

ART. XIX.—*On Newton's use of the term Indigo with reference to a Color of the Spectrum*; by Professor O. N. ROOD, of Columbia College.

THE coloring matter known as indigo has a dingy, dark blue color, which scarcely qualifies it to rank as a representative of one of the pure brilliant colors of the spectrum. Von Bezold has already objected to its use on account of the *darkness* of the tint, but in the present paper I propose to show that in another and more important respect it is equally inapplicable. Newton intended to designate by it the color of that part of the spectrum which is situated between the blue and violet; indigo, however, is really a representative, though a poor one, of an entirely different region of the spectrum, as will be shown by the following considerations.

Experiments were first made with three different samples of indigo in order to see whether important differences in hue existed when the substance was prepared by different persons. One of the best methods of studying the hue of a colored surface is to ascertain the nature and amount of the colored light which is complementary to it. Discs of card board were accordingly painted with indigo as a water-color pigment and these were combined by Maxwell's method with two discs painted with chrome yellow and vermilion, and neutralization effected by rapid rotation.

Indigo as a water-color pigment (prepared by Winsor and Newton).

Ratio of red and yellow necessary to neutralize it.

Chrome-yellow, 67. Vermilion, 33.

Indigo as a water-color pigment (prepared by Barnard).

Chrome-yellow, 65. Vermilion, 35.

Dry commercial indigo was then rubbed on white drawing paper, and gave a result similar to those just detailed; the ratio was:

Chrome-yellow, 62. Vermilion, 38.

In the dry state the color was then a little more greenish, a slightly larger quantity of the vermilion being required; the three experiments, however, substantially agree.

A solution of commercial indigo in water was also compared with the discs, and seemed to agree well with them.

Instead of comparing one of the dingy indigo discs directly with the brilliant-colored spaces of the spectrum, I made an accurate comparison of its color with that of a disc painted with Prussian blue, reserving the latter for direct comparison with the spectrum.

The Winsor and Newton disc which the previous experiment had proved to be the least greenish in hue, was now combined with one of vermilion and emerald green, and the following equation obtained:

$I\ 51.4 + V\ 29 + G\ 19.6 = 32.8$ white. A disc of Prussian blue similarly treated gave $P.b.\ 39.9 + V\ 35.7 + G\ 24.4 = 27.4$ white.

These equations prove that the *hue* of the indigo and Prussian blue discs were identical, for the ratio of the red and green required to effect neutralization is the same, being in the case of the indigo, 59.7 vermilion to 40.3 emerald green; in that of the Prussian blue, 59.4 vermilion to 40.6 emerald green.

The position of the Prussian blue disc in the normal spectrum was now determined with the aid of a large spectrometer, the eye-piece being provided with a slit which excluded all except a narrow slice of the spectrum. Such determinations can be made by a practiced eye with considerable certainty, as I propose to show at some future time. It was found that in a normal spectrum including from A to H 1000 parts the position of Prussian blue was at a distance from A equal to 740 of these parts. Now according to my observations on this spectrum, blue-green ends and cyan-blue begins at 698; also cyan-blue ends and blue begins at 749; hence the color of Prussian blue falls in the cyan-blue space near the beginning of the blue, and to this same position we must consequently refer the color of indigo.

It afterwards occurred to me that possibly Newton might have used the indigo in the dry lump, and accordingly I prepared a flat surface of dry commercial indigo and compared it carefully with the blue furnished by genuine and artificial ultramarine, its color being of course enormously darker, or one might say, blacker than that of either of these substances. A mixture by rotation of six parts of artificial ultramarine blue with two parts white and ninety-two parts black gives a color more or less like that of commercial indigo in the dry cake: that is to say, if a freshly *fractured* surface of indigo be compared with the compound disc just mentioned, the color of the indigo will be found somewhat too greenish; but on the other hand, if a *scraped* surface of the dry cake is used it will be too purplish. Newton therefore probably employed his indigo in the dry state.

I give below, according to my determinations, the positions and corresponding wave-lengths of indigo, Prussian blue, cobalt-blue, genuine ultramarine-blue and artificial ultramarine-blue, in a normal spectrum having from A to H 1000 parts.

| | Position in normal spectrum. | Wave-length in $\frac{1}{1000000}$ mm. |
|---------------------------|---------------------------------|---|
| Indigo, } | | |
| Prussian blue, } | 740 | 4899 |
| Cobalt-blue, | 770 | 4790 |
| Ultramarine (genuine), | 785 | 4735 |
| Ultramarine (artificial), | 857 | 4472 |

It has been shown then,

1st. That the color of indigo is really a greenish blue when it is used as a pigment or in solution.

2d. The color of the dry cake is not only very black, but variable according to the mode in which it is handled.

Taking all this into consideration, it would appear desirable to allow the term indigo to fall into disuse, and to substitute for it ultramarine, the color of the artificial variety being intended.