necessary to represent graphically these impressions as points on a curve of the form given by Helmholtz. A simple re-entrant curve, say a circle, as Newton imagined, seems most consistent with observed facts. And such a circle, though it cannot be completed by points representing visible spectral hues, which do not form a complete re-entrant series, can be completed to represent all the colour hues that we can otherwise perceive. That is to say, that, so far as colour hue sensations go, we can begin with one colour and pass on through others till we come to the first again. And this relationship and order of arrangement is one of which every individual possessed of a normal colour sense is more or less intuitively conscious.

In arranging round a circle points to represent the 150 or so hues which may possibly be distinguished in the spectrum, it has to be remembered that the arrangement to be representative of our re-entrant colour sense must be according to hue and not to wave length. It must be a physiological, not a physical arrangement. The reason of this is that the rate at which perceptible change in hue takes place for different wave lengths varies within very wide limits and in an altogether intermittent manner.

But it is not necessary to pursue such a speculative matter as the selection of the three points in the colour circle to represent symbolically the so-called primary sensations. The selection could not be purely arbitrary; it would be conditioned by being brought into accordance with such phenomena as the known effect of mixing colours, the existence of complementary colours, dichromatism, etc. But the three points being merely symbolic, when the idea of selecting them to represent such spectral colours as "make" white is rejected, need not necessarily be denoted otherwise than by letters or numbers.

THE LATE EFFECT OF TAR POISONING ON FISH

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THE question of river pollution by road tar or its bases has not received much investigation, but at the present time the subject of tar pollution and its effects upon fish is being considered by the joint committee appointed by the Board of Agriculture and Fisheries and the Ministry of Transport to enquire into it, and carry out experiments as to its poisonous effects. The following case which illustrates the late effect of tar poisoning, is therefore, we think, of some interest.

Some two or three years ago a well known Hampshire trout stream was poisoned by tar used upon the road. Fish were taken out in large numbers, dead, dying, and blind. From the description of the condition the blindness appeared to be due to maceration of the cornea. At the time it was proved definitely that the tar was the cause; tar was obtained from the actual road, and experiments were tried upon fish in ponds with the same effect as above described. It was also found that the phenol constituents of the tar—that is to say, those which were soluble in water—were the cause.

At the present time there are many semi-blind fish in the river; they frequently lie out in shallow water, quite uncovered by weed,

FIG. 1.—Anterior Staphyloma following a perforating corneal ulcer in a trout. Note the secondary pigmentation of the Cornea.

and, of course, will not take any fly on the surface of the water. The trout, the subject of this paper, was a fish of $1\frac{1}{2}$ lb., which ought, according to its length, to have been 2 lb. in weight, very dark in colour, and was lying in the middle of the stream in shallow water. On the left side one could approach quite close to it, and it was evidently quite blind. On the right side, although it could not see an object as big as a salmon fly, when the shadow of a person was thrown across it, it moved off rapidly into the water, and it evidently had a perception of light in that eye. As the fish was obviously of no use for sporting purposes it was removed from the water.

The right eye showed the cornea to be semi-opaque from an old nebula, affecting principally the anterior and lower half of the eye.

This has evidently been the result of corneal ulceration. The left eye was shrunk, and there was a scar in the front and lower part of the eye as the result of an ulcer which evidently had perforated the cornea, and to which the iris had become adherent. There was also considerable pigmentation in the superficial layers of the cornea. There are many fish in this river which do not seem to look at a fly, and no doubt a considerable number of them are semi-blind and are unable to see it.

Pathological Report on the Eyes of a Fish Preserved in Formalin

Microscopic Examination.

(1) The cornea is largely denuded of its surface epithelium, probably partly post-mortem. For a considerable extent to one side there is a cellular infiltration of the cornea, which extends deeply to a

FIG. 2.—Corneal Nebula following ulceration of the Cornea.

wide anterior synechia. The peripheral part of the iris is firmly welded, to an extent of half its radius, to the posterior part of the cornea on this side. In the area of the cornea which shows the greatest amount of cellular infiltration, there are many pigment cells in the superficial layers.

In the opposite half of each of these sections is seen a sheet of fibrous tissue, varying considerably in thickness and shape in successive sections. This is a posterior synechia, widely attached to the posterior surface of the iris near its root, and narrowing as it passes inwards and backwards to the lens capsule. This sheet is largely covered with pigment cells from the pigment layers of the iris.

The forty sections of this eye that were stained and mounted

show that there was anterior synechia with closure of the angle of the anterior chamber for at least a quarter of its extent and, that the sheet-like posterior synechia extended over an eighth of the circumference of the iris.

(2) The condition of the second eye is similar to that of the first, but with a greater vascular reaction in the cornea. In all the thirty sections stained and mounted from this eye there is a marked vascularity over almost the whole of the cornea. At the corneo-scleral junction there is a deep vascularity as well as superficial—in fact, new vessels throughout its depth. On one side the cornea is much thinner in section than on the other, and there is a slight degree of staphyloma. There is patchy pigmentation in the superficial layers.*

FIG. 3.—Section of the Cornea showing the pigmentation and new vessels in the superficial layers.

The anterior synechiae are chiefly peripheral.

The lens has marked vacuolation of the superficial layers chiefly on one aspect, and to a depth of about one-sixteenth of the diameter of the lens.

Conclusion

In both eyes there is evidence of the occurrence of:

- (1) *Ulceration of the cornea*.—In the second eye this must have been very severe and extensive. Apart from the condition of the lens, this eye has sufficient new vessel formation in the cornea to enable one to infer that it was practically blind.
- (2) *Anterior Staphyloma in the Second Eye*
- (3) *Iritis* with exudate behind the iris.
- (4) *Secondary cataract* in the second eye.

* Vascularity of the cornea extending into its deeper layers is not uncommon in inflammatory conditions in dogs and other animals, and the development of pigmentary infiltration of the superficial layers spreading from the pigment cells in the conjunctiva is of fairly frequent occurrence.