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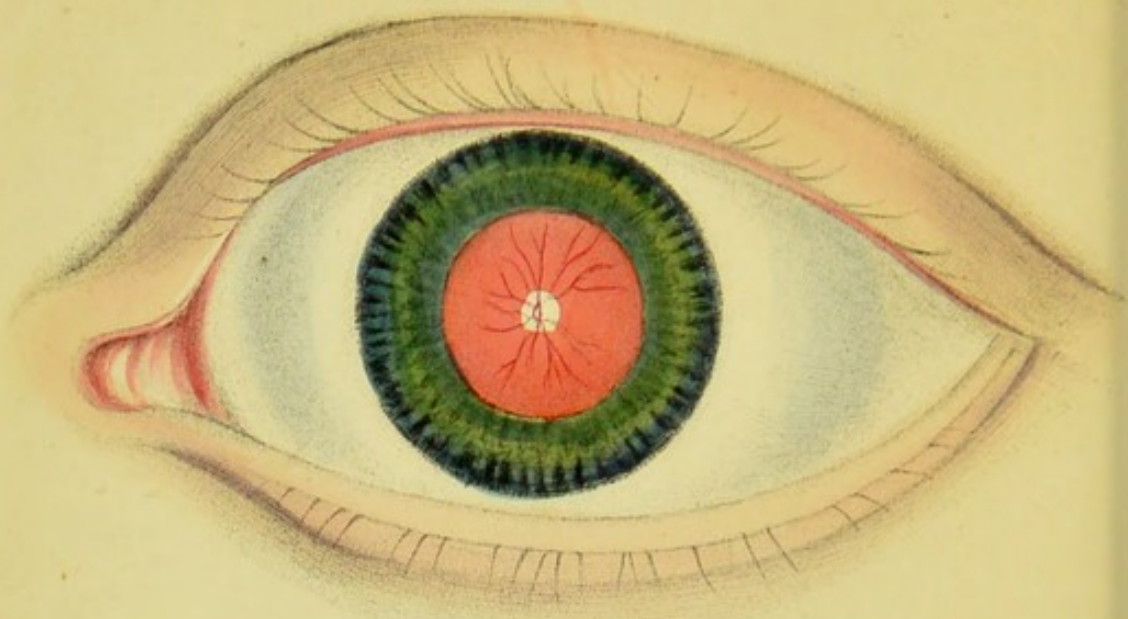


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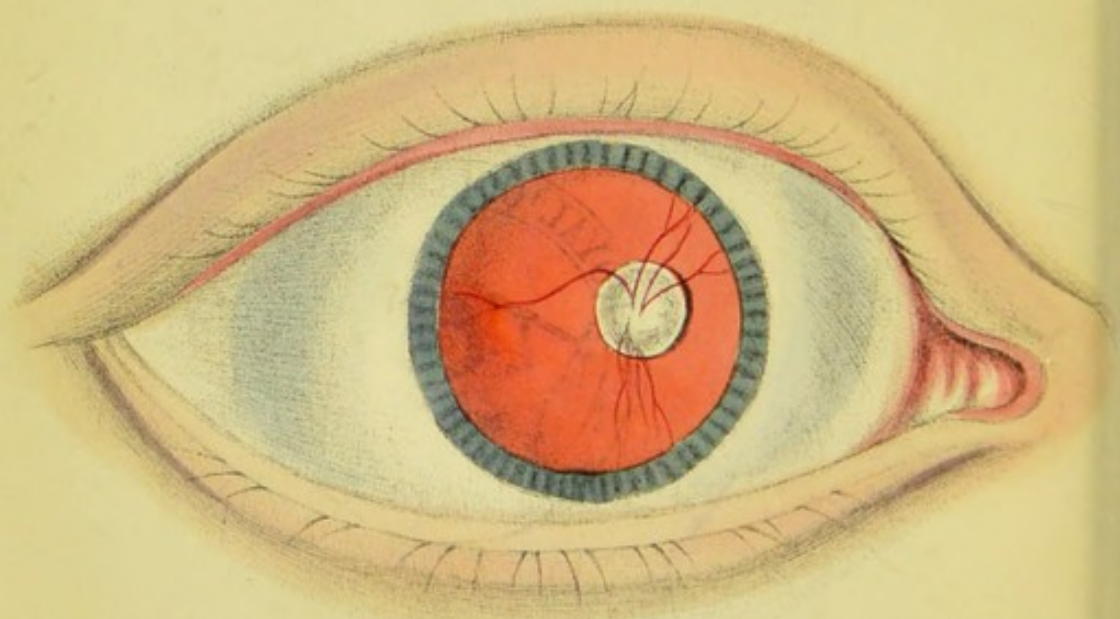
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COLOUR BLINDNESS.

BY

JABEZ HOGG, F.L.S. ETC.

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COLOUR-BLINDNESS.

BY JABEZ HOGG, F.L.S., &c.

THE eye—that index of the soul, that channel of human knowledge—conjures up a host of feelings when the mind is directed to it, as an object of especial attention. Of the five senses with which most of us have been blest, the loss of sight seems to be the greatest calamity that can befall us. Reflect for a moment on the condition of those deprived of this exquisite gift. To what a sad state are they reduced who, in a perpetual darkness in the midst of light, have not anything like a conception of what we mean when we talk of the golden sun, the bright stars, the ever-varying tinted flowers, the beauty of spring, the glow of summer fields, the ripening fruits of autumn, and all beside that clothes the face of nature so beautifully to our eyes!

Our theme, however, is not with those who have so large a claim to our sympathies, but rather with others among us who suffer from a partial kind of blindness,—not necessarily a mechanical or optical defect, but one which is almost unknown or unrecognized by those who suffer from it, and, being ignorant of its existence themselves, cannot easily be persuaded to believe it.

An explanation of this curious defect will be worth while listening to, the more so as many eminent philosophers have suffered from it; and it is perhaps owing to this circumstance that so much time and attention has been given to the investigation of so curious an anomaly. It is well known that a ray of light, from any source, may be divided by means of a prism into a number of rays of different refrangibility, forming a series, and called a spectrum, the most familiar instance of which is the rainbow. The drops of rain falling between the sun and the eye act as so many prisms, and each ray is thereby bent or refracted to a different angle, the red most and the blue least; and as thus the rays of light are made to enter the eye separately, we have produced the beautiful prismatic phenomenon of the rainbow, the outermost colour of which is red, the innermost violet, and the intermediate, from slightly intermixing and overlapping each other, we respectively name orange, yellow, green, blue, and indigo. The three homogeneous colours—yellow, red, and blue—have been shown by

Mr. Field, in a satisfactory manner, to be in the numerical proportional power as follows :—yellow, three ; red, five ; and blue, eight. When these three colours are reflected from any opaque body in these proportions, white is produced ; they are then said to be in an active state, but each is neutralized by the relative effect that the others have upon it. When they are absorbed, they are in a passive state, and black is the result. When transmitted through any transparent body, the effect is the same ; but in the first case they are material or inherent, and in the second impalpable or transient. Colour therefore depends entirely on the reflective or refractive power of bodies, as the transmission or reflexion of sound does upon their vibratory powers. By the undulatory theory of light, philosophers account for the variously coloured rays of the solar spectrum, by calculating the differences in the frequency of the vibrations of each ray—that is, the rays of light are supposed capable of vibrating in waves of different lengths. The shortest waves produce violet light, the longest red ; and with such precision have some of the more complex phenomena of light been studied, that mathematicians have absolutely been able to calculate the number of vibrations necessary to produce an impression of either white or coloured light. For instance, the periodical movements of the medium in white light regularly recur at equal intervals, five hundred millions of millions of times in a second of time ; in the sensation of redness, our eyes are affected four hundred and eighty-two millions of millions of times ; of yellowness, five hundred and forty-two millions of millions ; of violet, seven hundred and seven millions of millions ; and so on.

How seldom do the most reflecting amongst us think, as we gaze on the flowers composing a bouquet, and inhale their fragrance which perfumes the surrounding air, that in order to distinguish the yellow tint of the laburnum, five hundred and forty-two millions of millions of undulations of light must occur ; that the ruby fuschia requires the eyes to receive four hundred and eighty-two millions of millions of undulations in a second ; that the violet's tint is only distinguishable when seven hundred and seven millions of millions of vibrations have penetrated to the sensitive retina !

When objects are illuminated by homogeneous yellow light, the only thing which can be distinguished by the eye is the difference of intensity or brightness. It is now a generally received opinion that different bodies, according to the manner in which their minutest particles are arranged, possess the power of variously absorbing a part and reflecting the other portion of the rays of light that fall upon them ; and that on the proportions of the rays absorbed and reflected does the

colour depend, and that it is not a part of the object itself. The meaning of this will be best understood by an example. When a ray of light falls on the green grass, part of the ray is absorbed and part reflected, and the grass is only seen with the part that is reflected. The green we see consists of the original white light, deprived of a portion of its rays by absorption. It is, therefore, partial darkness, and not absolute light, consequently not a pure and absolute green, but only a residual group of the unabsorbed coloured rays. A poppy appears scarlet, as it absorbs all the colours of the rays except red, and hence its peculiar tint; but if it be looked at through green glass it will appear black: as the poppy only reflects the red ray, this is absorbed by the green glass. The red of the rose, the blue of the violet, the yellow of the jonquil, are due to their absorption of all the rays excepting the red, blue, and yellow. The pale-tinted rose, almost white, reflects nearly all the coloured rays. We can, therefore, easily perceive, without light, the face of nature would be that of a world in mourning; it is light that enlivens the scene, painting the exterior with a beauty, richness, delicacy, and harmony that man vainly attempts to rival. Colour is so dependent on light, that when artificially produced, as by candle or gas, from not being pure, many things appear of a different colour, as is well known by the lady who attempts to choose a ribbon or the artist who paints a picture by artificial light: a blue being mistaken for a green, and a green for a blue. On a moonlight night we cannot distinguish the colour of a chimney-pot; and were we to take a number of pieces of cloth, or different coloured papers, and examine them by the bright light of the moon, and write on the back of each the colour it appears, we should be astonished in daylight to see how much we had been deceived as to the true tint of each.

Assuming, therefore, that the sound eye can see perfectly well three simple colours—red, yellow, and blue—and that all the rest of the colours of the spectrum are mixtures of these with each other, let us now proceed to inquire what is the peculiar condition of sight in those persons who, being unable to distinguish certain rays, are, as we have already stated, *colour-blind*; but not necessarily owing to disease of the optic nerve or retina, but simply arising from inability to recognize those rays of light which consist of pure red.

Professor Maxwell, who has closely and philosophically investigated the subject, says:—"The mathematical expression of the difference between the colour-blind and ordinary vision is, that colour to the former is a function of two independent variables, but to an ordinary eye of three; and that the relation of the two kinds of vision is not arbitrary, but

indicates the absence of determinate sensation, depending upon some undiscovered structure or organic arrangement, which forms one-third of the apparatus by which we receive sensations of colour.

“Suppose the absent structure to be that which is brought most into play when red light falls on our eyes, then to the *colour-blind* red light will be visible only so far as it affects the other two sensations, say of blue and green. It will, therefore, appear to them much less bright than to us, and will excite a sensation not distinguishable from that of a bluish-green light.”

That is to say, the normal eye reduces its colour-sensations to three, and analyzes white light into three coloured elements, one of which is red; and that the colour-blind eye, on the other hand, reduces its colour-sensations to two, and analyzes white light into two elements, neither of which is *red*; for colour-blindness takes its character more from its non-recognition of red than its positive recognition of yellow and violet. An essential distinction which can thus be drawn between perfect vision and colour-blindness has induced Sir J. Herschell to adopt the term *dichromatic* (cognizant only of two colours) to characterize the colour-blind.* We shall now examine how far the withdrawal of the red ray affects other colours. In the first place, all the light tints, as well as the dark tints, are liable to be mistaken for each other. The orange is no longer red and yellow, but dark yellow; the yellow is purer, the green distinct, the blue purer, and the indigo and violet no longer red and blue, but blue mixed with more or less black, the violet being the darkest, as containing least blue in proportion to red, while the red part itself, though not seen as a colour, is not perfectly black. The red is generally seen as grey, or neutral tint; the orange as a dingy yellow; the blue as a dirty indigo, and the violet as a pale blue, mixed with black and grey.

In the “Philosophical Magazine” for 1857 and 1862 will be found a series of experiments, instituted by Professor Maxwell, to test the accuracy of his own eyes in distinguishing between shades of colour; and his data may be followed by any one curious in the same field of inquiry. A large variety of all shades and tints of coloured wools may be used for the purpose. They should be placed in a mixed heap before the person, who must try to arrange and name them, beginning with the

* Dr. Wilson employs the term *chromato-pseudopsis* (false vision of colours), as it, he says, “very fairly expresses the general character of the affection, which more frequently shows itself as an insensibility to certain colours, than as a total inability to discern them.”

darkest, and putting those tints together that are most alike. Professor Maxwell adds, "The intelligent testimony of the colour-blind may supply a sure foundation for the theory of vision."

Many other curious and interesting points in connection with the philosophical part of our inquiry might be entered upon did the space at command permit us to do so; but enough has been said about light and colour to enable the reader to comprehend the more intricate part of the subject we are about to enter upon—namely, colour-blindness. As I have already said, the defect does not necessarily interfere with the integrity of the eye as an optical instrument. Indeed, in a case recorded by Dr. Wilson of a Mr. R——, an engraver, he counts himself not a sufferer, but a gainer by his colour-blindness. "Thus, an engraver has two negative colours to deal with—black and white. Now, when I look at a picture, I see it only in white and black, or light and shade; and any want of harmony in the colouring of a picture is immediately made manifest by a corresponding discord in the arrangement of the light and shade, or, as artists term it, the *effect*. I find, at times, many of my brother engravers in doubt how to translate certain colours of pictures which to me are matters of decided certainty and ease. Thus, to me it is valuable. I am totally unable to retain certain colours in my mind, nor able to give their names when shown to me a second time. Sometimes I can see some reds and greens by lamplight. A few years ago I ventured to buy some green baize; but unfortunately bought a very bright red, which was excessively painful to my eyes by lamplight, but agreeable enough by daylight. One of my brothers is equally defective, and my grandfather was very deficient in his knowledge of colours. My sight is natural, and rather powerful; for I am able to see very minute objects without assistance from glasses, and I can also see very distinctly with but little light. With regard to the rainbow, or solar spectrum, I can see clearly there are different shades of colour, but I am unable to say which is the red. The violet and yellow are very clear and distinct."

Those who have compared a coloured drawing or oil painting with an engraving of it will appreciate the nature of the difficulty which Mr. R—— so easily surmounts. In heraldic engraving, for example, a system has long been followed of representing each colour by a separate set of marks. It comes, however, to be a very curious question whether this gentleman's version of a picture would satisfy one whose perception of colours was perfect. Professor Kelland and Dr. Wilson think it would not, as they have observed in the course of their inquiry that

colour-blind persons arrange different shades of the same colour according to their intensity, in a series which did not satisfy their eyes; and further, that their arrangement of different colours according to their intensities seemed discordant to both these gentlemen.

The celebrated Dugald Stewart, and Dr. Darwin, the poet and botanist, could only by shape discover the difference between cherries and the leaves among which they grow. Dr. Dalton, the propounder of the atomic theory in chemistry, was not convinced he was colour-blind, until by accident observing the colour of the flower of the *Geranium zonale* by candlelight in the autumn of 1792. The flower was pink, but it appeared to him almost a sky-blue by day: in candlelight, however, it was astonishingly changed, not having then any blue in it, but being what he called red; forming a striking contrast to the blue. He also compared sealing-wax to one side of a laurel leaf, and a red wafer to the other, and his doctor's scarlet gown to the leaves of trees. "I have seen specimens," writes Dr. Dalton, "of crimson, claret, and mud which were very nearly alike. Crimson has a grave appearance, being the reverse of every showy or splendid colour. The colour of a florid complexion appears to me that of a dull, opaque, blackish blue upon a white ground. Diluted black ink upon white paper gives a colour much resembling that of a florid complexion. It has no resemblance to the colour of blood." From the care with which Dr. Dalton investigated his own defect, it has become popularly known as "Daltonism." Nor was his case at all peculiar with regard to flowers, for the colour-blind are constantly found unable to distinguish the petals of the scarlet geranium from its leaves, the flowers of the wild poppy from the unripe corn amongst which it is growing. Moreover, those who thus mistake scarlet, regard green as a darkish colour, and confound it with drab.

The number of cases now upon record of persons afflicted in this way are very considerable; though until within these late years it was supposed to be confined to a very few individuals. From the calculations of various authors, that *one* person out of every *fifteen* is colour-blind, and from the investigations of the late Dr. Wilson upon 1,154 persons at Edinburgh made in 1852-53, we gather that—

- 1 in 55 confounded *red* with *green*,
- 1 in 60 confounded *brown* with *green*,
- 1 in 46 confounded *blue* with *green*;

hence, that *one* in nearly every *eighteen* had this imperfection. Professor Siebeck found five out of forty youths in the two upper classes in a school at Berlin colour-blind. Professor

Prevost considers it occurs on an average in one out of twenty persons ; and Wartmann, whose investigations almost exhaust the subject, thinks this estimate is not exaggerated. M. Lubeck rejects this conclusion as unsound, from the observations having been made in England and Germany, where blue is the prevailing colour of the eyes ; and it is a question with him whether it occurs so frequently in persons the *irides*-colour of whose eyes are black or hazel. In answer to this, it seems the great majority of cases examined by Wartmann had black irides.

This consideration, however, cannot be of much importance beyond the physiological correspondence observable with the ophthalmoscope between the colour of the iris and the fundus of the eye, by the relative determination of the *pigmentum nigrum* * in persons of different complexions. In adapting the eye to varying intensities of light, the pupil (iris) of course acts a principal part as to the amount of visual rays received, but its changes cannot have much effect upon the varying intensities of the vibrations to which the supplementary phenomena of colours are ascribed. It is the intensity rather than the character of the light that the iris controls, and which remains the same whatever sensation of colour is excited. It is different with regard to the influence which sex seems to exert, for on an analysis of upwards of two hundred cases, the proportion of males affected is no less than nine-tenths of the whole. Thus, it would appear that in this respect, the perfection of vision, the ladies have greatly the advantage over the gentlemen. There is, however, an interesting account given by M. Cumer of a family of thirteen females (extending through five generations), all of whom were colour-blind. On the other hand, Dr. Bronner, of Paris, relates the case of a learned chemist, a German, whose two daughters were free from their father's defect. The children of the eldest one were likewise unaffected, whereas three sons of the youngest were all colour-blind. A grandson, also, the son of one of these latter, inherited the defect. In the "American Journal of Medical Science," 1854, another similar case is reported, where seventeen descendants, chiefly males, of the maternal grandfather all inherited colour-blindness.

The two elder sons out of a family of four suffer from this defect. The second son, now an eminent sculptor, early in life exhibited great taste in drawing and painting, but after some few years of study was obliged to relinquish the art, in

* I make no apology for introducing technical terms into this paper, since the anatomy of the eye is so well explained in a paper which appeared in the January part of the present year. See page 220.

consequence of the many blunders he committed in the combination of his reds and greens. Upon my directing his attention not long since to a very brilliant carpet, having a bright scarlet ground, with vivid green fern-leaves running over it, he said he could see no difference except in the warmth of tone of the red over the green. I have repeatedly examined his eyes with the ophthalmoscope without observing any departure from the normal condition, except a small difference in the colour of the fundus; the choroid has less blood circulating in it, and the pigment-coat is certainly much paler. But this must be taken with some modification, as the irides are brownish, scarcely hazel: in every other respect the sight is nearly normal, as may readily be surmised, from his successful career as a sculptor. An only sister, it should be mentioned, paints to perfection.

From other instances on record, it would seem that colour-blindness is frequently compensated for by the greater exactness with which distant as well as near objects may be perceived, and this, too, in a comparatively obscure light. We find in the "Glasgow Medical Journal," vol. ii., a case of the kind with some valuable remarks by the individual himself. "All objects whatever, when viewed at a distance, lose their local colouring, and assume more or less of a pale azure blue tinge, which painters term *the colour of the air*: this is interposed between myself and a distant object. No colour contrasts to me so forcibly with black as this azure blue; and as you know that the shadows of all objects are composed of black, the forms of objects which have acquired more or less of this blue tint from being distant become defined and marked by the possession of shadows which are invisible to me in the more highly coloured objects in the foreground, and which are thus left comparatively confused and shapeless masses of colour. So much is this the case with me when viewing a distant object, as to overcome the effect of perspective, and the shading in the form and the garments of human beings at some distance from my eye is often so predominant, and marks them out so distinctly, as to overcome the effect of diminution of size; and although I see the object most distinctly, I am unable to tell whether it be a child near me or a grown-up person far off."

Both Professor Wartmann and Dr. Wilson examined and tested individuals who corrected by the touch erroneous judgments which they formed regarding colours. A case of the kind came under my own observation which I shall presently relate; and I know and have met with very many instances in the totally blind able to distinguish every variety of colours by the delicacy of the sense of *touch*: they tell me there is a

sensible difference in the degree of heat conveyed to the point of the finger.*

The fact that a difference of tint is recognized, although the eye of the colour-blind person does not appreciate any difference of colour, as red and green, when compared together, and that every one is educated to call things by certain names, whether he understands the meaning or not, may help to explain the slowness with which this defect is discovered; and again, that the report of every case is rendered hopelessly imperfect from the impossibility of subjecting the eye to the test of colour.

In the "Philosophical Transactions for 1859," Mr. W. Pole, a well-known civil engineer, thus describes his own case:—"I was about eight years old when the mistaking a piece of red cloth for a green leaf betrayed the existence of some peculiarity in my ideas of colours; and as I grew older continued errors of a similar kind led my friends to suspect that my eyesight was defective; but I myself could not comprehend this, insisting that I saw colours clearly enough, and only mistook their names. I was articled to a civil engineer, and had to go through many years of practice in making drawings of the kind connected with this profession. These are frequently coloured, and I recollect often being obliged to ask in copying a drawing what colours I ought to use; but these difficulties left no permanent impression, and up to a mature age I had no suspicion that my vision was different from that of other people. I frequently made mistakes, and noticed many circumstances in regard to colours which temporarily perplexed me. I recollect in particular having wondered why the beautiful rose light of sunset on the Alps, which threw my friends into raptures, seemed all a delusion to me. I still, however, adhered to my first opinion, that I was only at fault in regard to the names of colours, and not as to the ideas of them; and this opinion was strengthened by observing that the persons who were attempting to point out my mistakes often disputed among themselves as to what certain hues of colour ought to be called." At length Mr. Pole when about thirty years of age committed a glaring blunder, and this circumstance led him to make an investigation of his case, which ended in his discovering that he was colour-blind.

All who have investigated the subject of colour-blindness

* Professor Tyndall enters fully into all these matters in his work on "Heat as a Mode of Motion" (reviewed in the present number). The eighth chapter treats of the relations of light, heat, and colour, and will be found deeply interesting to those who have read this article, and desire further information on the subject.—Ed.

agree that in the greatest number of cases it is not a disease, but rather a remarkable type of vision. It is known, however, that the peculiarity exists sometimes as a matter of degree, and that an abnormal sensation of colour may be received, but of so short a duration and corrected spontaneously as to be a source of little inconvenience, and even passes unnoticed. But as many important facts in connection with the subject have come to light, it is now made essential, and very properly so, for every driver or guard of the railway train to pass an examination as to his power of perceiving and distinguishing different coloured signals used on railways. Dr. Wilson goes further, and says: "It admits of a question whether the demands of public safety would be best met by excluding colour from railway and ship signals, or by excluding the colour-blind from the office of signalmen." Red and green lamps are employed as signals at sea, as well as on railways, and many appalling accidents, no doubt, have been occasioned by mistaking the colour exhibited both on sea and land.

A mistake in colour may arise from the fact that the sensation can only be prolonged for a very *limited time*. Thus, whenever any one looks fixedly at a bright object placed on a surface of a dark tint, and then closes his eyes, or transfers them suddenly to another ground of a lighter colour, he immediately perceives an image presenting a colour complementary to the one last observed. This arises, also, when the eyes have been fatigued by the prolonged observation of a coloured and very bright object, as a coloured light, and then suddenly turned to look at another object of a different colour; or when the eyes are fatigued by overwork and hours of watching. Many remarkable cases are on record where coloured vision has been suddenly produced. The particulars of a somewhat remarkable case lately excited some attention, and a medico-legal question of importance was raised. The sufferer, a corn-dealer, brought an action against a railway company for compensation, inasmuch as that after the accident every thing appeared yellow, and all qualities of flour, therefore, were alike in colour. The evidence chiefly depended upon the man's own statement, as it appeared the eyes were carefully examined, and yet none of the medical witnesses could give any explanation as to the cause of the yellow vision. The jury, however, awarded £1,200 damages; and as a certain amount of coloured vision is not unfrequently found to be associated with paralysis, it is not difficult to believe the retina may have been partially paralysed by the severe shock received in this railway collision.

But whether we regard colour-blindness as only a curious physical phenomenon, simply a defect, or as a positively

abnormal condition in some one or more of the structures of the eye, it may be truly said we know so little concerning its true nature, that I need offer no apology for the few remarks I am about to add upon it. As I have often met with it associated with actual disease, and since by the invention of the ophthalmoscope we are now enabled to observe many very curious changes in the internal eye before unrecognized, it is not improbable by its aid we may ultimately discover some structural differences in the eyes of the colour-blind. And if the proposition be well founded that the colour of the internal membranes of the eye must affect its perception of colours, then the choroid, which is the most fully coloured of the tunics, and the one most liable to vary in extent and depth of coloration, must have a very important influence on colour-vision. Now, in the few cases that I have had the opportunity of examining, I noticed a considerable difference both in the quantity of pigmental colouring matter, in the size of the vessels, and in the amount of blood circulating in the eye. This will be seen by any one not conversant with these matters, upon comparing the size, and perfection of the vessels in the otherwise sound eye represented in figure 1 with that of figure 2, a drawing made from an eye in a state of disease, the person having also been colour-blind prior to the loss of sight. This, however, I am ready to admit, may prove to be the exceptional and not the general condition of the eyes in the colour-blind; further investigations alone will settle this point. The seat or cause of the defect probably lies altogether beyond our reach; but whatever we can learn concerning it is certain to be of service in determining the extent to which we may hope to cure or alleviate this affection of sight.

The first case of colour-blindness that fell under my notice was that of my late talented friend, Mr. Angus Reach, whose untimely death has been so much and so justly lamented. He was incapable of distinguishing green, and only partially so red. With him both were nearly the same. The former would sometimes appear more of a pink than even red. He had altogether but a very poor conception of the primary colours. This I detected on one occasion when endeavouring to demonstrate the gradation of beautiful colours displayed by some objects made to depolarize light when placed on the stage of my microscope. After a long endeavour to convince him of the fact, as he could see nothing wonderful in it, I discovered that he was unable to name the colours correctly; and he then told me he had always been indifferent about them. To prevent error he had been accustomed always to avoid describing them, except in relatively as light and shadow, or black and white. He remarked of the *vin-ordinaire* of France, that

to him it appeared so like ink that he once found himself endeavouring to write with it. He saw no red in it.

At this time, unfortunately, my attention was not so much drawn to ophthalmic disease as it has been since, and I omitted to make such an investigation of this remarkable affection which in one so fully capable of affording accurate information as to the phenomena observed would have been so valuable. Very soon after he was attacked with the first symptoms of softening of the brain, which gradually progressed during the two years his life was prolonged.

It has since several times occurred to me that the defective condition of sight might have been connected with the early development of the disease in the brain. The extreme condition of colour-blindness in which I found Mr. Reach's eyes must have been a progressive aggravation, for otherwise it is most probable more notice would have been taken of it than seems to have been the case. Indeed it might have been induced as the first symptom of an overworked brain, as I have had opportunities since of observing instances of colour-blindness arising from general disturbance of the system, and disappearing as this was corrected and relieved.

In another case, the fundus of the eyes upon examination were seen to be very pale; the defect gradually yielded to proper treatment. The gentleman, Mr. Raith, first noticed many peculiar appearances when looking at green leaves, chiefly so if growing with grass; then all appeared elongated and serrated. Even the leaves of trees—a willow-tree in particular—were not only indistinctly seen, but were very much serrated. Red flowers of most kinds could only be distinguished by their form from leaves; the exception to this was when they were globular in their form, as the dahlia.

Mr. W. Butcher was early put to the carpet trade, and after a short time he discovered some defect of sight which ultimately proved to be colour-blindness. By close observation he made himself well acquainted with the proper names of colours, and so kept his defect from those about him. By educating the eye to the peculiar *warmth* imparted when all the colours in carpets were said to harmonize, he was enabled to raise himself to the position of a salesman in a large house of business, and ultimately became travelling salesman. He has four brothers living, all of whom are colour-blind. Taking up the prismatic colours, he could distinctly see the line of demarcation between them, but confounded purple and crimson, pink and blue, red and green; and on placing before him a series of reds, scarlets, greens, and browns, he said, "They are all a mass of confusion, and it is totally impossible for me to distinguish one from the

other." Orange and yellow were selected easily, and appeared very bright to him.

About six years since, whilst in good bodily health and vigour, his sight began to decline, and now, for some months past, he has been quite blind. The present appearance of the internal eye when examined with the ophthalmoscope is shown in figure 2. It is technically called *white atrophy*—that is, the blood supply to the optic nerve and retina is in some way cut off: in consequence the vessels are very small and nearly obliterated; the choroid coat is sharing the general disorganization.

These are only a few of the facts which have been brought to our knowledge in connection with the very interesting subject of *colour-blindness*.

EXPLANATION OF PLATE.

Fig. 1. An enlarged view of the colour-blind eye free from other defect. The outer dark-coloured ring is the iris. On looking through the pupil, the circular opening in the iris, with the ophthalmoscope, we first see a bright pink background, the choroid coat; this with the optic nerve constitutes the *fundus oculi*. The small and nearly centrally situated circular disc observed when the eye is turned a little inwards, is the optic nerve, and from its centre issues the vessels of the retina. Artery and vein closely accompany each other for a short distance, and then divide, first into two branches, one of which, with its branch, is seen to proceed upwards, and another pair downwards; after passing the margin of the optic nerve they diverge, and again subdivide, split up into numerous smaller branches, some of which come forward to the ciliary processes. The vascular choroid coat imparts the pink colour to the back of the eye, which is nearly all reflected to the eye of the observer. The only difference observed in the eye of the colour-blind is the paler appearance of the fundus, or choroid coat, and occasionally whitish interspaces indicative of a small and languid blood supply.

Fig. 2. Shows the internal eye in an advanced state of disease, and is drawn from the eye of Mr. Butcher, who, it will be noticed, suffered from colour-blindness years before his disease deprived him of sight. It cannot, therefore, be supposed that his colour-blindness was in any way owing to the disease which destroyed vision. The pupil is nearly fully dilated, being a part of the diseased condition; consequently, a much narrower ring of iris is seen than is given in Fig. 1. The choroid coat, *fundus oculi*, is very deficient in blood, which gives the mottled appearance, and indicates a state termed atrophy; a condition in which the optic nerve and vessels of the retina show the supply of blood to the internal membranes is in some way impeded, or nearly cut off, probably by a tumour forming in the brain in close proximity to the optic nerve. In other respects, the gentleman was in good health, and it is impossible at present to say to what he can attribute his total loss of sight.

