Letters to the Editor.

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A Quantum Theory of Vision.

IN a paper appearing in the February issue of the *Philosophical Magazine* I have described a theory of vision which ascribes visual stimuli to the activity of light quanta in liberating electrons from the visual purple. Various phenomena associated with scotopic and photopic vision are considered. Those coming under the designation of simultaneous contrast did not appear to me, at the time of writing, referable to purely retinal actions. Since then it has occurred to me that simultaneous contrast effects find explanation in a very simple way on the same data as serve to explain successive contrast, *i.e.* in the external location of the sensitiser with reference to the cones and in the motion of these organs attending light stimulus.

Consider the case of a grey patch bordered by a black area. This disposition secures unused sensitiser around the retinal image of the central patch. When those cones which are covered by the image of this central patch retract, the unused sensitiser flows in around them. The conditions are, therefore, favourable to specially luminous sensation, and the grey patch looks bright. In the other case, when the grey patch is surrounded by a white area, the reverse conditions prevail. The retreat of the cones involves the inflow of used-up sensitiser around the cones covered by the central image. The conditions are favourable to lowered luminous sensation, and the grey area looks dark. When we substitute for the white border a coloured border, then the sensitiser invading the central area of the retinal image is "fatigued" for the particular tint of the border, and hence the central grey looks tinted with the complementary colour. The tissue-paper, which when laid over the patches accentuates these effects, acts probably in two ways. It renders good fixation impossible and, by the increased luminosity which it brings in, it causes the cone-movements to become more active.

In my paper I have invoked the "latent image" familiar to photographers. I think it explains more even than I claimed for it.

The latent image in the photographic plate may be ascribed to electrons which, having travelled a certain distance from their point of origin, become loosely attached to atoms. Afterwards they take part in the chemical effects attending development, or, if exposure is carried so far as to cause an accumulation of electrons to the point of instability under increasing electrostatic forces, the latent image runs down of itself. This is "solarisation" or "reversal." There may be a succession of such reversals under continued exposure.

It is quite to be expected that something of this sort will occur in the case of the cones, and possibly of the rods also. After-images find explanation in this way, and their theory becomes very complete when the motion of the cones under light stimulus is taken into account. As briefly referred to in my paper, the latent image serves also to explain the "dark" electrical response of the retina—a response which has the same sign as the "light" response. To understand this we have to consider that the latent image in the nerve-substance has less stability, very probably, than that which forms in the photographic plate, owing to the nature of the medium. It is probably kept in being by the continuous inflow of electrons from without the cone, and, normally, is also continually breaking down. When light is cut off, the whole accumulation runs down, attracted back to the positively charged ions developed around the cone. Hence there is a second stimulus, and it will, of course, be of the same sign as that attending the primary movement of the electrons. The final discharge of the latent image may be relatively slow, as the curves in some cases show. Looking at such a curve as that which Piper obtained for a pigeon's eye under brief periods of darkness alternating with light intervals, it needs little imagination to picture the happening of these events.

Fröhlich's results on the Cephalopod eye seem to involve the same effects. In this case the latent image builds up rapidly within the rods which are exposed directly to the light and as rapidly runs down, giving rise to rhythmic electrical responses from 20 to 100 per second. Just on account of this extreme instability of the latent image there is no definite dark response. In short, the dark response is a phenomenon connected entirely with the quasi-stability of the latent image, and is probably favoured by the location of the sensitiser external to the nerve.

From all this I think we must conclude that the stimulus is ascribable ultimately to the motion of the electron, its amount depending upon the kinetic energy, and this, in turn, upon the particular quantum which activates the electron. The return of the electron in some cases, under the electrostatic attraction at the point of origin, involves a fresh stimulus. This is a phenomenon similar to that which Lenard invokes in his explanation of phosphorescence.

On this view colour is appreciated in terms of the energy of the stimuli; brightness in terms of the concentration or density of the stimuli. Rhythmic succession of stimuli is not required, and does not exist. It will be understood that this theory does not involve views respecting the origin of the quantum. Thus, whether we believe that quanta originate at the source of light or come into existence upon its absorption—as Sir Oliver Lodge has suggested—the basis of the theory remains. The one thing essential is the relation between the energy of the photo-electron and the frequency of the light which gives rise to it.

I conclude with a question: Are there any good data available respecting the rate of motion of the cones under light stimulus? It is generally stated that it is slow even with strong lights (and faster for violet than for red). Definite information on this point seems worth seeking. For if the reaction towards the light were rapid, we could regard it as diminishing the effects of dispersion in the refractive system. It is probable (in harmony with the present theory) that the displacement would be greater for violet than for red rays. This would tend to bring cones illuminated by violet light nearer to the lens than cones illuminated by red light. There would be at least a partial correction for dispersion.

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The Constitution of Lithium.

POSITIVE rays of the alkali metals were first obtained by Gehrcke and Reichenheim by using as anode a heated metal strip upon which a suitable salt was