as five days after the dipping only 1–2 nymphs in moult were observed. A second dipping at 8–10 days interval would almost certainly have given complete control.

These results indicate that 1 : 1,700 of the gamma isomer alone or a 1 : 8,000 concentration as an addition to a plain arsenical dip with 0·2 per cent As_2O_3 will give complete control of the tick : a result that cannot at present be obtained by the arsenical dip alone. The nymphs in moult, however, are not sufficiently affected to obtain control by one dipping.

No adverse effects on the animals were observed, due to the 'Gammexane'.

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April 29.

Artificial Fertilization of Cod (*Gadus callarias* Linn.) at Port Erin

THE remoteness of most cod-fishing grounds from marine stations renders the accomplishment of the artificial fertilization of the cod (*Gadus callarias* Linn.) at Port Erin of considerable interest, particularly in relation to the experimental possibilities of investigating the variability exhibited by this species in different geographical regions[1].

This year the cod fishing has been productive off Port Erin, and acting on reports that the fish were running ripe, instructions were given to the fishery assistant, Mr. Kenneth Woodworth, to make artificial fertilization of the cod at sea by two methods, both of which were successful. Five successful fertilizations were made simply by means of squeezing eggs from a freshly caught running ripe female into a large bottle half-filled with sea water, afterwards adding milt from a freshly caught running male. One fertilization—also successful—was made by the dry method used for salmon, that is, eggs were shed into an empty bottle with the addition of milt and, fifteen minutes later, sea water.

The fertilized eggs were quickly transferred to the Marine Biological Station on the arrival of the boat in harbour, and were well washed with sea-water and kept under circulation by the admirable technique of the hatchery boxes in use at the Port Erin Station[2]. The mortality was high in the earlier experiments but low in the later ones with improved technique. Young fish hatched after ten days incubation at a mean temperature of 8·3° C. and mean salinity of about 33‰. Segmentation into two blastomeres occurred after 5 hours, into four after $6\frac{1}{2}$ hours, eight at $7\frac{3}{4}$ hours, sixteen at $8\frac{3}{4}$ hours. The eggs ranged in size from 1·22 mm. to 1·44 mm. with a modal size of about 1·3 mm. Further details will be given in later publications.

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April 12.

[1] Schmidt, J., *C.R. des Trav. Lab. Carls.*, **18**, No. 6 (1930).
[2] Herdman, W. A., 22nd Ann. Rep. Mar. Biol. Stat., Port Erin (1908).

Neotypes for Species Based on Pathological Specimens

IN a recent discussion on "The Naming of Pathological Specimens", Dr. L. F. Spath[1] arrives at the conclusion that a species based on such a specimen must be considered valid. No exception can be taken to this conclusion, but Spath's view that "a normal type [can] obviously not be chosen while the holotype [is] still in existence" might well be questioned.

G. G. Simpson[2] lists aberrance of a specific type explicitly among the cases in which "what is known about a specific type is . . . ambiguous". Such a type "fails to serve its purpose" (p. 29 of ref. 2) and has, therefore, to be replaced by a—normal—neotype.

Selection of that neotype devolves upon the student who first recognizes the pathological character of the holotype upon comparing it with normal specimens considered conspecific by him.

OTTO HAAS

American Museum of Natural History,
New York 24, N.Y.
March 19.

[1] *Geol. Mag.*, **82**, 251 (1945).
[2] *Bull. Amer. Mus. Nat. Hist.*, **85**, 30 (1945).

Factorial Analysis of Colour Vision

HOUSTOUN[1] has pointed out that a three-colour theory, such as that of Young and Helmholtz, inevitably leads to mathematical contradictions. It is well known in addition that a theory in which there are only three primary sensitivities, such as red, green and blue, becomes unsatisfactory when the many different forms of defective colour vision are studied in detail. Piéron[2] has recently attempted to meet these difficulties, but only by a complex and speculative hypothesis. Chapanis[3] has published results of experiments on variations of the saturations of spectrum colours, which are inconsistent with a three-colour theory.

In experiments at Glasgow, factorial analysis has shown interesting results. From combined correlations between measurements of sensitivity to four colours and brightness, using six different tests and 345 subjects with normal colour vision, three factors were extracted. They were : (1) general (which, like other general factors mentioned below, may be interpreted as expressing the subjects' ability to carry out the experiments, special variations of colour vision apart) ; (2) bipolar—red-green ; (3) bipolar—yellow-blue. For 38 red-green blind subjects, who form a statistically distinct group, the factors were : (1) general ; (2) bipolar—yellow-blue ; (3) inadequate evidence of a third factor. The axes were not rotated.

In another test, using eight monochromatic filters and purple, similar results were obtained with 175 normal subjects. The factors were : (1) general ; (2) bipolar—red-green ; (3) bipolar—yellow-blue. For 23 red-green blind subjects in the same experiment, however, the factors were : (1) general ; (2) bipolar—yellow-blue ; (3) bipolar—red + green *versus* yellow + blue. This shows the tendency for red and green to be identified in the red-green blind, but still to vary separately from yellow. It was interesting to compare these results with factorial analyses for two other statistically distinct groups, although the numbers were small. Nine green anomalous subjects gave the following factors : (1) general ; (2) bipolar—yellow-blue ; (3) bipolar—red-green. Three red anomalous subjects gave : (1) general, with a negative loading for red ; (2) bipolar—yellow-blue ; (3) bipolar—red-green. In all these experiments the brightness-level correlated positively with the general factor, with the blue side of the blue-yellow factor and with the green side of the red-green factor.

In a further experiment with monochromatic filters on 61 normal subjects, in which the colours were desaturated with their neighbours on the colour circle instead of with opposites or complementaries, three factors were obtained. They were : (1) general ; (2) bipolar—red + green *versus* yellow + blue ; (3) bipolar—a factor contrasting colours measured by desaturating each other. The second factor showed that in this experiment red-green sensitivities were being contrasted with yellow-blue. On the Young–Helmholtz or Ladd-Franklin theories, it is inconceivable that in such an experiment red and green should vary inversely with yellow and blue. On a four-colour theory of the Hering or Houstoun type it might be expected.

It appears that the Young–Helmholtz theory gains no support from these experiments, while a four-colour theory would be strongly supported. On such a theory it would appear that the primary sensitivities are red, green, yellow and blue : brightness-level being determined largely by general sensitivity irrespective of hue discrimination, by blue rather than by yellow and by green rather than red. Houstoun preferred peacock or blue-green to pure green. These experiments suggest green in preference to peacock. Factorial analysis strongly indicates that opposing pairs of sensitivities are inversely related : as red decreases, so green increases ; and similarly with yellow and blue. Burt[4] has obtained similar evidence. In the Glasgow experiments, in all types of red-green defectives the yellow-blue factor came out second and the red-green factor third, showing the change in relative emphasis of the factors. In the red-green blind subjects, red and green were combined in the third factor and still distinct from yellow.

Houstoun[1] has suggested two types of receptor, each capable of two alternative modes of response, namely, a red-green type and a yellow-blue type. It might be easier to consider four types of receptor, working in pairs, a red-green pair and a yellow-blue pair. The saturation and hue of a given colour mixture would then depend on the proportions in which the receptors were excited. In the red-green blind there might be a tendency for the red and green receptors to be excited by both red and green rays, and the degree of red-green blindness would then correspond to the degree of this failure of differential response. In the red and the green anomalous subjects, the position rather than the sharpness of change-over from mainly red to mainly green responses is affected, and a mixture of red and green light appears to them yellow in proportions widely different from those required by the normal subjects, though their colour discrimination in daily life is not greatly affected. On this general theory, brightness would be accounted for mainly by an independent system and partly by variations of green and of blue for normal subjects (while for those red-green defectives with darkened red vision it would also be affected by red).

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March 26.

[1] Houstoun, R. A., "Vision and Colour Vision", chapter 14 (1932).
[2] Piéron, H., "La Sensation : Guide de la Vie", pp. 152ff (1945).
[3] Chapanis, A., *J. Exp. Psych.*, **34**, 24ff (1944).
[4] Burt, Cyril, *Eug. Rev.*, **37**, 154 (1946).

Lantern Slides of Diagrams, Formulæ, etc.

FOR the past five or six years I have been using a method for making lantern slides of line drawings which is easier and cheaper than that indicated in *Nature* of Nov. 10, 1945, p. 574 [see also *Nature*, May 4, 1946, p. 591].

Take a clean lantern slide and coat it with egg albumin by allowing white of egg to run over it ; one egg will suffice for about twenty slides. Stand the slide against the wall for three or more hours to dry, taking care that dust does not fall on it. When it is sufficiently dry, it is fairly easy to write on it with ordinary indian ink of any colour.

An alternative method is to coat the slide with a thin solution of Canada balsam, just enough to cover the whole slide ; run off excess Canada balsam, and stand the slide to dry. Use indian ink.

Recently I have been using a still simpler method. Clean the slide until all traces of grease or fat have been removed, and dry it. Using any of the common glass inks, one may write directly without coating the slide.

Apart from the saving in cost and time by any of these methods, the luminosity of these slides is such that they can be projected in a room with practically all the windows fully open or with most of the electric lights burning in the room. This has proved very practical during lectures, as students can see the screen and make notes of the slide diagram or text. Here in Bombay the cost of slides prepared by any of these methods is about 2*d*.–3*d*. each. With a little practice it is an easy matter to prepare biological slides, chemical formulæ, etc.

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