Schedule:

Cut material so that vascular tissue is not more than ¼ inch long.

Under reduced pressure, place in killing solution consisting of formalin, 6.5 cc; 50 per cent. alcohol, 100 cc; glacial acetic acid, 3 cc; glycerin, 5 cc.

Leave in killing solution five minutes.

Put through two changes of water, two minutes each.

Flood with acetone for five minutes, then for five minutes each in the following percentages of celloidin and acetone: 3 per cent., 7 per cent., 10 per cent., and 14 per cent.

Place specimen on wood block with a thin covering of very thick celloidin. Let it become firm in air, then drop into chloroform until solid enough to cut.

Although infiltration was not complete, 12m sections without breaks were obtained, of a quality quite satisfactory for use in elementary classes.

UNIVERSITY OF ARIZONA PALMER STOCKWELL

SPECIAL ARTICLES

TRICHROMATIC FUNCTIONS OF THE AVERAGE EYE[1]

THE trichromatic color mixture curves have been studied on 68 subjects. Inasmuch as certain of the observations are quite inconsistent with classical color theory, it has been thought best to publish them in an abbreviated form in a periodical of general scientific circulation. The detailed report is in press elsewhere.

The apparatus is a modification of the Maxwell color-box, secured against stray light and equipped with variable slits in such a fashion that one can mix lights of any wave-length and a standard white in a semicircular field, and compare such mixtures with monochromes or mixtures in another juxtaposed similar field. The total field size was 1° 40′.

The source was two 500 watt tungsten lights operated at 2790° K diffused by three double ground sheets of optical glass (Eastman).

With standard white on one field and a mixture of the three primaries, 480, 517 and 670 mμ, on the other, each of the 68 subjects was asked to glance at the field (with centered pupil) and say how the appearance differed from a perfect match. In the light of his answer the color mixture was changed until the subject stated, after looking with each eye rested, that he could see no difference between the fields.

Dichromatic matches to monochromes were made in the same fashion.

The average amounts of the primaries required to match white are red 1.740 mm of slit-width; green 1.441 mm, and blue 1.249 mm after adjustments had been made for green excitation in 480 mμ. Instead of recalculating our data to conform to assumptions of equality of chromatic valence of the three primaries, any other match is presented and plotted directly as the slit-width of each primary required for a white or found.

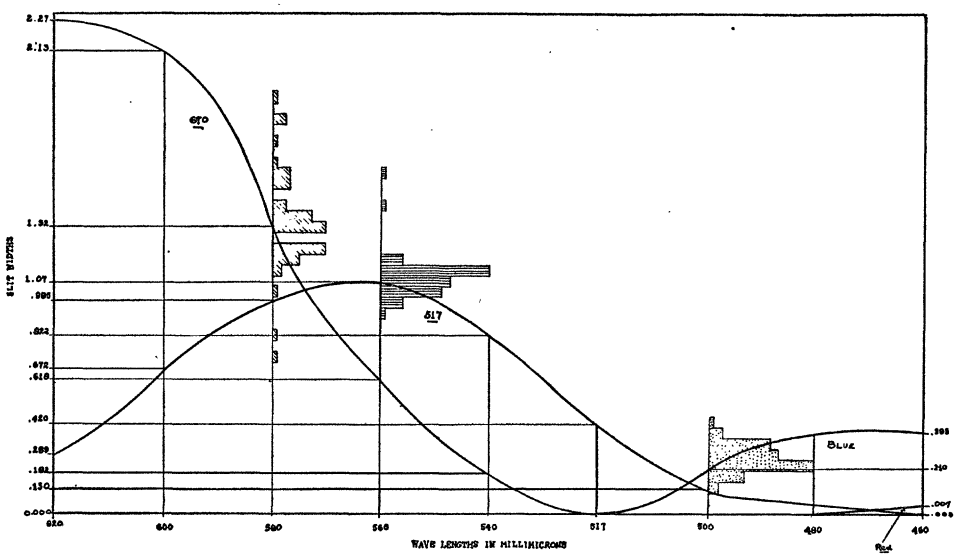

FIG. 1. Excitation Curves for Average Eye. (Showing also sample distribution of sensitivity in the population: diagonal is red; horizontal is green; stippled is blue.

[1] From the Department of Physiology and Pharmacology and the Department of Psychology, University of Louisville, Kentucky. This investigation was aided by a grant from the American Association for the Advancement of Science.

termination of the sensitivity of the average eye to each of the three primaries. Normal individuals differ widely in these respects. Yet each investigator has hitherto offered results for an inadequate number of subjects. We have, therefore, determined the sensitivity of 68 subjects in order to find the range of individual differences, their statistical significance, and tentatively to account for them. On the basis of data from only four subjects König has declared the population to be divisible into two separate sensitivity groups which would form a bimodal distribution curve. With our 68 subjects we find no such bimodal segregation, but simply a normal distribution with a distinct massing about the median. We have selected typical distributions for the primaries and blocked them in Fig. 1. We have shown for the match to 580 mμ the distribution of the red component only (diagonal lines); for the match to 560 mμ the distribution of the green component only (horizontal lines); and for the match to 500 mμ the blue component only (stippled). These three are typical of the distribution of sensitivity for each component in all the matches, and illustrate the normal distribution of sensitivity in the population.

The cause of differences in sensitivity to the primaries has generally been attributed to varying amounts of macular pigment from subject to subject. If this were true, variations in matches should have been greatest in the yellow-blue direction. We, however, found variations to be greatest in the red-green direction. This circumstance, together with other relevant facts, obliges us to suppose that macular pigment is at most a secondary cause of variation, and that the fundamental cause is a genuine difference in the sensitivity of physiological function of the receptors themselves.

The three curves are a plot simply of the average sensitivity of the 68 observers for each match, and supply data which are of value in discussing the chromatic functions of the average eye, and in establishing colorimetric standards.

(2) The second aim of our investigation was to determine where the loss of saturation of mixtures begins, why it occurs and particularly to establish the precise conditions under which it occurs.

All previous workers have reported this desaturation for the mixtures which match an extensive region of the spectrum, and have gone so far in assuming it to be a universal quality of color vision under all conditions as to think it unnecessary to describe the experimental situation under which it has been observed. We also find a loss of chroma, but for a very restricted region of the spectrum. Why this difference? They have worked under artificial conditions. These do not simulate the situation in ordinary useful vision which involves an adaptation of the retina to an intensity similar to the intensity of the photometric field. They have employed dark-adaptation and so have unwittingly admitted scotopic factors which cause a desaturation of the field containing the shortest wave-lengths. This is, of course, the mixed field. As our work, on the contrary, was done under light-adaptation, this scotopic desaturation was escaped, and the conditions of ordinary useful vision were reproduced.

But loss of saturation may also be due to an "impure" green primary; that is, one of such short wave-length as to stimulate the blue sensory apparatus as well as the green. Such a desaturation is introduced, again unwittingly, because the choice of primaries is fallaciously assumed to be indifferent since, as it is thought, results based upon different sets of primaries may be equated by means of suitable algebraic transformations. Our careful choice of 517 mμ as the green primary which is most nearly "pure" has eliminated this desaturating factor. By using 517 we have similarly avoided the loss of chroma caused by a green of too long wave-length which would introduce desaturating red excitation.

Another problem which we have treated is how to regard the supposed desaturation of the yellow region of the pure spectrum itself. Here we are not dealing with a loss of chroma due to a mixing of stimuli, but with a supposedly inherent desaturation arising from the unmixed yellow itself. As desaturation is held due to the simultaneous stimulation of the sensory apparatus for the three primaries, the blue curve is extended far into the long-wave region of the spectrum, to explain this. We feel that this extension of the blue is merely a postulate which has derived its force from tradition, and that under critical examination it becomes unwarranted. It is difficult to see how a set of curves with the blue primary extending up into the red can be made to harmonize with the color mixture data which we present. Fig. 1 shows that blue does not extend above 517. Why, then, has it been the fashion to extend it? We can account for the extension when we observe that the supposed equal chroma cancelling power of the primaries in producing white is assumed to mean also equal luminosity of the processes elicited by the stimulation of each of the three mechanisms involved in white. But since the blue which is sufficiently intense to cancel yellow chroma is much less luminous than the yellow itself, it is erroneously held, therefore, that yellow contains blue; *i.e.*, is unsaturated in the usual sense. Thus the ascription of an intrinsic blue process in the yellow arises from the illegitimate application of terms representing chroma cancelling power to situations involving luminosity.

We believe that the Gordian knot may be cut by discarding the traditional definition of white, and assuming that red and green, when mixed alone, tend to cancel each other's chroma without the intervention of any blue process whatever. This leaves but little chroma for the blue to cancel when mixed with yellow. Consequently, no intrinsic blue process need be assumed to accompany yellow, and the extension of the blue curve into the yellow region need not be postulated.

W. F. HAMILTON
ELLIS FREEMAN

CHEMICAL COMPOSITION OF RICE AND ITS RELATION TO SOIL FERTILITY IN CHINA AND JAPAN

IN 1929 W. F. Gericke[1] offered a new explanation of the fact that oriental countries have been able to maintain a relatively high production of rice without the exhaustion of the soil similar to that caused "by continued cropping of land to cereals of occidental countries if practiced without fertilizers." On the basis of experiments in which rice was grown in nutrient solutions, he comes to the conclusion that the rices of the Asiatic countries have adapted themselves so that normal crops are produced with a low content of minerals, especially calcium, magnesium, phosphorus and sulphur. He does not make clear whether this holds only for orinetal rices or also for rice grown in other countries. If he meant that rice in general has a lower content of the mineral elements than do wheat, barley, etc., it would have been simpler to compare the respective chemical composition of these crops given in the literature instead of referring to his "minima" experiments. It is well known, for instance, that rice contains, as a rule, less nitrogen, phosphorus and potassium (the three essential elements which are generally applied in fertilizers) than do the staple cereals of this country, especially wheat. However, the average yield of rice in America, China, Japan and India is two or three times as high as that of wheat. Accordingly a crop of rice will remove from the soil at least as much plant food as a crop of wheat. The article would seem to indicate, therefore, that according to Dr. Gericke's belief the range of variation of the mineral content of oriental rices is considerably below the corresponding range of those grown on soils not exhausted by continuous cropping or grown with artificial fertilizers.

It seemed to us that a comparative analysis of Chinese and American rices could throw some light on such a hypothesis. We obtained from China samples of rice of five varieties and analyzed them for ash, nitrogen, potassium, phosphorus, calcium and magnesium. We also determined these elements in three samples of rice grown in this country and one sample grown in Porto Rico. The results, calculated on the air-dried basis, are given in Table I.

CHEMICAL COMPOSITION OF CHINESE AND AMERICAN RICES

		Percentage on Air-dried Basis						
No.	Origin	Ash	N	P_2O_5	K_2O	CaO	MgO	S
1	China	1.22	1.23	0.60	0.259	0.014	0.187	0.087
2	"	1.24	1.26	0.64	0.273	0.020	0.206	0.084
3	"	1.32	1.23	0.65	0.264	0.020	0.208	0.105
4	"	1.39	1.26	0.68	0.293	0.020	0.224	0.086
5	"	1.30	1.23	0.66	0.312	0.019	0.214	0.086
6	United States	1.58	1.44	0.76	0.314	0.025	0.244	0.091
7	" "	1.20	1.46	0.58	0.238	0.022	0.208	0.098
8	" "	1.58	1.46	0.76	0.328	0.020	0.235	0.099
9	Porto Rico	1.24	1.01	0.56	0.306	0.025	0.193	0.065

It is realized that these results are too meager to form a basis for definite conclusions, but these samples, picked at random, do not indicate any striking differences in composition between the Chinese rices, grown on a soil presumably cropped for thousands of years, and the rices grown under the American method of cropping.

Moreover, Dr. Gericke's explanation does not take into account nitrogen and potassium, which, with phosphorus, are most frequently the limiting factors in crop production. Calcium, magnesium, sulphur and iron are found in crops in relatively small quantities and are seldom applied as fertilizers. Furthermore, the late Professor F. H. King, in his book, "Farmers of Forty Centuries" (quoted by Dr. Gericke), claims that "these people (Chinese and Japanese) are now and probably long have been applying quite as much of these three plant foods (nitrogen, potassium and phosphorus) as are removed by the crop" (p. 190). It is true, then, that rice in China and Japan is grown under continuous cropping but not without restitution of plant food.

JEHIEL DAVIDSON
C. E. CHAMBLISS
U. S. DEPARTMENT OF AGRICULTURE

[1] SCIENCE, 70; 1818, pp. 430–432.

BOOKS RECEIVED

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE: *Chemistry at the Centenary (1931) Meeting.* Pp. xi + 272. Illustrated. Heffer, Cambridge. 7/6.

CLARK, AUSTIN. *The Butterflies of the District of Columbia and Vicinity.* Pp. ix + 336. Illustrated. Smithsonian Institution Bulletin 157. U. S. Government Printing Office. $1.50.

SMITH, HOMER W. *Kamongo.* Pp. 167. Viking Press. $2.00.

TOHÔKU IMPERIAL UNIVERSITY. *Science Reports.* Vol. VI, No. 4. Pp. 573–809. Illustrated. Maruzen.

YATES, DOROTHY H. *Psychological Racketeers.* Pp. 232. Badger. $2.00.