Sp.C. = Spinal cord.
III.L., IV.L., V.L., VI.L., VII.L. = 3rd to 7th lumbar nerve roots.
I.S., II.S. = 1st and 2nd sacral nerve roots.
E.C. = External cutaneous nerve.
A.C. = Anterior crural nerve.
Obt. = Obturator nerve.
Sc. = Sciatic nerve.
× = Branch from 5th to 6th lumbar nerve root.

"A New Hypothesis concerning Vision." By JOHN BERRY HAYCRAFT, M.D., D.Sc. Communicated by E. A. SCHÄFER, F.R.S. Received February 16,—Read March 2, 1893.

(Abstract.)

It is suggested that many of the well-known facts of vision can be more easily understood when studied from the evolutionary standpoint. The eye is no exception to the general rule, accepted by evolutionists, that all parts of the body are gradually evolved under the environmental conditions of the species. Many species are devoid of a colour sense, but are able, nevertheless, to distinguish light from darkness, and where a colour sense is present it has been developed in relationship with environmental pigments: these points have been brought out with especial clearness by Darwin and Lubbock. We may infer, therefore, that the visual apparatus of a colour-seeing species—man, for instance—was at one time only able to distinguish light from darkness, and that the colours red, yellow, green, &c., were once seen as grey. This enables us to understand why it is that the outer, less used, parts of the retina are at the present day colour blind; this fact fits in at once with our evolutionary hypothesis. From the same point of view we may explain why a minimal stimulus from a red, green, or other coloured object gives rise merely to the sensation grey—"bei Nacht sind alle Kätzen grau"—even when it falls upon the centre of the retina. In this case the minimal stimulus is unable to excite more than the simple sensation of light, and the quality of this light is not seen. A parallel may in fact be drawn between sight and hearing and smell, for we may hear a sound too feebly to assign to it its pitch, and we may have to sniff a faint odour in order to make out exactly what it is. But a red, yellow, or green object, very brightly illuminated, also appears white, and this has been explained in various ingenious ways. It is suggested, however, that this is merely a special case of

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the law of *maximal stimulation*, which states that when a stimulus is increased beyond a certain amount it is not followed by any increased sensory effect. If you illuminate, say, a piece of red paper with an intensely brilliant light, it appears white, for the red pigment is unable to absorb all the blue and green spectral rays, which it would be able to do by a medium illumination, and enough of these green and blue rays are reflected to produce a maximum effect, and the red and yellow rays, though no doubt falling in greater quantity on the retina, produce likewise their full sensory effect and no more.

As the eye has been evolved by the action of the common pigments of nature, their examination throws light upon some of the facts of vision, and the sensory results of stimuli composed of certain mixtures of spectral rays may be explained from the evolutionary standpoint. If spectral rays near to each other, such as red and green, be mixed, their colour is that of the spectral ray which lies between them, in this case yellow. Now, when common natural pigments are observed spectroscopically, they are seen to transmit broad bands of spectral rays, generally extending to parts of the spectrum other than that part which corresponds in colour to that of the pigment. Thus a yellow natural pigment transmits a full flood of red, yellow, and green spectral rays. If we put it another way, the sensation yellow has in the course of evolution been produced by pigments which stimulate the eye by yellow spectral ray *plus* red and green spectral rays. These red and green spectral rays given out by natural pigments do not give rise to their respective sensations when mixed, for there is no such thing as a red-green sensation; but they intensify the yellow sensation which would be produced to a less extent by the intermediate yellow ray when acting alone. It is a *fact*, beyond which we cannot go, that the combination red *plus* green spectral ray stimulating the eye whenever we regard a yellow pigment produces the sensation we call yellow; an artificial mixture of such spectral rays of course gives rise to the same sensation. Similar explanations hold for the mixtures of green and violet, &c.

It is a fact that a sensation of white or grey is produced (*a*) when the eye is stimulated by all the spectral rays, (*b*) when it is stimulated, as shown by Helmholtz, by certain pairs, *e.g.*, red and blue-green. It is suggested that the colour top of Maxwell has, as a physiological experiment, been misinterpreted. When you mix on the disc a blue and yellow and get grey, the blue paper transmits to the eye one-half of the spectrum, viz., violet, blue, and some green, and the yellow paper transmits the other half, viz., some green, yellow, and red. You are therefore looking at what is physically the same stimulus as that given by a piece of white paper seen in half light. That the sensation grey occurs is not to be wondered at, for

the same stimuli give rise to the same sensation. That certain pairs of *spectral rays*, red and blue-green, for instance, produce grey or white is quite another fact, and may possibly be explained in the following way. All the pairs of spectral rays which together make grey or white are far apart from each other in the spectrum, and are not present in rays given out by any saturated pigment. Thus red and green rays stimulate the retina when any yellow object is observed, a pigment which gives out, in addition, the blue-green rays, is of a pale whitish-yellow. Thus, while pigments which give out red and green rays appear more yellow, those which give out red and blue-green rays appear less so and approach the primitive achromatic sensation.

Without knowledge of the changes which actually take place when light falls upon the retina, and before therefore the subject is really opened up, scientific observers have brought forward complete theories of vision. Both in the theory of Young and in that of Hering the visual organ is "conceived" by them, and in the absence of facts these theories can only be looked upon as tentative. In this paper an attempt has been made to arrange new facts by the side of old ones, in order that they may be understood the better. Beyond the point at which it is possible to explain a subject in terms of what we already know in physics and physiology, no progress has been attempted. Such attempts have in other departments of physiology proved too often unsuccessful to encourage effort in a subject the threshold of which every physiologist will agree that we are only about to enter.

"The Har Dalam Cavern, Malta, and its Fossiliferous Contents." By JOHN H. COOKE, F.G.S. With a Report on the Organic Remains, by ARTHUR SMITH WOODWARD, F.L.S., F.G.S., F.Z.S. Communicated by HENRY WOODWARD, LL.D., F.R.S., V.P.G.S. Received February 2,—Read February 23, 1893.

(Abstract.)

The Har Dalam cave is situated in the eastern part of the island of Malta, near Marsa Scirocco Bay. The headlands around the bay are composed of Lower Coralline Limestone, capped by *Globigerina* Limestone. Numerous valleys intersect the land at right angles to the coast line, forming small creeks and bays at their embouchure.

The Har Dalam gorge, in which the cavern is situated, is a valley of erosion which carries off the drainage of the land above, and was no doubt excavated at a time when the rainfall of Malta was much greater than at present. This is indicated by the heaps of rounded