was by birth an Irishman. His father, who was descended from an ancient French family, left his native land just before the Revolution and emigrated to Ireland, where he married a Miss Thompson. About 1820 they returned to France with their six children who had been born in Ireland. Two of the children, the brothers, Antoine and Arnaud, became scientists and performed much of their scientific exploration together in Abyssinia and Ethiopia. Antoine was chief of the Venus expedition to Hayti in 1882. Exploration, seismology, geodesy, meteorology, astronomy, claimed his attention at different periods of his life. His principal published work was the monumental "Geodésie de la haute Ethiope" (1873), which appeared shortly after his election to the Academy of Sciences.

General Jean Baptiste Marie Charles Meusnier de Laplace was born at Tours in 1754, and died at Mayence in 1793, as the result of wounds received in battle. Although thus cut off at the early age of 39 "il laissait" to quote the words of one of his friends, "des traces brillantes d'un intelligence d'élite secondée par un zèle infatigable."

His single memoir in pure mathematics was written just as he was leaving the École Polytechnique and contains a complete theory of the curvature of surfaces[3] from an entirely different point of view from that which Euler illuminated in 1763.[4] When Meusnier's memoir was presented to the Institut in 1776 it created a sensation (d'Alembert exclaimed, "Meusnier commence comme je finis"); and although only 22 years of age he was immediately elected a correspondent of the Academy of Sciences. While connected with the army during the next few years, Meusnier constructed a machine for the distillation of sea water and the extraordinary results, in connection with both the theory and practise of aerostation, which he presented to the Academy in 1784, brought about his election as academician.

It was in 1783 that Lavoisier and Laplace maintained before the Institut that the "element" water was formed by the combustion of hydrogen in oxygen. But some doubt existed as to the conclusions. This doubt was forever removed a year later, through experiment inspired by the genius of Meusnier. The subject was presented to the Academy in a "Mémoire . . . par MM. Meusnier et Lavoisier."

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[3] "Mémoire sur la courbune des Surfaces," *Savants étrangers*, t. X., 1785, pp. 477–510. It is this memoir which contains the famous theorem concerning the curvature of oblique sections of surfaces, with which Meusnier's name is always associated. English writers and the American historian Cajori incorrectly write Meusnier's name without the *s*.

[4] "Recherches sur la courbune des Surfaces," *Mémoires de l'Acad. d. sc. de Berlin*, [t. XVI.] (1760), 1767, pp. 119–143 + 2 Taf. A memoir with this title was presented to the academy by C. G. J. Jacobi on September 8, 1763.

Color Standards and Nomenclature. By ROBERT RIDGWAY, M.S., C.M.Z.S., etc.; Curator of the Division of Birds, U. S. National Museum. Pp. iii + 44, with 53 plates containing illustrations of 1,115 named colors, and providing a system of nomenclature permitting the definite location and designation of over 4,000 colors. Published by the author, Washington, D. C. Press work by A. Hoen & Co., Baltimore.

This work is a conspicuous example of that devotion to science which has led a few men to give the better part of their lives to the accomplishment of some important task, their hope of reward being little more than the satisfaction of having finished a work that will serve to advance science, and thus contribute to the welfare of mankind. More than twenty years ago the author began the attempt to supply a practical means of identifying the color of natural objects, so that this important property of these objects might be used with some degree of precision in identifying them. The task has been an enormous one, involving much pioneering in a little understood field of science. Many important problems had to be solved before the work reached the final stages, and a vast amount of work had to be done over and over again as advances were made. The manner in which the more important of these problems have been met is set forth below.

This book is, of course, not the first attempt that has been made to supply standards of color. Ridgway himself had made an earlier attempt.[1] On this subject the author, in his preface, remarks: "Many works on the subject of color have been published, but most of them are purely technical, and pertain to the physics of color, the painter's needs, or to some particular art or industry alone, or in other ways are unsuited for the use of the zoologist, the botanist, the pathologist or the mineralogist; and the comparatively few works on color intended specially for naturalists have all failed to meet the requirements, either because of an insufficient number of color samples, lack of names or other means of easy identification or designation, or faulty selection and classification of the colors chosen for illustration."

The scheme of classification used is essentially that suggested by Professor J. H. Pillsbury.[2] The key to the arrangement of colors in this scheme is the solar spectrum, augmented by adding to the violet end of the spectrum the hues obtained by mixing violet and red in various proportions by means of the Maxwell color disks.[3]

In determining the number of color standards to be used the first problem was to determine the number of segments into which the original fundamental series should be broken. It is both impracticable and unnecessary to break this continuous series into the more than one thousand hues that are recognizably different to the normal eye. On the other hand, the number of segments must be sufficiently large that the gaps between them may be small enough to serve the practical purpose of identifying colors. On this point the author says: "Distinctions of hue appreciable to the normal eye are so very numerous that the criterion of convenience and practicability must determine the number of segments into which the ideal chromatic scale or circle[4] may be divided in order to best serve the purpose in view. Careful experiment seems to have demonstrated that thirty-six is the practicable limit,[5] and accordingly that number has been adopted."

As far as possible the gaps between each successive pair of these 36 elements of the fundamental series are in each case the same in amount of visual color difference. The scheme of nomenclature adopted provides for an additional color in each of these gaps, so that the fundamental series really consists of 72 named (or rather symbolized) colors, though only 36 are given on the color plates.

The fundamental series of colors thus obtained is modified in three different ways in order to cover the whole range of color variation. Each of these modifications produces a continuous series, which we may call a secondary series. Each of these secondary series begins with the fundamental series, either pure or as modified in a previous secondary

[1] "A Nomenclature of Colors for Naturalists," etc., 1886.

[2] See SCIENCE, June 9, 1893; also *Nature*, Vol. LII., No. 1347, August 22, 1895, pp. 390–402.

[3] If a wheel made up of sectors of different color be rapidly revolved on its axis the various colors will appear to blend into a single color. This is the principle of the Maxwell color disks. Throughout this review when reference is made to the mixing of colors what is meant is the blending of colors produced on a rapidly revolving Maxwell disk having its sectors differently colored. In this sense we may with propriety speak of the blending, say, of black and red as the mixing of these two colors, using the term color in its broadest sense. The mixing of pigments is a different thing, and is not here referred to.

[4] The addition of the hues obtained by various mixtures of violet and red renders the fundamental series a repeating one, and the various hues of which it is composed may hence be arranged in a circle in which there is at all points a gradual change of hue in passing from one primary spectrum color to another. (Footnote by the reviewer.)

[5] "That is to say, the practical limit for pictorial representation of the colors in their various modifications." (Footnote of the author.)

series, and ends with either white, black or neutral gray, according to the character of the modification under consideration. The nature of these secondary series will be understood from the details that follow.

Neutral gray is defined by the author as "being the gray resulting from mixture (on the color wheel) of the three primary colors (red 32, green 42, violet 26 per cent., which in relative darkness equals black 79.5, white 20.5 per cent.)." It may also be described roughly as follows: If by means of a white and a black disk on the color wheel a series of grays be prepared extending from white to black, the visual difference between each of the successive elements of the series being the same, the middle member of this series would be neutral gray. In other words, and roughly speaking, neutral gray is optically half way between white and black.[6]

The first of the three modifications of the fundamental series above mentioned consists of mixing the colors of the fundamental series with neutral gray. This produces a continuous series of "broken," or dull, colors. Since it is manifestly impossible to illustrate on the color plates every infinitesimal element of such a series, it becomes necessary to choose certain points in such series as standards. This choice is based on considerations similar to those involved in breaking up the original fundamental series into segments. Five different admixtures of neutral gray were used, giving five series of broken colors. The elements of the fundamental series are designated in the scheme of nomenclature adopted by the cardinal numerals from 1 to 72, only those designated by the odd numbers being illustrated on the color plates. The first series of broken colors, which are obtained from the fundamental series by the admixture of 32 per cent. of neutral gray, are designated by the primed numbers from $1'$ to $71'$. The second series of broken colors contain 58 per cent. of neutral gray, and are designated as $1''$ to $71''$. The third contains 77 per cent. of neutral gray, and are designated by the numbers $1'''$ to $69'''$. The fourth, 90 per cent., and designated as $1''''$ to $69''''$. The fifth, 95.5 per cent., designated as $1'''''$ to $67'''''$.

The fundamental series and the five series of broken colors are represented on the color plates by 150 color specimens. These are arranged in sequence, beginning with red of the fundamental series, and running through the spectrum six times. They form a horizontal line crossing each plate in the middle of the page, and constitute the middle elements of vertical series extending above and below them as follows:

Extending upward from each of these 150 color specimens is a series of "tints" of that particular color. These tints are obtained by mixing each of the 150 colors mentioned with white. Three tints of each color are shown, the first being obtained by mixing with the original colors of the series 9.5 per cent. of white, the second by the admixture of 22.5 and the third of 45 per cent. of white. Above the last tint in each vertical series is a specimen of white.

Extending downward from each of the 150 middle elements described above is a series of "shades" of these elements. The first of these shades is obtained in each case by the admixture of 45 per cent. of black with the original color of the middle series. The second shade contains 70.5 per cent. of black, and the third 87.5 per cent. At the bottom of each vertical column is a specimen of black. For each of the 150 elements obtained from the fundamental series and the five series of broken colors obtained directly from it by the admixture of neutral gray we therefore have a vertical series of shades and tints of that color. Each vertical series extends from white to black, the middle point being one of the 150 middle elements of the scheme of classification. This arrangement of the colors greatly facilitates the comparison of any object with the 1,115 color standards illustrated in the color plates with a view to determining and recording its color.

The system of nomenclature used by the author has already been partially detailed

[6] Some authorities use this term to mean gray of any shade or tint provided it shows no spectrum color.

above. It is the excellent system of identifying each color variation by means of symbols which serve to show the location of the color in the scheme of classification that is the most distinctive and original feature of the work. As stated above, each of the 36 segments of the fundamental series is designated by the odd numbers 1, 3, 5, etc., to 71, the even numbers being reserved for colors intermediate between them. These same numbers modified by the use of primes are used to designate the same colors modified by the admixture of neutral gray. Thus the color designated as 27‴ is number 27 of the fundamental series weakened by the admixture of 77 per cent. of neutral gray (third series of broken colors).

The tints of any color are designated by the number of the color with the addition of one of the letters a, b, c, d, e, f or g. The three tints of each color illustrated on the plates are designated by the letters b, d and f, the other letters being reserved for tints intermediate between those of the specimens in the book. The shades of a color are similarly designated by the number followed by one of the letters h to n. Thus, 35″ i denotes the thirty-fifth segment of the fundamental series diluted as shown in the second series of broken colors, and further reduced by the admixture of 45 per cent. of black.

The system thus provides a means of designating not only each of the 1,115 specimens of color given in the plates, but all kinds of intermediates between them, the total exceeding 4,000 color variations. The magnitude of this task will be appreciated when it is remembered that in the author's previous book the number of colors named and illustrated was only 186, while in Milton Bradley's excellent little treatise on elementary color there are only 126.

The problem of choosing just what hues, tints, shades and broken colors should be represented in the color plates presents many practical difficulties. The simplest phase of this problem is that of choosing the particular spectrum hues to be designated by the simple names red, orange, yellow, green, blue and violet. The authorities are by no means agreed as to just what part of the spectrum is the reddest part of the red, the greenest part of the green, etc. Thus the red of ten different authors varies from 644 to 703×10^{-7} cm. in wave-length. Most of the other colors vary as much according to different authorities. Each author is a law unto himself in such matters. This is one of the reasons why any system of color standards which will serve the main purpose of such standards, namely, that of identifying the actual colors met with in nature and in the arts, would be eagerly adopted by naturalists, as well as by those who find need of color standards in the arts.

A much more important difficulty arises from the fact that certain hues of the fundamental series require more elements than others in the series of tones between white and black in order to make the optical intervals between the tones chosen as standards equal in the different series of tones. The author has chosen to represent three tints and three shades of each of the pure colors. This gives a series of seven elements in each series of tones. Except in the yellows this seems to be very satisfactory, but the eye can distinguish such small differences of tone in this part of the spectrum that a larger number of elements in the series of tones would have been helpful. In the yellows and greens there is also a considerable optical interval between the darkest shade (containing 95.5 per cent. of black) and the adjacent samples of black.

The fact that in the series of broken colors the optical intervals between the adjacent hues are less evident than in the full colors also gives rise to a number of practical difficulties in determining just what elements to drop out in order to make the intervals of suitable magnitude and still cover the range of color variation in a satisfactory manner. None are omitted in the first and second series of broken colors, but in the third and fourth each alternate hue is omitted, while the fifth series contains only the six hues ordinarily designated as the primary spectrum colors, except that yellow-orange replaces orange as being more nearly intermediate between red and yellow.

The last of the 53 color plates gives two series of tones of gray, one obtained by mixing white and black on the color wheel, the other by mixing lamp black and Chinese white. Plates XXII. and XXIV. are extras, from one of several series made during the progress of the work, given because they show a number of important intermediates of the present series that are very useful. Both these plates fall in the first series of broken colors.

Every one of the 1,115 specimens of color shown on the plates is given a name. The method used in selecting these names is given in considerable detail. An excellent index of color names is given on pages 29 to 40, with references to the corresponding specimens in the plates.

Not the least valuable feature of the book is the list of definitions of color terms on pages 15 to 20. The list of dyes and pigments used in the preparation of the Maxwell disks representing the 36 colors of the fundamental series is given on pages 26 and 27. The text ends with a list of a few of the modern books on the subject which the author found most useful in his work.

It is perhaps too much to say that this monumental work is the final solution of the problem of color standards, but it is doubtful if any one so competent as Ridgway in matters relating to color will in the near future devote a very important portion of his working life to the subject as Ridgway has done. He has certainly produced a *usable* set of standards.

W. J. SPILLMAN

U. S. DEPARTMENT OF AGRICULTURE

Microbes and Toxins. By E. BURNET. Translated by C. BROQUET and W. M. SCOTT. G. P. Putnam's Sons. 1912.

When Professor Metchnikoff was asked by the publishers of the Bibliothèque de Philosophie Scientifique to prepare for that library a book on microbes and toxins he turned the task over to one of his younger colleagues, Dr. Etienne Burnet. An English translation has promptly been prepared and makes a volume of some 300 pages. There are four introductory chapters—on the carbon and nitrogen cycles, on the presence of microbes on the surfaces of the human body, on the morphology, and on the physiology of the microbes—and a concluding chapter on chemical remedies for microbic disease (sleeping sickness and syphilis). The other ten chapters forming the bulk of the book deal directly with the problems of infection and immunity.

The book is a little difficult to place. According to Professor Metchnikoff's preface it appears to be intended for general reading. "It is time," he says "for bacteriological science to leave the laboratory and the lecture theater and to take its place before the great public, in order that its benefits may receive the widest and readiest application." It takes a mature mind and a special gift, however, to produce a really popular and yet valuable book upon a technical subject. The present volume is crammed with minute details and discussion of controversial points and seems to the reviewer quite unsuited for the general public. Even for a student's text-book, there is more detail than is desirable. On the other hand, the treatment is by no means sufficiently full and complete to serve as a reliable work of reference for the advanced worker.

Its greatest value perhaps lies in the fact that it presents very fairly the position of the Pasteur Institute headed by Professor Metchnikoff; and the important part played by this school in the development of our knowledge of immunity makes such a "brief," if it may be called so, a valuable contribution to the history of bacteriology. The problems of intestinal bacteriotherapy in Chapter II., of phagocytosis in Chapters VI. and X., and of the mechanism of immunity in Chapter XI., for example, are of special interest.

The view is of course always that of Professor Metchnikoff and his associates rather than a well-rounded presentation of generally accepted opinion; and doubtful points are often dismissed with what one is tempted to