s case appear worth notice. The spectacle of many bright colours exhibited together, which is a source of pleasure to those who have a normal perception of them, painfully distracted this gentleman, and any lengthened effort to match or arrange colours invariably produced headache.

On the other hand, he unconsciously betrayed an effort to supplement his defective vision of colours by all secondary aids. If coloured papers were shown him he fixed upon any difference in shape, smoothness, or configuration, which they presented, and when they were shown him again, recognised them by differences which would have escaped most other eyes. He would frequently, accordingly, have appeared to a stranger to recognise colours, where in reality he was only recalling the form or condition of surface of

the coloured body. If liquids were shown him, a difference in transparency caught his eye, and he set down the most transparent as metallic solutions, and the least transparent as vegetable infusions. Of the last he knew that the one most likely to be found in a laboratory was infusion of litmus, so that he had only red or blue to choose between, as the colour of the muddier liquid. But, when perceiving this, I placed before him an acid and an alkaline infusion of the purple cabbage, each equally muddy, he would not speak confidently as to a difference between the bright red of the one, and the bright green of the other.

With all this inability to distinguish between colours, Mr P. was conscious of no difficulty in arranging shades of the same colour, or of different colours, according to their intensity. Such a power is possessed by the great majority of colour-blind persons; but how far their arrangement of shades of colour would satisfy a normal eye, is a question interesting in many ways which I shall leave unnoticed in this place.

Mr Walker, at my request, examined Mr P.'s eyes, and found them quite natural, the pupil presenting the same grey colour as in Mr D. The iris has that light hazel or golden colour which Wartmann<sup>1</sup> thinks has some claims to be regarded as a characteristic sign of colour-blindness. Vision was perfect, and could be exercised in the presence of a very faint light, as Mr P. had observed, whilst working as an amateur photographer. He was a good draughtsman, a very good manipulator, and except where colour was concerned, had a trained and accurate eye.

CASE III.—Mr W. L. Hughes, learning that I was interested in colour-blindness, kindly made his case known to me, and allowed me to give his name. He is at present studying medicine at the University of Edinburgh, but he followed for some years the profession of civil engineer, and was trained as a draughtsman. He has thus been accustomed, for years, to use colours, and was the prize student of his class as a sketcher from nature. He discovered his peculiarity of vision some six years ago, and found it specially inconvenient when drawing sections, from his constant liability to confound red with black. His eye is natural and healthy; the iris is dark grey; vision apart from colour is perfect; and he is long-sighted. In the rainbow he sees blue, yellow, and orange. He is doubtful whether he sees other colours in it, except red, to which he is not altogether insensible. Blue he regards as the colour which he is least liable to confound with others, and red as his great stumbling-block. He cannot, unless near them, distinguish flowers with red petals, from the accompanying green leaves.

On asking Mr Hughes to give names to Mr Hay's colour-diagrams, he erred most between dark greens and red browns.

<sup>1</sup> Taylor's Scientific Mem., 1846. P. 171.

When I showed him coloured powders he pointed to green oxide of chromium and red oxide of iron, as shades of the same colour. He also confounded dark reds with browns. When asked to select from a number of pieces of coloured glass all the specimens which were red, the majority were rightly chosen, but two or three were green; and in the same way, when assorting greens, he placed a few reds among them.

This gentleman has paid a good deal of attention to chemistry, but the colours of precipitates have been a constant cause of perplexity to him, and he feels equally uncertain as to the action of acids and alkalies on vegetable colours. He has further noticed that he is liable to confound pink with light blue, and that by artificial light greens acquire a blue tint.

Unlike most colour-blind persons whom I have conversed with, Mr Hughes is exceedingly prompt in his judgments on colours, and adheres firmly to the names he first gives them. His case is a well marked and interesting one, for it will be seen that he confounds bright red with bright green, ruddy brown with dark green, pink with pale blue, brown with red, and what, perhaps, is rarest of all, black with red. He gave me a very interesting illustration of the extent of his colour-blindness in reference to red and green. When acting as assistant to the engineer of the Granton railway, he frequently returned in the evening from Granton to Edinburgh on one of the engines, without, however, taking any part in managing it. On these occasions he observed, that although his undivided attention was directed towards the signal-lamps, the light of which was visible to him a long way off, he could not, till he was close upon them, distinguish whether they were red or green. He feels certain that he could tell a blue from a red light at a distance which would make green and red appear the same. He has no relatives with a defective sense of colour.

CASE IV.—Dr William Bryce, one of the four prize medallists among the Edinburgh graduates in medicine of this year, was introduced to me by Mr D. (Case I.) as one afflicted like himself, but not so severely. Dr Bryce (who allows me to give his name) has been aware of his defect for some years, and found it specially inconvenient when engaged as a teacher of chemistry. He had frequently to ask, instead of telling his pupils, what the colours of precipitates were, and he was uncertain as to the full action of acids on litmus, and still more as to that of alkalies on turmeric.

His eyes had suffered a little from over-study, but vision is excellent. The iris is hazel, and he is long-sighted. In the rainbow he sees blue and yellow, but so far as he remembers no other colours; certainly not red or green. In natural objects he distinguishes blue and yellow readily, but he is very uncertain as to red and green.

I had but one interview with this gentleman, and was not able to examine his case minutely, but its characters are sufficiently marked.

At first it seemed but a slight one, for he readily distinguished bright red, and bright green linen and glass, when held near to the eye in full sunshine. The darker shades of these colours, however, stumbled him. He could see no difference between olive and russet, either on broad cloth or on paper, and three yellow greens and three red purples (Mr Hay's 13th plate, Nomenclature of Colours) appeared to him identical. He also confounded purples with browns.

I might have supposed this the extent of his colour-blindness, had he not observed to me that he was not nearly so bad as Mr D. This led me to point to a bed of scarlet geraniums about forty feet distant from the window at which we were sitting, and to remark, that though the sun was shining so brightly on them, Mr D. would be unable to distinguish the petals from the leaves. To my surprise Dr Bryce proved to be in the same predicament. With difficulty he made out the flowers, but he could not distinguish their colour. I then directed his attention to a single scarlet verbena, distant only twenty feet from the window, and asked if that plant was in flower. He replied in the affirmative, and that it was one of the *cruciferae*: its colour he hesitatingly added was yellow: it was in reality one of the reddest shades of scarlet.

I mention these apparently trivial circumstances because they lead to a conclusion of great importance in reference to the use of coloured signals on railways and elsewhere, which all the records of colour-blindness will, I apprehend, be found to justify. The majority even of colour-blind persons are able to distinguish bright red from bright green, when these are *near the eye* and well illuminated, but the power of distinguishing between these colours diminishes with great rapidity when they are removed to a distance from the eye, so that a separation of a few feet or a few yards, according to the severity of the case, abolishes all sense of distinction between red and green. Further, those who are thus quickly put out by distance in their discrimination of these colours, may be detected by their inability to distinguish close at hand russets and ruddy browns from olives and other dark greens. And as the coloured day-signals on railways, especially the flags, which alone are available in some of the most pressing emergencies, soon tarnish and darken, the effect of time is to change light reds and greens into much darker shades, and thereby continually to diminish the distance (small at the best) at which the two danger-signals can be distinguished from each other by a colour-blind observer. I shall return to this topic in another part of the paper.

CASE V.—Dr C. has long been aware of his inability to name colours so as to satisfy others, and has tried in vain to cure himself of his liability to error. So far as I had an opportunity of examining this gentleman I found him call four shades of purple, three of which were red purples, *brown*; four shades of olive he styled also *brown*; and russet or ruddy brown he pronounced to be *green*.

Three shades of pale azure blue, and three shades of brown, he also pronounced to be all *green*. I did not detect any confusion between bright red and bright green, but he counted them among his difficult colours, and regarded blue and yellow as the colours most easily distinguished.

This case, it will be seen, presents little remarkable, and I would not have recorded it were it not that it is interesting in a statistical point of view, as I shall have occasion afterwards to notice more specially. Dr C. is one of three medical officers attached to a public institution, and another of them is colour-blind as well as he.

CASE VI.—Dr E., the colleague of Dr C. referred to in last paragraph, is in several respects an interesting example of colour-blindness. Like many other colour-blind persons, he is a great lover of the fine arts, and a skilful draughtsman. He was led in consequence, early in life, to discover his inability to arrange his own palette, and was accustomed to rely upon a relative to select his colours, whilst he had no difficulty in graduating their shades. His eye is natural and quite healthy; the iris large and dark brown; the pupil very dark, and vision apart from colour perfect. In the rainbow he distinguishes blue, yellow, and orange. Green he never sees in it, and he is very uncertain as to red. In coloured objects he has no difficulty with blue or yellow, but he stumbles at red and green, and olive and brown. The reddening action of an acid on blue litmus paper is invisible to him; he has no difficulty, however, in observing the action of an alkali on turmeric paper.

Reds and greens he does not always mistake; but they are frequently undistinguishable as separate colours, especially on such surfaces as those of moss and of velvet. Green moss, indeed, and red and green velvet make the same impression on his eye, so far as colour is concerned. He is foiled also by worsteds of these colours; and on one occasion betrayed his peculiarity of vision by his inability to see the contrast between the scarlet berries and green leaves of the mountain ash. On another occasion, he was surprised to find on returning home from a journey, that a letter which he had written during his absence was one half in black and the other in red ink.

A red brick house, which to others is a conspicuous object in the landscape, even at a great distance, is to him an inconspicuous one, and made out with difficulty solely by its form.

These results of his experience were confirmed upon trial. I noticed also that ruddy browns were confounded with olive greens; by candlelight bluish greens were said to look bluer than by daylight, and the contrast between red flowers and their leaves was much more marked than by daylight.

What interested me most in this case was the occurrence of colour-blindness in a friend, whom I had known intimately for many years

without discovering or suspecting that he laboured under it, although we seldom met latterly without exploring together the beauties of his flower-garden. From his fondness for paintings, he was the last person I thought of as likely to be colour-blind, and it was my request that he would look out for cases among his patients that led him to tell me that "it was not necessary in seeking for them to go beyond the doctor." He afterwards added that he had not been conscious of his defect for more than thirty years, without finding out many ways of supplementing and concealing it, so that although indifferent to its being known, it was known to few. I mention this because it has an important bearing on the statistics of colour-blindness. I have been frequently cautioned against being deceived by pretenders to this affection, but few have apprehended that true cases might be concealed. Yet there can be little question that colour-blindness occurs more frequently among females than the published records indicate, and that there is more reason to fear the concealment than the feigning of cases by them. The majority of men set little value on the possession of a nice sense of colour, but women highly value it, and cannot be expected to be ready to confess to its want. Colour-blindness can be as readily detected in them as in men, when an opportunity of testing their sense of colour is afforded, but cases far more rarely present themselves where it is worth while to institute a formal examination.

CASE VII.—Dr K., a medical man, aged about 40, has described his own case so fully in the letter which I subjoin, that it demands scarcely any commentary. After stating that, in its general features, his colour-blindness resembles that of Dalton, he continues:—

"I have, from a very early age, made great efforts to overcome this defect by studying works and papers on colour, among which I derived great assistance from Syme's Nomenclature of Colours, and Hay's Harmony of Colouring—indeed, in 1833, I brought these two works under the notice of Chevreul, who was then engaged in the investigation of this curious subject. To endeavour to familiarize my eye to the primary and prismatic colours, I keep in my writing desk, and look almost daily at, a chart of the primary and prismatic colours. These, I think, I know on the card, but I make sad blunders when I leave the card and look at silks, cloths, powders, fluids, or flowers. Indeed, *I dare not name any colour*, and endeavour at all times to describe objects by other characters than those of colour.

"When a boy at school, my attention was directed to my want of knowledge of colour by finding I could not see what my father called the *bright red* berries of the holly. When other children easily found out the trees which were loaded with ripe cherries, I never could till I came so near the tree as to detect the form of the fruit. The discovery of this defect in vision distressed my father exceedingly, and he endeavoured to cultivate in me a knowledge of colour by giving me lessons in painting, making coloured charts for me of the prismatic and other colours, wishing to believe that the defect resulted from want of education in colour, not from a visual defect. I destroyed many a painting of flowers, etc., by putting on wrong colours, as blues for purples, green for some kinds of red, and yellow for others. I still remember the surprise he exhibited when he found I could not detect a red cloak spread over a

hedge, across a narrow field—hedge and cloak appeared to me the same exact hue, and they do so to this day.

“Blue and yellow are to me the brightest of colours. Red (that is scarlet) is to me a pleasing sober colour, which refreshes my eye as much as green; indeed I cannot tell any difference in colour between certain shades of these. Red sealing wax and grass, for instance, are absolutely the same exact colour. Some shades of brown, green, and red, I cannot detect to be different. Prussian blue and rouge have the same hue. A rose, the lips, a ruddy complexion, and the face of a man discoloured by nitrate of silver, are to my eyes absolutely the same. Yet my eye can appreciate most delicately the various shades of all these colours, but they are all to me but shades of *one* colour, and that colour varieties of what I see in the pure deep sky or in Prussian blue—in fact, blue in various dilutions. Red hot coals and gamboge yellow are to me identical in colour. Infusion of red cabbage deepened by alkalies, or reddened by acids, to me exhibits *no change of colour*, but only a greater intensity or depth of colour in the acid jar—the actual colour remains absolutely the same. I cannot detect cherries, strawberries, or the red fruits from the leaves but by their form.

“In purchases I have consequently made many mistakes. For instance, I bought a red dress thinking it a green one. I have, on more than one occasion, bought red and green trousers thinking they were brown, and had to get them dyed afterwards to get them worn. In Paris, I bought a red cap to wear instead of a hat, thinking it a green one; in fact, I could give very many instances of similar mistakes.

“The only fact which somewhat staggered me relative to phrenology was, that a phrenologist, then unknown to me, now a valued friend, asked me one day to answer him candidly whether I knew colour, as in me the bump of colour was absent. Several phrenologists who have seen my head since have agreed as to the absence of the so-called bump.

“As to hereditary transmission I can say nothing. So far as known to me none of my relatives had any defect in the perception of colour. My three eldest children distinguish colours accurately; it would be premature to speak of the others who are under six years.

“I believe the affection to be much more common than is imagined. In the cases where I made mistakes in purchases, the shopmen who served me could not put me right; for, knowing my defect, I always took especial care to ask what the colour was lest I should make a blunder.”

In the preceding explicit account, Dr K. has, in addition to direct statement, supplied an incidental proof of his colour-blindness. He refers to infusion of red cabbage as being deepened in colour by alkalies; but this infusion, which is originally purple, is not rendered darker by alkalies, but is changed into a bright green. An equally striking, and withal amusing, evidence of inability to distinguish colours is afforded by the chart of prismatic colours to which Dr K. alludes. He was adventurous enough to prepare it himself, and the result may be anticipated; a youthful member of his family soon informed him that one of the spaces was wrongly coloured; and on asking sight of the chart I found that what was called the violet band was a full crimson, so that both extremities of the prismatic spectrum were represented as red.

Such a chart could plainly but increase the evil which it hoped to cure. It supplies a new occasion for the query, “quis custodiet ipsos custodes?”

Dr K.'s inference that the shopmen in warehouses where coloured

goods are sold are frequently unable to distinguish colours, is founded on the fact, that although they were asked to show him only red silks, *ex. gr.*, he was allowed to purchase a green one; but this inference is perhaps scarcely warranted; for a salesman who has exhausted his display of goods of one colour without securing a purchase, very naturally produces goods of a different colour, and might reasonably infer that his customer had only changed his mind when he selected another tint than that which he inquired for at first. But it is quite certain that dyers, painters, weavers, clothiers, and the members of other callings much conversant with colour, are not unfrequently colour-blind. I myself have very recently been offered "any reasonable fee" if I would cure a worthy working tailor of almost total inability to distinguish colours. Dr K. may have encountered a similar case, for I know of cases among haberdashers and silkmercers; and on inquiring at one of the latter, who had served under a colour-blind master, and thereby had his attention directed to the matter, what became of those haberdashers who could not distinguish colours, he made the unexpected reply, "that they generally ended in mourning-warehouses."

(To be continued.)

ARTICLE II.—*Contagion and Infection in Relation to Epidemic Diseases.* By JOHN GROVE, Esq., M.R.C.S.L, etc., etc.

(Read before the Epidemiological Society, August 1853.)

"How many controversies have occupied the mind for ages, and have filled almost innumerable volumes, which have essentially turned upon the definition of a word."—Dr Bostock's *History of Medicine*.

NEARLY three years have now passed since this Society published in the form of a circular a short, though comprehensive, statement of the objects for which the Society was instituted. At the close of the second paragraph under the heading, "Objects of the Society," is the following sentence:—"To point out those methods of investigation by which the misleading influence of false or deficient evidence may be best avoided."

It is in the furtherance of this object that the following observations have been put together for consideration and discussion by the members.

Starting with a common purpose in any investigation it is necessary for the successful pursuit of our objects, that the elements of our subject should be reduced to their most concise definition, and that the terms and expressions in ordinary use should, by general assent, be understood in a given determinate sense.

"Definition of words," said Sydney Smith, "has been commonly called a mere exercise of grammarians; but when we come to consider the innumerable murders, proscriptions, massacres, and