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What shall be the means of checking them? Having said this, they betook themselves to meditation."

They did not discuss questions of life and health only, but moral and religious subjects also, and their effect upon life in general. The wind, or breath, disorders of the billiary system and phlegm, or improper secretions, seem to have been fully recognized as causes of bodily diseases, while passion and darkness of mind brought about mental disorders. Long lists of drugs and directions for their proper use are given, and there is abundant evidence that the properties of vaccine matter were well known. We are told that "He who knows how to apply these in disorders is conversant with the science of medicine." And listen to the following in regard to drugs and those who use them: "He who is acquainted with their applications according to considerations of time and place, after having observed their effects on individual patients, should be known as the best of physicians. An unknown drug is like poison, or weapon, or fire, or thunder, while a known drug is like nectar. Drugs unknown by name, appearance, and properties, or misapplied even if known, produce mischief. Well applied, a virulent poison, even, may become an excellent medicine, while a medicine misapplied becomes a virulent poison. Only a physician who is possessed of memory, who is conversant with causes and applications of drugs, who has his passions under control, and who has quickness of decision, should, by the application of drugs, treat diseases."

Thirty-two kinds of powders and plasters and six hundred purgatives are next described, after which a chapter on food and its proper use gives us as good advice as is to be found in any treatise published in this learned nineteenth century. Great stress is laid upon the proper care of the teeth, and a list of plants is given from which brushes can be made, there not being manufactories of such articles as there are now.

"As the chief officer of a city protects his city, as the charioteer protects his chariot, after the same manner should the intelligent man be attentive to everything that should be done for the benefit of his own body." Therefore, bodily, mental, and, if we may so call it, religious hygiene is discussed at length, and many excellent rules given.

The question of the duality of the mind and of its connection with the understanding and the soul leads us into all the intricate mazes of Hindu philosophy, but are here discussed in such a lucid manner that one is not bewildered and can easily follow the line of thought with pleasure and profit.

"The objects of the mind are ideas. Here, again, the proper, excessive, scant, and injudicious correlation of the mind with its objects, or of the mental understanding with its objects, becomes the cause of the normal or abnormal condition of oneself." In other words, a man is sane or insane according to the proper or improper agreement of the mind and its ideas, the ideas the understanding conceives; and, therefore, "One should act in such a way as to preserve one's normal condition, in order that one's untroubled senses and mind might continue in an untroubled state; that is to say, by keeping oneself in touch with such objects of the senses as are productive of beneficial results; by properly achieving such acts as deserve to be achieved (and abstaining from such acts as should be abstained from), repeatedly ascertaining everything by a judicious employment of the understanding; and, lastly, by resorting to practices that are opposed to the virtues of the place of habitation, season of time, and one's own particular nature or disposition (as dependant upon a preponderance of this or that attribute or ingredient). Hence all persons desirous of achieving their own good should always adopt with heedfulness the practices of the good."

Selfishness was never a cause of happiness, and we are told "one can never be happy by taking or enjoying anything alone without dividing it with others." And this advice is good in every age of the world — "one should not trust everybody, nor should one mistrust everybody."

Hindu works teach that everyone should have complete mastery of his body and his senses, hence we frequently come across such a sentence as this: "One should not suffer oneself to be overcome by one's senses."

A very interesting chapter is that which treats of "The Aggregate of Four," that is, "the physician, nurse, drugs, and patient." Each is considered and as good advice as can be found given for the guidance of three of the aggregate. One thing, the first of the four, is taught which it were well to remember in our day; that is, that time must be considered in the treatment of all diseases, and one must not try to force a cure.

It would take more time and space than are at our disposal for us to consider all of even the four parts of the Charaka that have been published so far, but if any of our readers are interested, we would be glad to give them any information in regard to the work or the other publications of the learned editor of this great monument of ancient Hindu wisdom and leaaning.

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## A NEW THEORY OF LIGHT SENSATION [1]

BY CHRISTINE LADD FRANKLIN, JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

THE reasons which make it impossible for most people to accept either the Hering or the Young-Helmholtz theories of light sensation are familiar to every one. The following are the most important of them:

The Young-Helmholtz theory requires us to believe: (*a*) something which is strongly contradicted by consciousness, viz., that the *sensation* white is nothing but an even mixture of red-green-blue *sensations;* (*b*) something which has a strong antecedent improbability against it, viz., that under certain definite circumstances (e. g., for very excentric parts of the retina and for the totally color-blind) all three color-sensations are produced in exactly their original integrity, but yet that they are never produced in any other than that *even* mixture which gives us the sensation of white; (*c*) something which is quantitatively quite impossible, viz., that after-images, which are frequently very brilliant, are due to nothing but what is left over in the self-light of the retina after part of it has been exhausted by fatigue, although we have otherwise every reason to think that the *whole* of the self-light is excessively faint

The theory of Hering avoids all of these difficulties of the Young-Helmholtz theory, but at the cost of introducing others which are equally disagreeable; it sins against the first principles of the physiologist by requiring us to think that the process of building up highly organized animal tissue is useful in giving us knowledge of the external world instead of supposing that it takes place (as in every other instance known to us) simply for the sake of its future useful tearing down; it necessarily brings with it a quite hopeless confusion between our ideas of the *brightness* and the *relative whiteness* of a given sensation (as is proved by the fact that it enables Hering to rediscover, under the name of the specific brightness of the different colors, a phenomenon which has long been perfectly well known as the Purkinje phenomenon); the theory is contradicted (at least the present conception of it) by the following fact—the white made out of red and green is *not the same thing* as the white made out of blue and yellow; for if (being mixed on the color-wheel) these two whites are made equally bright at an ordinary intensity, they will be found to be of very different brightness when the illumination is made very faint.

Nevertheless, the theory of Hering would have to be accepted if it were the only possible way of escape from the difficulties of the Young-Helmholtz theory. But these difficulties may be met by a theory which has the following for its principal assumptions.

In its earliest stage of development vision consisted of nothing but a sensation of grey (if we use the word grey to cover the whole series black-grey-white). This sensation of grey was brought about by the action upon the nerve-ends of a certain chemical substance set free in the retina under the influence of light. In the course of development of the visual sense the molecule to be chemically decomposed became so differentiated as to be capable of losing only a part of its exciting substance at once; three chemical constituents of the exciter of the grey-sensation can therefore now be present separately (under the influence

[1] Abstract from the Proceedings of the International Congress of Experimental Psychology, London, 1892.

of three different parts of the spectrum respectively), and they severally cause the sensations of red, green and blue. But when all three of these substances are present at once they recombine to produce the exciter of the grey sensation, and thus it happens that the objective mixing of three colors, in proper proportions, gives a sensation of no *color* at all, but only grey.

This theory is found, upon working it out in detail, to avoid the difficulties of the theories of Helmholtz and of Hering.

Its assumption of a separate chemical process for the production of the sensation of grey gives it the same great advantage over the Young-Helmholtz theory that is possessed by the theory of Hering; it enables it, namely, to account for the remarkable fact that the sensation of grey exists unaccompanied by any sensation whatever of color under the five following sets of circumstances—when the portion of the retina affected is very small, when it is very far from the fovea, when the illumination is very faint, when it is very intense, and when the retina is that of a person who is totally color-blind. This advantage my theory attains by the perfectly natural and simple assumption of a *partial* decomposition of chemical molecules; that of Hering requires us to suppose that sensations so closely related as that of red and green are the accompaniments of chemical processes so dissimilar as the building up and the tearing down of photo-chemical substances, and farther that two complementary colors call forth photo chemical processes which destroy each other, instead of combining to produce the process which underlies the sensation of grey.

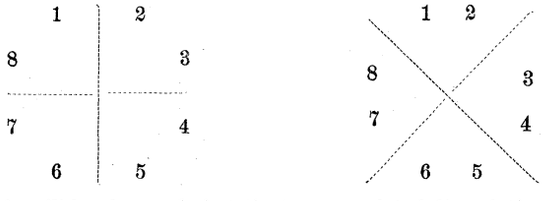
Of the first four of the above enumerated cases the explanation will readily suggest itself; in the case of the totally color-blind it is simply that that differentiation of the primitive molecules by which they have become capable of losing only a part of their exciting substance at one time has not taken place; the condition, in other words, is a condition of atavism. In partial color-blindness and in the intermediate zones of the retina in normal vision the only colors perceived are yellow and blue. This would indicate that the substance which in its primitive condition excites the sensation of grey becomes in the first place differentiated into two substances, the exciters of yellow and blue respectively, and that at a later stage of development the exciter of the sensation of yellow becomes again separated into two substances which produce respectively the sensations of red and of green. In this way the unitary (non-mixed) character of the sensation yellow is accounted for by a three-color theory as completely as by a four-color theory. A three-color theory is rendered a necessity by the fact that it alone is reconcilable with the results of König's experiments for the determination of the color-equations of color-blind and of normal eyes,[1] experiments which far exceed in accuracy any which have yet been made in color-vision, but which, owing to the intricate character of the theoretical deductions made from them, have not hitherto been allowed their due weight in the estimation of color theories.

The explanation which the theory of Hering gives of after-images and of simultaneous contrast are not explanations at all, but merely translations of the facts into the language of his theory. My theory is able to deal with them more satisfactorily; when red light, say, has been acting upon the retina for some time, many of the photo-chemical molecules have lost that one of their constituents which is the exciter of the red sensation; but in this mutilated condition they are exceedingly unstable, and their other two constituents (the exciters of the sensations of blue and of green) are gradually set free; the effect of this is that, while the eyes are still open, a blue-green sensation is added to the red sensation with the result of making it gradually fade out into white, and, if the eyes are closed, the cause of the blue-green sensation persists until all the molecules affected are totally decomposed. Thus the actual course of the sensation produced by looking at a red object,—its gradual fading out, in case of careful fixation, and the appearance of the complementary color if the illumination is diminished or if the eyes are closed,—is exactly what the original assumption of a partial decomposition of molecules would require us to predict. The well-known extreme rapidity of the circulation in the retina would make it impossible that the partly decomposed molecules just referred to should remain within the boundaries of the portion of the retina in which they are first produced; and their completed decomposition after they have passed beyond these boundaries is the cause of the complementary color-sensation which we call simultaneous contrast. The spreading of the actual color which succeeds it would then be accounted for, as Helmholtz suggests, by a diffusion of the colored light in the various media of the eye.

No effort has hitherto been made to explain a very remarkable feature in the structure of the retina,—the fact that the retinal elements are of two different kinds, which we distinguish as rods and cones. But this structure becomes quite what one might expect, if we suppose that the rods contain the undeveloped molecules which give us the sensation of grey only, while the cones contain the color molecules, which cause sensations of grey and of color both. The distribution of the rods and cones corresponds exactly with the distribution of sensitiveness to just perceptible light and color excitations as determined by the very careful experiments of Eugen Fick.[2]

Two other theories of light sensation have been proposed besides the one which I have here outlined, either one of which meets the requirements of a possible theory far better than that of Hering or of Helmholtz; they are those of Göller[3] and Donders.[4] The former is a physical theory. That of Donders is a chemical theory, and very similar to the one which I here propose. Every chemical theory supposes a tearing down of highly complex molecules; Donders's theory supposes, in addition, that the tearing down in question can take place in two successive stages. But Donders's theory is necessarily a four-color theory; and Donders himself, although the experiments of König above referred to had not at that time been made, was so strongly convinced of the necessity of a three-color theory for the explanation of some of the facts of color-vision that he supplemented his four-process theory in the retina with a three-process theory in the higher centres. The desirableness, therefore, of devising a partial decomposition of molecules *of such a nature* that the fundamental color-processes assumed can be three in number instead of four is apparent.

But the theory of Donders is open to a still graver objection. The molecules assumed by him must, in order to be capable of four different semi-dissociations, consist of at least eight different atoms or groups of atoms. The red green dissociations and the yellow-blue dissociations we may then represent symbolically by these two diagrams respectively:




But it will be observed that the two completed dissociations end by having set free *different* combinations; in the one case 1 is combined with 2 and in the other case 1 is combined with 8, etc. If, now, the partial dissociations are so unlike as to cause sensations of yellow and blue (or of red and green) it is not probable that completed dissociations which end in setting free *different* chemical combinations should produce the *same* sensation, grey. The difficulty introduced by Donders's theory is therefore (as in the case of Hering's theory) as great as the difficulty sought to be removed. It is the desire to secure the advantages of a partial dissociation theory, without the disadvantages of the theory of Donders, that has led me to devise a partial dissociation of molecules of a different kind. The theory will be found more explicitly set forth in the next number of the *Zeitschrift für Psychologie*.

[1] A König und C. Dieterici. *Sitzungberichte der Berl. Akad.* vom 29 Juli, 1886.

[2] Studien über Licht und Farbenempfindung. *Pflüger's Archiv*, Bd. XLIV., s. 441, 1888.

[3] Die Analyse der Lichtwellen durch das Auge. *Du Bois-Reymond's Archiv*, 1889.

[4] Noch einmal die Farben-systeme. *Gräfe's Archiv für Ophthalmologie*, Bd. 30 (1), 1884.