

COLOUR-BLINDNESS GENERALLY  
CONSIDERED.

COLOUR-BLINDNESS has now passed from the category of ailments denominated interesting, and is recognized as a visual infirmity the importance of which cannot be over estimated. Before entering upon a discussion of the subject it will be well to lay down a definition of colour-blindness that shall run on all fours with the latest scientific findings in the matter. Colour-blindness is merely the inability of the eye to recognize the quality of the light that falls upon it, *i.e.* to discriminate between ether waves of varying refrangibility, the impingement of which upon the retina conveys to us the sensation of colour. Total colour-blindness is the inability to distinguish any colours. To a person so afflicted all bodies are either black, or white, or grey, according to the intensity of the light reflected from them. This form of the disease is very rare. Colour-blindness in ordinary is merely a question of degree, no two persons having exactly the same colour perception. A popular, but erroneous, belief respecting human vision is that good eyesight, *i.e.* accurate perception of form and distance, carries with it a keen perception of colours. This belief is deeply rooted, the impression that colour perception is an integral part of *good* eyesight being of almost universal adoption. The eye, however, that has the most perfect appreciation of form and distance *may* utterly fail to discriminate between two differently coloured objects of the same shape, and placed at equal distances from the observer. In this case a variation in the intensity of the light reflected from the objects under view would enable the colour-blind to discriminate between them, for along with colour ineptitude there generally exists the most delicate sense of discrimination as to the relative intensities of two sources of light.

The majority of people are undoubtedly afflicted with a mild form of colour-blindness. They are physically incompetent to differentiate exactly between the nicer shades of the more composite colours, such as browns, greys, and neutral tints. Yellow would appear to be the colour that gives least trouble to the colour-blind, and blue, if strongly illuminated, is readily recognized.

Red would appear to be the colour the want of the sense of which may be said to be characteristic of colour-blindness; and as a person blind to red is usually blind to its complementary colour, green, ordinary colour-blindness may thus be defined as the inability to discriminate between red and green. The normal eye would appear capable of analyzing white light into three coloured elements, one of which is red; the colour-blind eye, on the other hand, analyzes white light into two elements, neither of which is red. Why this visual defect should manifest itself in inability to distinguish that part of the spectrum which is the result of the slowest of the series of ethereal undulations is by no means clear. Physiological knowledge as to the exact relationship between external colour factors and our mental idea of colour is yet in its infancy. A consensus of opinion would, however, appear to obtain, that, of the rods and cones to which the nerve terminals of the retina are generally compared, the latter are responsible for the processes of analysis by which a compound ether wave is decomposed into its constituent elements, each of which produces an influence upon a corresponding nerve fibre. That the rods and not the cones are least responsible for our sensations of colour would appear to be borne out by the fact that among predatory animals, to whose nocturnal habitat a colour percipient apparatus would be an unnecessary adjunct, the cones are wanting, while the rods are very highly developed. Which theory may be ultimately accepted as best explaining the varied phenomena of colour-blindness is at present matter of speculation.

Authorities on colour-blindness are, however, agreed

that in the majority of cases it is congenital; that to a great extent it is amenable to the same laws that govern the transmission of other hereditary tendencies; and while in some very few cases where it is induced by accident, such as concussion of the brain, or is the residual product of some malady or alcoholic excess, it may be palliated, yet colour-blindness is absolutely incurable.

The knowledge that something like 3 to 4 out of every 100 of our adult population are afflicted with colour-blindness is of serious importance, and statistics show that this is no over-estimation of the case. The following table shows the percentage obtained from a large number of cases:—

Examiner.	Number Examined.	Number Colour-blind.	Percentage.
Holmgren ...	32,165 men	1,019	3.168
Dr. Joy Jeffries ...	18,556 "	764	4.117
London Committee ..	14,846 "	617	4.156
Total ...	65,567 men	2,400	3.66%

The percentage of female colour-blinds is much less. My own findings show 0.162; Dr. Joy Jeffries, however, found a lower proportion than this, as among 14,557 females tested only 11 were colour-blind.

This great disparity between the numbers of the colour-blind in the two sexes has been long known, and various causes have been assigned as accountable for it. As far back as 1855, Prof. Wilson, while admitting the superiority of colour perception in the female, could not believe that the number of colour-blind women were so few as compared with the number of men similarly afflicted. He took up the view that women were not so willing to be tested as men, so that unless they were members of some public institution it was quite a voluntary matter whether they were tested or not. He argued, too, that women attached greater importance to perception for colour than men do, and would consequently strive to screen their defect from others. Thus the only women who would voluntarily submit to be tested for colour would be those who had no doubt but they were possessed of perfect colour-vision.

Unfortunately, however, this method of reasoning is based upon an hypothesis altogether fallacious. Colour-blind people do *not* of themselves realize their condition. They cannot tell that there is any difference between red and green as they see them, and red and green as viewed by the normal eye.

The fact that females have more practice in handling colours than males is not sufficient to account for this disparity, unless we assume that the present condition of the female colour percipient is the resultant of the gradual development and training transmitted through ages of time. The superior colour percipience of the female must, we believe, be regarded as an inherent quality of the sex, which no amount of individual artificial training and practice can attain to.

There is just one thing, however, which may discount a little this feminine superiority. As colour-testing was first applied, too much importance was attached to the correct *naming* of colours, and as this is a province in which the masculine section of humanity is decidedly inferior, the ratio of male to female colour-blinds may have been increased in consequence. Assuming that the percentage of 3.66 of adult male colour-blinds is correct, we are confronted with the fact that there are over 4000 colour-blind seamen in the British mercantile marine. This number is exclusive of pilots, canal or lightermen, and firemen. Now, all of the 4000 are liable to be called upon to officiate as look-outs, *i.e.* they may be placed in circumstances where it is necessary they should distinguish instantaneously between the colours of the regulation side-lights of an approaching vessel. As far back as 1877, the Board of Trade, acting in accordance with the

recommendation of the ophthalmic section of the British medical profession, came to the conclusion "that all candidates for masters' or mates' certificates shall pass a test examination as to their ability to distinguish the following colours, which enter largely into combination of signals by day or night used at sea; viz. black, white, red, green, yellow, and blue"; and they state that "the Board have been led to this decision because of the serious consequences which might arise from an officer of any vessel being unable to distinguish the colour of the lights and flags which are carried by vessels."

So far so good. But there the matter stopped. An officer failing to pass in colours is not deterred from going to sea; his certificate is simply endorsed "*failed to pass in colours*," and then it is optional with the owners, if they know of a man's colour imperfectness, to engage him or not. In the majority of cases they do not know. Wishing to obtain accurate information as to the views of the Liverpool shipowners upon this subject, I submitted to them the following queries:—

(1) Do you consider a colour-blind officer, mate, or captain, competent to have command of a vessel, steam or sailing?

(2) Would you consider a colour-blind man fit to be a look-out man?

In reply, 110 firms answered both questions in the negative, while *one* answered both in the affirmative.

Six said "Yes," to the first query, and "No," to the second.

Six expressed the opinion that no colour-blind officer should have command of a vessel; but that colour-blindness was not a barrier to a seaman officiating as look-out.

The language of the firms that answered both questions in the negative was such as to show that there was not the slightest hesitancy in the minds of the writers as to the utter undesirability, not to say danger, of employing a colour-blind man in any capacity in which he was responsible, in part or whole, for the safe navigation of the vessel.

Such expressions as "emphatically no," "absolutely unfit," "not fit to serve on a ship," "very unsuitable," &c., show in unmistakable terms the views held by Liverpool shipowners on the subject.

Liverpool shipowners certainly seem alive to the dangers of colour-blind *employés*. The practice of private examination would seem to be coming into common practice among first-class firms. But the Board of Trade have still to realize that look-out men, as well as officers, should not suffer from colour-blindness. If shipowners themselves deem it necessary for their own interests, and the safety of the *voyageurs* and property intrusted to their care, to debar colour-blind seamen from their service, it is surely incumbent upon the Board of Trade, in the interests of the travelling community over whose welfare they are supposed to preside, to make perfect colour-vision a *causa sine qua non* that shall apply to *all* seamen of our mercantile marine. It is but fair, however, to that complex and overburdened instrument of government to add that they have introduced a so-called voluntary test, whereby a seaman, on payment of a fee of 1s., may be tested as to the perfectness of his vision for colour. Such a test must, from the very necessities of the case, be absolutely worthless. What A.B. would be likely, had he the slightest suspicion of his colour-blindness, to seek that confirmatory evidence which would debar him from following his calling? Sailors may be pardoned if they prefer to remain in a state of blissful ignorance as to their colour-vision, since they have nothing to gain, and possibly everything to lose, by undergoing an examination in colours. It must be admitted, however, that there are not wanting those who aver most positively that colour-blindness is not responsible for maritime disaster of any description whatever.

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Rear-Admiral P. H. Colomb is of this opinion. In discussing the action of the Washington International Maritime Conference relative to colour-blindness, he stated, "I never knew myself a case of collision where colour-blindness was in question. The statements were generally perfectly clear that wrong helm was given deliberately in the face of the colour seen, and as no authoritative teaching had existed to show that it mattered what colour was seen as long as danger was denoted, I have never been able to lay stress on the colour-blind question."

Again, Admiral Colomb expressed the opinion "that collisions at night occurred through the helm being ported to the green light, and starboarded to the red light."

Undoubtedly this is a fertile source of disaster, but seamen, unless we assume them wilfully negligent, or astoundingly nervous, could hardly fail to act correctly at the critical moment in so many instances, if there were not some other factor at work which brought them to grief. I admit the truth of Admiral Colomb's statement as to collisions at night occurring through the helm being ported to the green light, and starboarded to the red. But I would go further, and inquire why such a wrongful procedure should be adopted in so many cases. I cannot believe it is done wilfully with the intent of causing collision, I cannot accept nervousness on the part of men, many of whom have spent a lifetime at sea, as the sole, or even a likely cause. I believe that in many cases the reason why the helm is ported to the green light and starboarded to the red light is that the persons responsible for the porting and starboarding are visually incapable of differentiating between one colour and the other.

Admiral Colomb's cause is undoubtedly the immediate means of effecting the collision; but that cause traced to its original source will, in the majority of cases, show neither negligence nor nervousness, but will stand revealed as the inevitable resultant of eyesight that cannot distinguish red from green. Pronouncements such as those quoted above, coming from those in high places, and pregnant with the weight of authority that usually attaches to such utterances, are mainly responsible for the general laxity and half-heartedness which are so characteristic of the Board of Trade's officials in respect to colour-blindness. A perusal of the records of inquiries into collisions at sea, or of the courts which settle questions of maritime and commercial law arising therefrom, reveals an astounding amount of conflictory evidence as to the relative positions of the colliding vessels as judged by their side-lights. It would be more charitable to suppose that the witnesses examined were colour-blind, rather than guilty of wilful and deliberate perjury. In such cases the question of a look-out's colour perception is never discussed. An examination of the witness *on the spot*, as to his capability of discriminating between the port and starboard lights of a ship, would set at rest the question of his physical competence to assist in elucidating the problems under consideration.

The Dutch Government has long been alive to the dangers accruing from *induced* colour-blindness—I use the term induced in contradistinction to congenital—and adopt the most drastic measures to prevent a colour-blind officer from holding a position in their mercantile marine. Among other qualifications necessary to procure a warrant empowering a man to act as mate in the merchant marine, the royal order requires:—

"Colour perception perfect for transmitted light in one eye, and at least one half in the other, according to Donders's method."

Also that "the report and declaration of the expert, as required in the above, shall be considered valid for one month only from the time the test is made."

In Holland the tests are made by experts. In England they are applied by persons who, however well they may be qualified to examine candidates in navigation and seamanship, have certainly no *locus standi* in the matter of reporting upon the perfectness, or otherwise, of a man's visual organs.

The tests themselves that these navigation examiners have to apply are far from being perfect. They are established upon a wrong principle. Candidates are made to name colours, and according to the Parliamentary Report of 1887 "the only reasons for which they are reported as having failed are inability to distinguish red from green, and either from black by daylight, and red from green and either from ground glass by artificial light."

Candidates are first required to give correct colour names to a series of eight cards coloured black, red, green, pink, drab, blue, white, and yellow, respectively. A candidate is passed, however, if he names correctly the first three.

The second test consists in naming the colours of glasses some eleven in number, viz. ground glass, standard red, pink, three shades of green, yellow, neutral tint, two shades of blue, and white. The candidate need, however, only name the ground glass, the standard red, and the standard green.

Clearly, with such tests as these, the colour-blind may easily escape detection.

The Board of Trade return relative to colour tests for the year ending May 31, 1891, shows that out of 4688 candidates who presented themselves for masters' and mates' certificates, 31 were rejected on account of deficient colour sense. That these should be rejected after serving an apprenticeship to the sea, is manifestly unfair. The test should be applied at the commencement of their nautical career, and not when the initial stage is passed. Four of the 31 were reported as passing on subsequently undergoing examination, although medical expert opinion is emphatic in stating that colour-blindness is absolutely incurable. Perhaps it may be that the examiners were disposed, by their leniency in passing young men whose previous "failure in colours" proved them colour-blind, to atone in some slight form for the bad system which allows lads to spend the best years of their life in mastering the irksome details of a profession, before it informs them that they are visually unfitted for it. It is to be hoped that the investigation into the whole system of colour-testing at present being conducted by a committee appointed by the Royal Society, may lead to thorough and effective reforms.

T. H. BICKERTON.

ON VAN DER WAALS'S TREATMENT OF LAPLACE'S PRESSURE IN THE VIRIAL EQUATION: A LETTER TO PROF. TAIT.

MY DEAR PROF. TAIT,—I gather from your letter of September 28 (NATURE, October 8, p. 546) that you admit the correctness of Van der Waals's deduction from the virial equation (1) when the particles are infinitely small, in which case

$$\left(\rho + \frac{a}{v^2}\right)v = \frac{1}{2}\Sigma mV^2 \dots \dots (1)$$

$a$  representing a cohesive force, whose range is great in comparison with molecular distances; and (2) when, in the absence of a cohesive force, the volume of the particles is small in comparison with the total volume  $v$ , in which case the virial of the repulsive forces at impact gives

$$\rho(v - b) = \frac{1}{2}\Sigma mV^2 \dots \dots (2)$$

For hard spherical masses, the value of  $b$  is four times the total volume of the sphere. But you ask, "How can

the factor  $(v - b)/v$ , which Van der Waals introduces on the left (in the first case) in consequence of the finite diameters of the particles, be justifiably applied to the term in  $K$  (or  $a/v^2$ ) as well as to that in  $\rho$ ?"

In my first letter I desired to avoid the complication entailed by the consideration of the finite size of the particles; but it appears to me that the argument there given (after Van der Waals) suffices to answer your question. For, if the cohesive force be of the character supposed, it exercises no influence upon any particle in the interior, and is completely accounted for by the addition to  $\rho$  of  $a/v^2$ . In so far, therefore, as (2) is correct when there is no cohesive force, the effect of such is properly represented by

$$\left(\rho + \frac{a}{v^2}\right)(v - b) = \frac{1}{2}\Sigma mV^2 \dots \dots (3)$$

in which  $b$  is to be multiplied by  $a/v^2$ , as well as by  $\rho$ .

Yours very truly,

October 13.

RAYLEIGH.

NOTES.

AT the Royal College of Physicians, on Monday, when the Harveian Oration was delivered by Dr. W. H. Dickinson, the Baly Medal was given to Prof. Michael Foster for distinction in physiology; the Morgan Medal to Sir Alfred Garrod for distinction in clinical medicine.

DR. DICKINSON, in the Harveian Oration, presented an admirably clear and vigorous account of Harvey's great discovery, and of the scientific results to which it has led. The earliest and most important of these results was the completion of Harvey's work by the discovery of the capillary system by Malpighi, who was born in the year in which Harvey published his famous treatise. "Harvey," said Dr. Dickinson, "had never seen a capillary, nor did the state of the microscope in his time allow of it. He was fain to conclude that the blood passed from the arteries to the veins partly by anastomoses but mainly by percolation, as water, to quote his own illustration, percolates the earth and produces springs and rivulets. Had it been possible, we may imagine the delight with which he would have witnessed the completion by vessels of his circular route." Dr. Dickinson also referred, among other results of Harvey's discovery, to embolism, and to our knowledge of inflammation, or at least as much of it as concerns the capillaries. In conclusion, he said:—"Knowledge has been advancing since Harvey's time in many and independent lines; the achievements of Bell, Bright, and Addison had no direct connection with his, but it is not too much to assert that the medicine of to-day is scarcely less permeated with the results of Harvey's discovery than is the human body with the circulation he discovered. It does not make him small to say that what he found out must have come to light had he never lived. If Columbus had not discovered America some one else must have done so before now. The law of gravity might even have been revealed in the fulness of time to another if not to Newton. But the discoverer is before his time; in this lies one measure of his praise; another, and a more important one, is in the results of his discovery."

THE Electrical Exhibition, to be opened at the Crystal Palace on January 1 next, promises to be one of great interest and importance. The requests for space—which already exceed a total of 200—include electric lighting plants for country and town houses, for mines, for steamships, for railway trains, and even for private carriages. There are also included the newest forms of motors, generators, accumulators, and other machinery employed for producing and storing electricity. Several of the more important exhibits at the Frankfort Exhibition will be