M. Balcom

INTER-SOCIETY COLOR COUNCIL
NEWS LETTER

NUMBER 179 November-December 1965

INSTRUMENTAL APPROACHES TO COLORANT FORMULATION

This ISCC Symposium, scheduled at Williamsburg, February 7-9, 1966, is a sellout! Everyone who has been accepted has been notified. All speakers and topics have been settled. Chairman Max Saltzman reports that speaker topics and registrants are all excellent.

Monday: "Precision and Accuracy of Color Measurement"
Dr. F. W. Billmeyer
Mr. I. Nimeroff
Mr. H. R. Davidson and Dr. H. Hemmendinger
Dr. W. D. Wright

"Advances in Instrumentation for Colorant Formulation"
Mr. R. F. Lehman
Mr. E. L. Lewis
Mr. J. H. Ward

Tuesday: "Application of Instrumental Colorant Formulation Techniques: Session 1"
Dr. R. E. Derby, Jr.
Mr. R. P. Best
Mr. J. L. Landry
Dr. Ernst Ganz
Dr. Ulrich Gugerli
Dr. Konrad Hoffman
Mr. C. G. Leete and J. Dickerson

"Theoretical Advances in the Principles of Colorant Formulation"
Dr. J. T. Atkins
Dr. E. Allen
Mr. A. R. Hanke

Wednesday: "Application of Instrumental Colorant Formulation Techniques: Session 2"
Miss Ruth Johnson and Mr. T. Richards
Mr. I. Pobborovsky and Mr. M. Pearson
Mr. Oscar Smiel
Mr. H. R. Davidson and Dr. H. Hemmendinger
Mr. J. A. C. Yule

Honorary Chairman: Dr. Deane B. Judd

SCOTTISH COLOUR GROUP

The Scottish Colour Group opened its first series of meetings with a lecture and exhibition. K. McLaren, Imperial Chemical Industries, presented a lecture on "Illumination and Colour." An exhibition of illuminants was provided by the lighting industry.

A Scottish meeting of the Colour Group (Great Britain) will be a symposium, "Colour Vision: Colour Measurement." It will be held in the Visual Laboratory, Department of Psychology, Edinburgh University, April 1, 1966.

INDUSTRIAL DESIGNERS SOCIETY PRESENTS DESIGN AWARDS

Five Certificates of Design Merit were presented to American designers in recognition of excellence in industrial design by the Industrial Designers Society of America at its banquet in October at the Drake Oakbrook in Oak Brook, Illinois. ISCC member, Arthur H. Carpsey, shared an award with his associate at Eastman Kodak. The award was presented in recognition of the excellent design of the Kodak Instamatic M-6 Movie Camera.

ANNUAL CONFERENCE OF PHOTOGRAPHIC SCIENCE & ENGINEERING

Conference Chairman, T. Kenneth Cornell, announced that the 1966 Conference of SPSE will be held at the Hilton Hotel in San Francisco from May 8th to May 13th. A papers program is being developed to cover new processes and methods, and significant advances in the state-of-the-art. With information being made available on the expansion of knowledge over the past year and the projected developments for the future, this may well be one of the most important conferences you could attend.

DEANE JUDD RECEIVES 1965 STRATTON AWARD

Dr. Deane B. Judd, Assistant Chief of the Metrology Division, received the 1965 Samuel Wesley Stratton Award of the National Bureau of Standards, U. S. Department of Commerce. The award was presented at a special staff meeting by NBS Director Dr. Allen V. Astin. The Stratton award is given each year by the Bureau to recognize outstanding scientific or engineering achievements in support of the NBS mission by a member of the staff. Dr. Judd was awarded a bronze plaque and a $1,500 honorarium.

Dr. Judd was cited for "major basic contributions to the science of color measurement and color vision and the development of color standards for business, science and industry." In thirty-eight years with the Bureau, Dr. Judd has probably become the world's leading authority on color measurement. With a uniquely broad and deep knowledge of physics, psychology, and mathematics, he has worked on problems ranging from standards for color measurement to camouflage and color blindness.

THE AESTHETICS OF COLOR

Enclosed with this Newsletter is a reprint of "The Aesthetics of Color: A Review of Fifty Years of Experimentation," by Victoria K. Ball, from The Journal of Aesthetics and Art Criticism, XXIII/4, Summer 1965, pages 441-452.

ELECTIONS

Early in 1966 voting delegates will elect four officers and four directors of the Inter-Society Color Council. Three of the delegates from each of the 29 member bodies are eligible to vote. Ballots will be mailed from the Secretary's office to voting delegates. The Board decided to publish photographs and biographical material about the candidates so that voting delegates and other council members could know more about the candidates.

For President

WARREN L. RHODES, Manager
Duplicating and Graphic Arts Dept.
Applied Research Laboratory
Xerox Corporation
Webster, New York 14580

Member

Fellow, Institute of Printing (England)
Society of Photographic Scientists and Engineers
Technical Association of the Graphic Arts
Technical Association of the Pulp & Paper Industry

Council Status

Editor, Inter-Society Color Council Newsletter
Delegate from the Technical Association of the Graphic Arts
President-Elect, Inter-Society Color Council

NOTE: In accordance with Article V of the By-Laws, the President-Elect shall succeed to the office of President at the expiration of the term of office of the President. In accordance with Article VI the Board of Directors shall consist of the four officers ex-officio, four directors to be elected and the retiring President. In the forthcoming election one director will be elected from each of the four groups in order to give broad representation from the various member bodies.

For President-Elect

RANDALL M. HANES
Principal Staff, Applied Physics Laboratory
The Johns Hopkins University
Silver Spring, Maryland

Member

American Association for the Advancement of Science
American Psychological Association

Council Status

Chairman of Subcommittee for Problem 20: Basic Elements of Color Education
Voting Delegate from the American Psychological Association
Director, Inter-Society Color Council

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FRED W. BILLMEYER, JR.
Professor of Analytical Chemistry
Rensselaer Polytechnic Institute
Troy, New York

Member

American Chemical Society
American Physical Society
Optical Society of America
Society of Plastics Engineers

Council Status

Chairman of Subcommittee for Problem 22: Procedures and Material Standards for Accurate Color Measurement
Chairman of the Delegation from the Society of Plastics Engineers
Director, Inter-Society Color Council

For Secretary

RALPH M. EVANS, Director
Photographic Technology Division
Eastman Kodak Company
Rochester, New York 14650

Member

Illuminating Engineering Society
Optical Society of America
Photographic Society of America
Society of Motion Picture and Television Engineers
Society of Photographic Scientists and Engineers

Council Status

Secretary, Inter-Society Color Council
Chairman of the Delegation from the Society of Motion Picture and Television Engineers

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For Treasurer

NORMAN MACBETH, President
Macbeth Corporation
Newburgh, New York 12553

Member

Illuminating Engineering Society
Optical Society of America
Society of Motion Picture and Television Engineers

Council Status

Treasurer, Inter-Society Color Council
Chairman of the Delegation from the Illuminating Engineering Society

For Directors - Group I

MISS MIDGE WILSON
Executive Director
The Color Association of the United States, Inc.
200 Madison Avenue
New York, New York 10016

Member

Color Marketing Group
Fashion Group
National Home Fashions League

Council Status

Chairman of the Delegation from the Color Association of the United States, Inc.

***

MISS MARTHA JUNGERMAN
Color Coordinator
W. T. Grant Company
1441 Broadway
New York, New York 10018

Member

American Home Economics Association
Color Marketing Group
Fashion Group
National Home Fashions League

Council Status

Voting Delegate from the Color Marketing Group

For Directors - Group II

KARL FINK
Karl Fink and Associates
515 Madison Avenue
New York, New York 10022

Member

American Institute of Graphic Arts
Package Designers Council

Council Status

Chairman of the Delegation from the Package Designers Council

***

MISS BEATRICE WEST, President
Beatrice West Studios, Inc.
333 East 46th Street
New York, New York 10017

Member

American Institute of Architects
American Institute of Interior Designers
Architectural League of New York
Building Research Institute
Color Association of the United States, Inc.
Color Marketing Group
Fashion Group
National Association of Home Builders
National Home Fashions League

Council Status

Chairman of the Delegation from the American Institute of Interior Designers

For Directors - Group III

MAX SALTZMAN
Technical Assistant to Vice President
National Aniline Division
Allied Chemical Corporation
40 Rector Street
New York, New York 10006

Member

American Association of Textile Chemists and Colorists
American Chemical Society
Optical Society of America
Society of Dyers and Colorists
Society of Plastics Engineers, Inc.

Council Status

Chairman of the Delegation from the Dry Color Manufacturers' Association
Member of the Delegation from the Federation of Societies for Paint Technology

***

S. LEONARD DAVIDSON
Chief-Paint Division
National Lead Company
1050 State Street
Perth Amboy, New Jersey

Member

American Chemical Society
American Society for Testing and Materials
Federation of Societies for Paint Technology
Optical Society of America

Council Status

Chairman of the Delegation from the Federation of Societies for Paint Technology

For Directors - Group IV

GEORGE W. INGLE
Manager of Research
Plastics Division
Monsanto Company
P. O. Box 1531
Springfield, Mass. 01101

Member

American Chemical Society
American Society for Testing and Materials
Optical Society of America
Society of Plastics Engineers

Council Status

Chairman of the Delegation from the American Society for Testing and Materials
Member of the Delegation from the Optical Society of America

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EUGENE ALLEN
Research Associate
American Cyanamid Company
Bound Brook, New Jersey 08805

Member

American Association of Textile Chemists and Colorists
American Chemical Society
Optical Society of America

Council Status

Chairman of Subcommittee for Problem 18: Colorimetry of Fluorescent Materials
Voting Delegate from the American Association of Textile Chemists and Colorists

PLANNING FOR THE WEST COAST COLOR GROUP

In a communication to President Ralph Pike, Angela C. Little of University of California, Berkeley, disclosed that steps have been taken toward the forming of a new color group in California. In September, a letter and questionnaire were sent to approximately one hundred people whose names were selected from the ISCC directory and other sources. The response was very good.

Several people expressed willingness to participate in planning the first general meeting. They were all invited to a pre-organizational meeting held October 28. At this meeting, a temporary steering committee was formed, consisting of Angela Little, Chairman; Lawrence Miller, W. P. Fuller Company; Ailene Morris, Presbyterian Medical Center; David Waldren, E. I. Dupont; Ann Mardell, Zinke, Secretary, University of California. The first general meeting is tentatively scheduled for Wednesday evening, February 24.

The objects of the Council which have been proposed are to stimulate cooperative exchange of information and ideas having to do with color among those involved in the applications of color in science, art, and industry. Many who have expressed an interest are already members of Inter-Society Color Council. ISCC wishes the West Coast Color Group success in their venture.

JOSEPHINE TOMASZEWSKI RETIRES FROM U.S.D.A.

Her many friends in the Inter-Society Color Council will be interested to know that Miss Josephine Tomaszewski retired on December 30th from the U. S. Department of Agriculture where she has worked for many years under the classification of cotton color technologist. "Miss Jo" is widely known in the Council for her service to the ISCC, especially those many years in which she served virtually as its assistant secretary. During the years she worked with me, first as secretary, later as assistant in the laboratory, she kept up with all Council activities, prepared the notes and stencils necessary for our reports and - for a time - even for the Newsletter. Without Miss Tomaszewski I could not have functioned as Council Secretary, 1938-1952. It is she who has served annually at the registration desk, surprising many of you when she called you by name as you walked in! At George Gardner's request she has continued to serve annually in this capacity until this past year when a shift in duties following my own retirement in 1964, made it difficult for her to leave the laboratory at the time of the spring meetings.

On December 13 she was one of some 80 persons in the Agricultural Research Service for whom a special retirement party was given by the Administrator. On December 17 her A.R.A. laboratory co-workers, together with her long-time associates in the Cotton Division, gave her a special retirement party of her own, a very festive affair, at which they presented her with a parting gift and wished her Godspeed. I am sure her friends in the Council will join in wishing her well in whatever new venture she may now undertake. She has been a capable and loyal co-worker in color in practically all of my own color activities of the past 30 years, and has served the Council so well behind the scenes that I am glad on this occasion to make this known to those of you who may have been unaware of her continued contributions to Council activities. I am sure I speak for the Council as well as myself in wishing "Miss Jo" many future years of health and happiness.

Dorothy Nickerson

IN MEMORY OF FRANZ MUNK

Prepared by Deane B. Judd from an article by E. A. Becker in Farbe und Lack, 70, 299 (1964).

On the 24th of February 1964 after a long and painful illness, Dipl.-Ing. Franz Munk died in Goslar at the age of 64 years. In this way there has departed from us a colleague who has served us all well.

Franz Munk was born 29 April 1900 in Teplitz-Schönau in the Sudetenland. He attended the public schools in his native city which he left as a 17-year-old graduate to attend the German technical high school in Prag. In 1921 he finished his chemical studies with the degree of Chemical Analyst. In 1932 he was employed by the Society of Chemical and Metallurgical Production in Aussig to study titanium dioxide, lithopone, and iron-oxide red. The results of this creative period are the hydrolysis of titanium dioxide, and patents on the improvement of the weather resistance of white pigments through addition of barium carbonate, and on pressure drying for reducing the oil requirement of pigments. In addition to these outstanding research results of immediate practical importance, Franz Munk also concerned himself with theoretical problems. Thus there resulted from his stay in Aussig publications on titanium dioxide, on the connection between the brightening power and the hiding power of white pigments, on the sphere multiplier for determining traces of color in white pigments, and above all the two-constant theory of white layers developed and experimentally verified by him in collaboration with Kubelka, with which both authors - after the passage of some years - achieved world-wide international fame.

Further positions are his employment from 1935 to 1938 as research director of the Esten Farbenfabrik in Prag, and from 1939 to 1944 as applications chemist for lithopone with the then I. G. Farbenindustrie in Leverkusen.

At the end of the second world war we see Franz Munk from 1945 to 1946 again in his first work place, the Chemical Works in Aussig Falkenau in the field of resin technology. In 1947-1948 he held a teaching position in chemistry, and in 1949 he again returned to the pigment industry. From 1949 to 1963, largely confined to bed by a severe illness, Franz Munk was employed as a consulting chemist in the sales department of the Harz zinc oxide firm, Werner & Heuback KG, Langelshein in Harz. Here he put to use his extensive experience as a chemist for white pigments so as to make of Harz zinc oxide a standardized pigment and to enrich it with a series of special qualities.

The most influential of his achievements is undoubtedly the two-constant theory which he established in collaboration with Kubelka in 1931. With this theory Kubelka and Munk succeeded in placing on a firm scientific basis the solution to a problem up to that time unsolved, namely: determination of the hiding power of white layers. Kubelka and Munk found it possible to express the hiding power of white layers as a function of the thickness of the layer and the scattering and absorption coefficients of the material. The two-constant theory led to a comparatively simple final formula for hiding power.

This theory led to many scientifically new thoughts. First evaluated merely as an "interesting" study, the full importance of the new theory was recognized after some years in the United States by researchers such as Steele, Judd, and Davidson, and the Kubelka-Munk equations were put into practice, not only in the paint industry, but still more in the paper, ceramic, printing, and textile industries.

From the USA the Kubelka-Munk theory streamed back into Europe and in recent years has found full recognition in many industrial countries in Europe. By applying the Kubelka-Munk equations wavelength by wavelength, the theory developed for white layers serves for layers of any color; and from the fact that the absorption and scattering coefficients of a mixture of colorants are simply the concentration-weighted averages of the corresponding coefficents of the constituents, the Kubelka-Munk theory provides a solution to the important general problem of formulating colorants to match any given color. With their two-constant theory Kubelka and Munk have thus supplied a lasting service to colorant technology, and with this special field their names will remain forever bound.

JESSE B. ELLIOTT, ISCC NEWSLETTER PRINTER, DIES

Jesse Elliott was a kind, quiet-mannered southern gentleman, who helped me, and some of those before me, prepare and print the ISCC Newsletter. He was always gracious and willing to cooperate in any way he could. All of us that had the privilege of working with Mr. Elliott found him agreeable and cooperative, even under the most difficult circumstances.

Mr. Elliott treated employees with kindness and consideration almost as though they were members of the family. He was one of the first businessmen to hire handicapped employees. He helped several of these handicapped individuals to establish their own shops.

On Thursday, December 9th, 1965, Jesse B. Elliott died at the age of sixty-three. He owned and operated Mimeoform Service, Washington, D. C. Mimeoform Service maintained the ISCC mailing list, printed the ISCC Newsletter, and sent out ISCC notices for as long as I have been associated with the Council (since 1955). I am not sure how much longer Mr. Elliott performed these services for ISCC, but at the time of my arrival, he was well known and highly appreciated by the Secretary and previous Newsletter editors.

The news report of his death states that he was a native Washingtonian. He went to Miami in 1926; during World War II he was stationed in Bermuda as a civilian employee with the engineer corps. Following the war, Mr. Elliott served with the National Radio Institute in Washington and designed several radio components.

He was secretary of the Master Printers Division, Printing Industry of Washington, and a member and former officer of the Washington chapter of the Mail Advertising Service Association. He has been active in the Advertising Club and in the Direct Mail Advertisers Club.

Surviving are his wife, Dorothy; two sisters, Mary Elliott of Daytona Beach, Florida, and Mildred Berl of Washington; a brother, Virgil of Oslo, Norway; and a stepson, Donald Riley of New Orleans.

Our sympathies go to his wife. We shall sorely miss a pleasant and willing helper and a good friend of the Inter-Society Color Council.

W. L. Rhodes

THE SILENT LANGUAGE

"Americans treat colors informally as a whole--that is, situationally. We may use a spot of yellow or of red, or yellow and red to accent a gray wall. We would be unlikely to put the yellow and the red next to each other. The colors themselves have little or no value. If they do, the criterion is taste. To the Navajo the situation is quite different; colors are ranked just as we rank gold and silver--only more intensely. Not realizing this caused considerable embarrassment to a number of Indian Service employees years ago. In their attempt to bring "democracy" to the Indians these well-meaning souls tried to introduce a system of voting among the Navajos. Unfortunately, a great many Navajos were illiterate, so someone conceived the idea of assigning the various candidates for the tribal council different colors so that the Navajo could go into the booth and check the color he wanted. Since blue is a good color and red bad, the result was to load the dice for some candidate and against the others. Nowadays photographs are used on the ballots."

Edward T. Hall

THE CHEMICAL BASIS OF COLOUR VISION AND COLOUR BLINDNESS

(Newton Lecture, 1965, W. A. H. Rushton, F.R.S., Trinity College, Cambridge.)

Just three hundred years ago, Newton, then twenty-two years old, was building a telescope that was to be very much more powerful than Galileo's. He had, of course, to grind his own lenses and he was having trouble with the objective glass for he could not get the image of a star to focus really sharply. I think he must have seen, when he stopped down the objective glass and allowed rays only to pass near the centre, that the star image was a sharp point, but when the stop was moved to the periphery of the objective then, instead of being a point, the image was a streak running in the direction of the excentric stop. It was not just that the curvature of the lens here was not quite right, for the streak could not be brought to a point focus no matter where the eyepiece was placed. It really looked as though Snell's Law could not be exact and that parallel rays that were deviated, were not all deviated to the same extent. It was difficult with an objective glass and starlight to see what was happening. It would be much clearer to use sunlight and deviate the light through a large prism where the result should be much more definitely visible. He bought a prism at the fair on Midsummer Common, but before he had time to perform experiments with it the Great Plague spread from London to Cambridge, and in the autumn of 1665 the University disbanded, and Newton went to his home farm in Lincolnshire. He did not do experiments there nor did he do farming, but his time was not altogether wasted, for he saw the apple fall, extended his concept to the moon, and invented the calculus to solve the problems of celestial mechanics that resulted. But in the summer of '66 the plague abated from Cambridge and Newton came back to his rooms in Trinity College and cut "a hole in the shut of his window" and placed there his prism, and produced the solar spectrum on the far wall. We know how he discovered chromatic aberration and found that rays of light with different refrangibilities produce images usually of different colours, though from respect to the title of our first Newton Lecture I must remind you that "the rays were not coloured." Newton also performed experiments in colour mixture and enunciated his Centre of Gravity Law for the way in which different colours were produced. Now the Centre of Gravity Law implies the trichromacy of colour vision, and no one could have seen this more plainly than Newton. Nevertheless he did not draw that conclusion. He preferred to reject his experiments (which were somewhat rough), and to stress the similarity between sight and hearing. He divided the spectrum into seven regions corresponding to the tones and semitones of a diatonic scale, and concluded that each point on the retina has resonators to respond to every frequency of light.

I must pass over much work that followed: Lomonosov, still tied to the concepts of alchemy but the first to state the principle of trichromacy; the brilliant physical conjectures of Thomas Young, and the massive experimentation of Helmholtz already well under way at the time that the Centre of Gravity Law was proved by another student of twenty-three, James Clerk Maxwell, whose rooms faced those of Newton across the Great Court of Trinity. Since Newton's rooms faced south, Maxwell's faced north, and he could not get the sunlight into them; and, as is well known, he performed his experiments with coloured papers spun upon a top of his own construction. With this simple appliance he was able to plot the tristimulus values for a range of colours and to show that the red-blind type of colour defective lacked the red primary sensation; so that, plotted upon the colour triangle, their confusion loci were straight lines converging upon the red corner of the triangle.

In the century that has elapsed since Maxwell's early experiments the technique of colour matching has enormously improved. Maxwell himself later used spectral lights mixed by an ingenious device, and with the classical work of Professor Wright, our first Newton Lecturer, the problem of trichromatic colour mixtures was virtually completed, so that it was possible to say for a light of any known spectral composition what mixture of the three primary colours would match it exactly. But though this result, which was confirmed by Guild and by Stiles, allows us to specify the colour mixture in every circumstance, it tells us nothing uniquely about the colour mechanisms in the eye. It is here that the investigation of the actual visual pigments in the retina proves of some help.

PHOTOSENSITIVE PIGMENTS

Light imprints its image on the retina in very much the same way as it does upon a photographic plate. The lens system of the eye forms a pretty sharp image and the retina, like a plate, contains a photosensitive pigment that will break down when light is absorbed. Ninety years ago Kuhne worked out the properties of the visual purple, or rhodopsin, that can be seen in the eyes of frogs and mammals, and he showed how this purple pigment was bleached to whiteness on exposure to light and how, in the living eye, it was regenerated again by the biochemical processes in the retina and pigment epithelium. Dr. Dartnall, who is well known to the Group, is one of the world authorities on these visual pigments, particularly when extracted and brought into solution where the most accurate measurements are made. He has, in fact (with Dr. Crescitelli), been able to extract rhodopsin from fresh human eyes and correlate the absorption spectrum with Dr. Crawford's measurements of the twilight sensitivity spectrum, and shown that the two coincide very closely indeed. This adds great strength to the belief that rhodopsin is the pigment underlying twilight vision; but, as we all know, twilight vision is colourless vision, and therefore rhodopsin is not the pigment to be studied if we are interested in the chemical basis of colour. Rhodopsin is the pigment of the rods in the retina. We need the pigments in the cones.

Unfortunately there is so little pigment in cones that no one has ever satisfactorily obtained an extract of cone pigment from any mammal. Such extracts are so contaminated by rhodopsin that the small cone contribution cannot well be measured. But we can get round this difficulty by a trick. If, instead of taking out the whole retina and mixing together all the ingredients, as happens when pigments are extracted,- if, instead of this, we can make measurements in the living human retina, then we may take advantage of its well known structural peculiarity, namely, that at the centre in the fovea centralis there are no rods, there is no rhodopsin; measurements made here cannot be contaminated by rhodopsin, and if we can make the measurements at all it must give us nothing but cone pigments. But how are we to make measurements in the living eye?

The principle that we use is that of the ophthalmoscope, or of the eye shine that comes back from a cat's eye when it is caught in the head lamps of a car. That light has been twice through the retina and must bear upon its spectral composition the imprints of the pigments through which it has passed and which have absorbed part of the light. This is not the place to discuss the techniques of measurement. As the Group well knows, both Dr. Weale and I have devised and built equipment that is capable of analysing the light returning from the eye and deducing from it some properties of the visual pigments through which the light has passed. My densitometer was designed to make measurements as accurately as possible even though it took some time to make them. So, by means of a phase-sensitive rectifier, we obtained a rather good signal-to-noise discrimination, and using one wave length at a time and taking between five to ten seconds for a measurement, we got reliable estimates of the pigment. When Dr. Weale built his equipment he did not follow our pattern but designed an instrument to do quite a different kind of thing; namely, to make measurements throughout the whole spectrum extremely rapidly so that he was able to record the reflectivity at over a score of spectral wave lengths within a second. It is clear that my equipment is better designed for equilibrium or slowly changing conditions whereas Dr. Weale's is ideal for the rapid record of transient changes throughout the whole spectrum. In the experiments that I wish to speak of now we are concerned with measurements as accurate as possible in steady states, and therefore the Cambridge densitometer is probably the instrument of choice, and it is to our results that I shall refer.

The first definite results were published just ten years ago, and we were able to show that the protanope (the red-blind kind of colour defective) lacked the red-sensitive pigment that is present in the normal; so exactly a hundred years after Clerk Maxwell (1855) showed that protanopes lacked the red primary sensation, we were able to demonstrate (1955) that the physiological entity that they lacked was the red-sensitive pigment, erythrolabe. In the subsequent ten years we have improved the technique a good deal and made measurements on a very large number of normal and colour-defective subjects, and the results seem to come out as König suggested long ago. In the red-green range protanopes lack the normal red pigment, erythrolabe, and contain the green-sensitive pigment, chlorolabe, only. Deuteranopes, on the other hand, lack chlorolabe and contain erythrolabe only; but normal eyes contain both erythrolabe and chlorolabe and everyone (except tritanopes) has the blue-sensitive pigment, cyanolabe. The evidence for this will take me most of the rest of this lecture.

THE EVIDENCE

In order to see whether a protanope contains one pigment or two in the red-green range we use the most powerful of all the scientific tools, that of substitution. In the first experiment we bleach the fovea by a red light; in a second experiment we bleach with a blue-green light. Everything else in the experiment is the same and the intensities of the two bleaching lights are chosen so that had the protanope, in fact, had a red-sensitive and a green-sensitive pigment, but lacked the power to discriminate between their outputs, it would be the red-sensitive pigment that was chiefly bleached with the red light, and the green-sensitive pigment chiefly with the blue-green light. If then we measure the change after bleaching in the two cases, they ought not to be at all identical; for the change after red should be greatest in the red, and the change after green should be greatest in the green. But when this experiment was done it was found that the change was very nearly identical in the two cases and where there was a small change it was not systematic but just the sort of change that occurred when the experiment was repeated with apparently identical conditions. We may therefore conclude that the protanope has only one photosensitive pigment in the red-green range, or at least if he has another it is in such small quantity that it cannot be detected by our technique.

Now when in any spectral range there appears to be only one photosensitive pigment present, we can tell whether or not it is the visual pigment of that range by the tests, mentioned earlier, that Dartnall & Crescitelli and Crawford, applied to human rhodopsin, namely, to see whether the action spectrum of the pigment corresponds to the spectral sensitivity of vision. This test we applied to the pigment chlorolabe in the protanope and we found that lights of different wave lengths, adjusted in intensity to bleach chlorolabe equally fast, were judged by the protanope to be equally bright using flicker photometry. We may there conclude that the pigment that we can measure in the protanope is that which generates the signal that he sees.

These experiments on the protanope were repeated on the deuteranope with exactly the same results. The deuteranope was proved to have only one pigment in the red-green range since bleaching with a deep red light or with a blue-green light that the deuteranope found of the same intensity, produced the same change in pigment. Thus he has only one pigment present and this was found to correspond with his spectral sensitivity curve. Consequently the pigment that we measure on the deuteranope is not the same as the pigment we measure on the protanope: there is a difference that corresponds to the well-known difference in the spectral sensitivity curves of these two types of dichromate.

Turning now to the more difficult case of the normal eye where two different pigments have to be measured at the same time, we can gain a great deal of strength from the results with protanopes and deuteranopes. If we bleach the normal eye with a deep red light that has no bleaching effect upon the protanope, the pigment affected appears to be the same as the erythrolabe of the deuteranope, for the two pigments have the same difference spectrum, the same action spectrum, the same photosensitivity, and the same regeneration rate; and the spectral sensitivity corresponds very closely to that of the Stiles' red mechanism II_5. Rather similar considerations lead us to the conclusion that chlorolabe in the protanope is the green-sensitive pigment of the normal eye whose action spectrum corresponds closely to Stiles' green colour mechanism II_4. There are four very different kinds of approach that lead to similar spectral sensitivity curves for the red and the green mechanisms in the eye (Fig. 1 A and B). Stiles, by his two colour increment threshold, has shown that there is a red mechanism and a green mechanism whose spectral sensitivity is the same whether determined by varying the colour of the flash or varying the colour of the background. The dots in Fig. 1 plot his II_1 (blue), II_4 (green) and II_5 (red) mechanisms. Willmer has shown that these curves are very similar to the spectral sensitivity of protanopes and deuteranopes measured upon the fovea (Fig. 1 circles). Crosses show the spectral sensitivity in Brindley's artificial monochromacies produced by adapting the eye to very bright red or green lights together with violet. Finally the squares show the action spectrum of erythrolabe and chlorolabe determined objectively upon the fovea by retinal densitometry.

These congruent results are supported by the fine work of Marx, Dobell & MacNichol recently reported from U.S.A. They have succeeded in measuring the visual pigments in single cones from the eyes of monkeys and man. This is a remarkable achievement because there is so little pigment in a cone that it is bound to be bleached away by the light used to measure it. They used a computer instructed to take into account the inevitable bleaching as measurements went on, and give the adjusted answer. Fig. 2 shows their results, each point being a computed measurement, and each curve so formed being obtained from a separate cone. It is seen that all the points lie approximately on one of three curves; that means that each cone contains one of three kinds of pigment. The heavy circles and dots are plotted from our (previously determined) difference spectrum of erythrolabe and chlorolabe. So this new work with single cones confirms and extends our conclusions. Erythrolabe lies in one kind of cone, chlorolabe in another, and yet a third class of cones contains the blue pigment, cyanolabe, which we have not been able to measure reliably. I think we may say that the chemical basis of colour vision is virtually settled.

To this statement there may be several in the Group who will feel inclined to answer "Well, the chemistry of something may be settled, but why do you say it's the chemistry of colour vision? In all the lecture I don't remember that you mentioned colour at all, and if you did, it certainly wasn't the colour of colour that you were speaking about. Where does colour come in?" This I think is the view of Dr. Edwin Land.

COLOUR APPEARANCE

I was talking to Dr. Land at a meeting on Colour Vision last summer and he said to me "Have you noticed that at meetings on Colour Vision people never talk about Colour. They discuss the structure of the eye, the pigments involved and the electrical signals. When it comes to appearances they are concerned with whether fields look identical, or what is the threshold for detecting a difference. But no one is indiscreet enough to say 'What colour did it seem to be?'"

I am sure that for very many of the Colour Group Dr. Land's complaint is a very pertinent one. Perhaps the majority of you are concerned mainly with what the colour seems to be in a range of conditions of viewing, and I think some of you may feel that there is quite a perverseness - particularly in physiologists, in blandly treating this central aspect of colour as though it did not exist or was so trivial that it deserved no mention. If in this Lecture I have never touched on colour-appearance it is certainly not because the subject is too obvious or too unimportant. For my part I think it is fascinating, but it is very hard to investigate.

There are two stages in the encoding of colour. The first we know now is the catching of quanta by three visual pigments each situated in its own kind of cone. The output of each cone, like the output of a photocell, is univariant; it depends upon the total quantum catch but not independently upon the wave length of the quanta caught. The second stage is nerve interaction as a result of the various cone signals. It is an organization of the utmost complexity and its stages occur at many different levels of retina and brain.

Now the only colour relations that are exact and rather general are those that depend upon the pigment stage - the stability of metameric matches and of Stiles' II mechanisms.

It is their stability and simplicity that have encouraged most of the great investigators to study them, and, as we have seen an attack from all sides has now at last captured this citadel - or is it only the first pill box on the long advance?

At any rate this is about as far as a physiologist can go at present in his contribution towards colour vision. These vital factors in appearance - aperture colour or surface colour, colour memory, colour association - even colour prejudice - these and many more, have at present no clear correlation with neurology nor electrophysiology.

If then I do not mention the Appearance of Colours it is not that I undervalue it, but simply because it is still too difficult a question, as it was 300 years ago when in his first paper Newton wrote:

"But to determine more absolutely what Light is ... and by what modes or actions it produceth in our minds the Phantasms of Colours, is not so easie. And I shall not mingle conjectures with certainties."

MEXICAN DYES ARE CLUE TO EARLY MIGRATION

Research in ancient dyes may provide some clues on the migration of civilizations to the New World long before Columbus's discovery of America.

Dr. Sidney M. Edelstein, a student of the history of chemistry, made a long trip recently into Mexico to confirm that the Indians of Mexico and Hebrews in ancient times used the same kind of dyestuffs.

For Dr. Edelstein, who is president of Dexter Chemical Corporation of New York, it all started in June, 1960, when Professor Yigael Yadin of the Hebrew University in Jerusalem requested him to study the colors in fragments of cloth found in a cave in the Judean desert.

Dr. Edelstein studied the cave which contained remains and artifacts of followers of Simon Bar Kochba, who led a revolt against Rome some 1,800 years ago. Bar Kochba's people eluded their Roman pursuers by holing up in a cave, but slowly starved to death. Their dyed, colorfast clothing and shrouds withstood the ravages of time in the dark, arid cave.

New techniques showed that a sample of purple cloth from the cave was colored with indigo and shaded over with the dye from the cochineal bug, an insect that furnished the fast red dyes of Biblical as well as medieval times.

"More recently," Dr. Edelstein said in an interview, "I was informed that a band of Indians living in Mexico still go down to a remote part of the Pacific to collect a shellfish to dye cotton yarn used in making the posahuanco, a wrap-around skirt with alternate horizontal stripes of blue, red and purple."

Dr. Edelstein pointed out that the ancient Hebrews used the dye of the purple shellfish for dyeing the blue cord of the ritual tassels known as tsisis. The Babylonian Talmud has a large section devoted to specifications for the threads used in the tassels and instructions for dyeing them. He investigated the remains of the cochineal industry in Mexico, started long before Cortez's conquest. After their arrival, the Spaniards intensified cochineal production by growing special cactuses upon which the insect fed. After Spain lost Mexico in the middle of the 19th century, the industry declined and only recently have attempts been made to revive it.

The party spent some time at an experimental plantation for the cochineal and nopal Cactus situated between Oaxaca and Tehuantepec, gathered specimens of the bug and cactus and then proceeded to Puerto Angel near Salina Cruz on the Pacific Ocean. Here Dr. Edelstein investigated procedures followed by fishermen in gathering the murex, the mollusk providing the purple dye for the posahuanco.

Indians from Pinotepa de Don Luis, a village situated between Acapulco and Oaxaca, walk the long distance to Puerto Angel to dye the yarn used in weaving the posahuanco. They gather the mollusks, open them and dip their yarns directly into the shellfish secretion.

Dr. Edelstein points out that at least three dyes used in ancient times in the Mediterranean area were used almost simultaneously by the Indians in Mexico and Central America. These were the blue from the indigo plant, purple from the shellfish and red from the cochineal or similar insects.

The Indians also had the madder plant, providing what is known as alizarin red, which is still used in wool dyes and which was known before Biblical times.

His study of the cochineal has convinced him, he said, that the cactus plant upon which the insect feeds existed in the Near East in ancient times despite the general belief that it was brought from the New World after the time of Columbus.

MISCELLANY

Colour: Colour is tremendously important. The experts say that when a lady sets out to buy a garment, the first thing she has in her mind is colour. Colour can make or break a cloth. The wrong colours in the right cloth will have disastrous and disappointing results. The teenage market is extremely colour-conscious and the trend is still for bright colours, both for spring and winter. In fact, we have a winter range that includes white and all sorts of light colours which only a few years back would have been considered a spring range. The advent of clashing colours that defy the classical approach to colour blending is another important feature. As an export supplier, our problem is made more difficult in areas like Scandinavia, where the best liked colours are brown and black, but in general, all cloths, whether they be plains or tweeds and fancies, must have lift and brightness, both for spring and winter. This is outstandingly noticeable in the U.S.A. I was once told by an American customer to remember that all ladies of whatever age are young ladies and to-day most of them want cheerful cloths and colours.

"Textile Institute and Industry," April, 1965

<u>Hens Show Color Sense</u>: Chickens tend to like bright colors and dislike dull or drab colors and black, a poultry scientist says.

However, chickens, like people, are individuals and also show individual preferences for different colors, says Dr. George D. Quigley of the University of Maryland, College Park, Md.

For instance, yellow is generally "disliked" by the chickens Dr. Quigley is testing for color recognition and preference. Nevertheless, some of the chickens apparently "think" it is prettier than all other colors by the prefence they show for yellow.

Dr. Quigley said he has had the nests of the chickens he is testing painted pink, red, blue, orange, yellow, tan, brown, black and metallic gray. He also uses such combinations as a brown nest box on a yellow background.

Dr. Quigley said a hen habitually lays its eggs in a certain nest. When the poultry scientist finds out where a hen lays its eggs, the two nest boxes on either side of the one the hen uses are painted in colors different from the dull neutral gray of the unpainted nest. If the hen changes its egg-laying to one of the painted nests, it has recognized the color and shown preference for it.

Dr. Quigley said color preference does not seem associated with food preference. Also, as far as it has been determined, the color of the nest does not influence the hen to lay more or less eggs. On the other hand, the color a hen prefers may be a clue to the health of the bird, Dr. Quigley said.

The color perception of chickens is different from that of humans; they do not see as well in blue light as humans do but see better in red light than humans do.

Dr. Quigley plans to find out if baby chicks will be influenced by a color if exposed to it for only one to three days after birth. Using this method, called imprinting, Dr. Quigley will later expose the chickens to the same color, among many other colors, to see if they remember it.

He said that so far he had only preliminary results of the color tests but expects to have further results of his studies this summer.

Purple Makes Birds See Red: FARNBOROUGH, England When birds see purple they fly into a rage.

This is the notion behind a British scheme to paint airfields purple in an attempt to minimize the hazard of birds' flying into windshields or being sucked into jet engines and causing accidents.

Aviation experts the world over are in a constant battle against birds, which have been implicated in numerous air disasters. Until now, the experts have tried, without success, any number of antibird remedies from noises to tape recordings of bird distress calls to keep airfields bird-free.

The purple airfield idea might prove more effective. The idea is credited to anonymous but ubiquitous British amateur gardeners, who discovered that birds would not eat grass seed dyed purple.

Following up this lead, officials of the Royal Aircraft Establishment here have set their scientists to work grasping at purple straws. Aided by a scientist on loan from the Ministry of Agriculture and Fisheries, British air experts are experimenting with dyed grass, as well as with the possibility of developing a purple grass.

The aim is to surround airfields with purple grass. The hope is that the birds will avoid the grass and hence the airfields.

Whether the British will actually turn green grass into purple at any of the major airfields is now a subject of minor debate here. One view is that the expense would be heavy and the grass, like a woman's bleached hair, would need constant retouching. The other view is that the cost would be small when matched against the loss of modern airplanes as a result of collisions with birds.

Howard Simmons The Washington Post Foreign Service
Washington Post 8/11/64 (front page)

Color Quotes: From THE LONGHORNS by J. Frank Dobie: "The Spanish ranchers often set a high value on color than on any other characteristic. The old-time hacendados would keep their manadas - a manada being a bunch of mares, with their colts, dominated by a stallion - of duns, bays, browns, grullas, sorrels, greys, pintos, and so on, all absolutely separated. To this day, country Mexicans consider milk from a black cow more healthful than that from a cow of any other color and seek it for ailing children. In the seventeenth and eighteenth centuries the breeding of black cattle in Mexico was much encouraged. The seed cattle brought into Texas, California,Arizona - from one to two hundred years after Onáte and Ponce de León bid against each other on "cattle" and "black cattle" - seem to have been mostly of the black kind."

Architectural Valor Saved Lafayette Square, But The Ending Isn't Happy: Last paragraph: "In his efforts to preserve the residential character of the square, Warnecke fought valiantly and won many a battle. But the towers should have been lighter in color. As it is, he may have lost the war." This concerns the highrise blocks in which the architect attempted to reproduce the material, color, and workmanship of the little houses that line the east and west sides of the park. The highrise blocks are back of the three story fringe or row houses, and are designed to withdraw from the square. But the deep red color of these background blocks forces them to the foreground, so that they shoot a full 130 feet into the air with the unfortunate result "that the little houses, preserved with such effort, now decorate rather than define the Square." Such is the power of color!

THE WASHINGTON POST column by Paul Richard, Dec. 12, 1965

Office Desks Tell Who Has Status: BOSTON (AP) It's easy to tell who has status in the new 22-story office building opened by the State of Massachusetts this week in Boston.

All the desks in the structure that will eventually house 3,200 state employees are color-coded. Secretaries will have yellow metal desks, supervisors blue metal desks, administrators black metal ones and commissioners all-wood desks.

LIST OF ARTICLES ON COLOR RECEIVED BY NEWSLETTER

"Evaluation of Single-Number Expressions of Color Difference," Angela C. Little, J. Opt. Soc. Amer., 53, No. 2, pp. 293-296 (February 1963).

"An Evaluation of Various Weather-Ometers for Determining the Service Life of Organic Coatings," L. J. Nowacki, Off. Digest, 34, No. 454, pp. 1191-1215 (November 1962).

"Factors Affecting Induced Color," J. S. Kinney, Vis. Res., 2, pp. 503-525 (1962).

"Field Trials of Color-Mixture Functions," W. S. Stiles and G. Wyszecki, J. Opt. Soc. Amer., 52, No. 1, pp. 58-75 (January 1962).

"Fluorescent Agents for Detergents," H. W. Zussman, J. A. O. C. S., 40, p. 695 (1963).

"Forces between the Molecules of Compounds Organic," Rudolf Signer, Palette, No. 13, pp. 20-26 (Summer 1963).

"Four-Year Color Preference Survey," Anon., Paint Industry, 77, No. 12, pp. 23-24 (1962).

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