with varied climate and a great diversity of conditions, mountains and valleys, forests and open plains, left through long ages entirely to its own resources, was the closed arena of rapid development divergent from the rest of the world. The result is plainly obvious now. Though the elevation of Central America and the Isthmus into land joined Notogæa with the northern continent and the way of migration thus opened led to an extensive infusion of northern elements in the southern fauna, South America still remains, after Australia, the most peculiar region of the earth.

North America had quite a different fate; its connection with the south was a mere episode which led to the transitory reception of a considerable number of Notogæan forms and the permanent establishment of a very few. Its oft-repeated connection with the Old World was far more significant from the zoological point of view, for that maintained the essential community of mammalian life all over the northern hemisphere. To this connection it is due that North America is a part of Arctogæa and that its Arctic and Boreal zones are inseparable from the great Holarctic Region of Europe and Asia. In the Pliocene and Pleistocene, North America was the meeting-ground of currents of migrating animals, from the west and from the south and for a time the fauna was of an exceptionally composite character, Old World and Notogæan elements mingling with the richly variegated indigenous stocks. But this condition was much modified by the Pleistocene extinctions which almost entirely exterminated the invaders from the south and greatly reduced the number of autochthonous forms. The destruction of immigrants from the Old World was less extensive and thus the zoological relations of North America in the Pliocene and Pleistocene were quite different from what they are now.

The problems which deal with the possible connections of South America with continents other than North America and especially with Africa and Australia, are extraordinarily interesting from many different points of view, but there is no time to enter upon a discussion of them here, nor are they altogether germane to the subject before us, which is the zoological relations of the western hemisphere as conditioned by the Isthmus of Panama and its geographical history.

W. B. Scott

Princeton University

THE NEEDS OF APPLIED OPTICS[1]

We have formed this Association for the Advancement of Applied Optics because we believe that the interests of all branches of applied optics may be materially furthered by such an organization. It seems fitting, therefore, to devote this first meeting to a discussion of the needs of applied optics and to the outlining of plans for securing the advancement desired.

The interests of every one who uses light are affected by applied optics in its broader interpretation. In the formation of this society we have invited the cooperation of all who are directly interested in the study and use of light and of optical instruments of all kinds. We therefore include, among those whose interests we aim to serve, astronomers, designers of optical instruments, illuminating engineers, photographers, ophthalmologists, photometrists, colorists, petrologists, microscopists and all investigators of optical problems. The field to be covered is broad and the interests affected many and diverse.

[1] An address inaugurating the formation of the Association for the Advancement of Applied Optics delivered at the first meeting held in Rochester, January 4, 1916.

Beyond question, the greatest present need of applied optics is cooperation. Workers in one field are often lacking in knowledge of the data, methods and principles developed by those in other fields. For example, the illuminating engineer desires more complete information relating to photometry, radiation laws, scattered light, and above all on the properties of the retina upon which depend the conditions for best illumination. Such information is difficult to obtain in any case and much of it is not available at all. Again, either the eye or a photographic plate is an essential part of every optical instrument, yet what designer of optical instruments posesses a full knowledge of the characteristic properties of either? The ophthalmologist desiring to know more of the nature and properties of light is confronted by a highly technical mass of information, largely in mathematical language and almost useless to him. A great many persons, vitally interested in the color of materials, are almost entirely without information as to the precise analysis or synthesis of color. Nearly every one could make good use of a knowledge of the conditions of illumination conducive to the best seeing, yet evidences of profound ignorance of those conditions are on every hand. Similar instances of lack of coordination of interests in applied optics might be multiplied indefinitely.

We believe that such a condition of affairs is best met by the formation of such a society as this. It is our aim to provide for the free interchange of ideas in the meetings of this society. A clearing house and a storehouse of data and information will best be provided by the establishment of a journal for the publication and dissemination of new and useful material in the various fields of applied optics. As soon as such material shall have reached a permanent form, it should be crystallized in convenient books of reference. The need for the organization, the journal, and for reference texts will hardly be questioned by any one.

Aside from the need for cooperation and the dissemination of the knowledge already available in the various fields of applied optics, the great need is for more information along various lines. It is a fitting occasion to briefly review the several branches of applied optics, calling attention to fields of research in which investigation appears to be most urgently needed.

The very ground work of all applied optics is of course pure optics. Little progress can be made without a thorough knowledge of the laws of the refraction, reflection, absorption and emission of light, nor of diffraction, interference, scatter or polarization. Most of these laws are well known and familiar but there are conspicuous exceptions of vital importance in applied optics. The laws of radiation applicable to a perfect radiator are fairly complete but very little is known of the corresponding laws applicable to the practical case of heated bodies or to gases conducting an electric current. While the laws of reflection and refraction are commonly considered well known, as a matter of fact we know almost nothing of the laws applicable to a layer whose thickness is comparable with the length of a light wave. In this case practise has not waited for theory, for lens surfaces are said to have been prepared giving greatly decreased loss of light by reflection. Another and conspicuous gap in our knowledge of pure optics relates to heterogeneous media. Light is scattered by small particles and absorbed by still smaller ones but very little attention has been given to the laws governing the scatter and diffusion of light so important in illuminating engineering.

In the field of lens calculation, though great results have been achieved, our methods and mathematical tools are those of fifty years ago. We still calculate lenses largely by the cut and try method of triangulating a bundle of rays through the lens and finding whether they meet in the image plane. It is possible that no other method of calculating lenses will ever prove of practical value, yet a number of our ablest mathematical physicists have attempted to apply the best modern mathematical methods to lens design. Their results have been interesting, but of practical value only in limited fields. The consensus of opinion to-day appears to be that if the seven lens aberrations could but be expressed in a suitable mathematical language, they would assume comparatively simple forms readily soluble. It is quite certain, however, that such simplicity is impossible in any of the mathematical systems yet tried, and that the desired result will only be possible in some system not yet invented.

Our next greatest needs in lens design are generalizations and publicity. In every complete set of calculations for a given lens, conclusions are arrived at relating changes in radii, thicknesses, separations and glass indices to variations in the degree of correction, in other words, a set of differentials is obtained, by the laborious methods of ray triangulation. Yet these very valuable results are regularly allowed to go either to the waste basket or to the locked notebook. The renowned Abbe set a worthy example of world-wide usefulness by having prepared and published tables for the selection of companion glasses for telescope objectives, thereby saving others hundreds of hours of labor. If we followed his worthy example, we should publish sets of differentials applicable to each of the important lens types as soon as obtained and thus obviate a tremendous waste of time in duplicating results.

In particular, we need publication and public discussion of such material as general rules for the spectral correction of objectives for photographic and visual purposes, general rules for reducing distortion, for locating and displacing Gauss points, limits of tolerance in definition and resolving power, the best methods of testing objectives and the like.

In the design of optical instruments a similar lack of coordination and generalization is apparent. The instrument-using public has been too often ignorant and always tolerant of defective design. The average user accepts without question, as he is without recourse, instruments hastily conceived and imperfectly worked out in design. Our largest makers employ specialists in the design of each class of instruments. Lesser makers of the less used instruments, such as spectroscopes, photometers and radiometers, seldom have the benefit of the crystallized general opinion of those users of his instruments who know what the performance of a first-class instrument should be. We trust that every class of both user and designer of optical instruments will derive benefits from this organization.

No optical instrument can be of any service without either an eye or a photographic surface as an adjunct. The properties of these should, therefore, be well known to the designer of lenses and instruments as well as to those more directly interested in them. The material of these three chief branches of applied optics (lens design, vision and photography) is, however, widely scattered and few who are well posted in one branch are even well informed in the other two.

The fundamental problem of the photographic surface is the rendering of the light impressed upon it. The quantitative relations between exposure, development and density of image were obtained by Hurter and Driffield twenty years ago. Since that time much has been found out concerning the nature of the latent image and of development and the conditions which govern speed and density gradient. The greater part of the preliminary work in photographic research may be regarded as complete.

Investigation in photography is now centered upon the more recondite problems and a clearing up of the nature of the photographic processes. We are not yet able to express photographic density as a function of energy, wave-length and time. The relation between plate speed and wave-length is known for but few emulsions. Speed varies with both absolute intensity of radiation and the rate at which it is applied according to laws not yet understood. The maximum density gradient obtainable varies with exposure, wave-length, emulsion and development in ways now being investigated. A knowledge of the resolving powers of the photographic surface, of the eye and of the lens or optical instrument is of the utmost importance to workers in almost every line of applied optics.

The photographic emulsion is optically a translucent medium of high scattering power. The penetration of light into such media varies a great deal with the wave-length of the light, with size of grain and with distance and direction in the medium. Hence, a knowledge of the optical laws governing scattered light is of the utmost importance in photographic research and of such laws but very little is known.

The photographic reactions to light bear a close resemblance in many respects to the reaction of the retina and from the optical properties of the retina much information may be drawn that throws light on the photographic effects and vice versa. Hence, the investigation of the retinal and photographic reactions may very properly be carried on side by side and results obtained in either field applied in the other.

Intimately related to all branches of applied optics are the visual properties of the human eye. Broadly stated, what is known of the eye as an optical instrument constitutes but a rough working knowledge of it. The curvatures, thicknesses and refractive indices of the various eye media in an average normal eye are fairly well known as well as the location of the nodal points and center of rotation. Three of the third order aberrations are important in vision, namely, the spherical aberration, the chromatic variation of the spherical aberration and the axial chromatic aberration. Of these only the last has been studied and measured and that only recently. One remarkable result of these measurements is the discovery that many eyes possess a type of axial chromatic correction previously unknown in lens optics and which probably could not be duplicated in a glass lens. It is to be hoped that methods of measuring the two other aberrations will shortly be devised and applied.

The nature of the reactions of the retina to light have been extensively studied during the last twenty years. But the problems requiring investigation are many and difficult and scarcely more than preliminary results have yet been obtained. The visual impression requires time to originate and grows at a rate varying with both the intensity and wave-length of the light producing it as well as with the previous treatment of the retina. It is no simple matter to isolate and measure these various effects nor to correctly interpret the results obtained.

Most studied and best known is the relative brightness of the same amount of radiation of various wave-lengths, the so-called "Visibility" of radiation. This is a measure of the relative sensibility of the retina to light of different wave-lengths but of equal energy. This relation is known for a great number of subjects to a quite satisfactory precision. It establishes the ratio of the light unit to the energy unit, hence, is of fundamental importance in illuminating engineering. Strictly speaking, we can neither define nor measure light without it.

When it comes to measuring the light sensation caused by a given light impression, an apparently insurmountable difficulty is encountered, for a sensation can not be directly measured. The sensation is, however, the integral of the sensibility and the sensibility is proportional to the reciprocal of the just noticeable difference in intensity and this may readily be measured. The necessary data are being accumulated and before long we shall be able to formulate the general laws of the visual reaction to light intensity in the case of white light. Similar data relating intensity sensibility to color, intensity and time must next be obtained.

On entering a dark room we become able to distinguish objects after a shorter or longer interval of time depending upon various conditions not yet worked out. Rate of adaptation curves must be determined for all initial conditions of adaptation, not only for white light but more particularly for the reds, yellows and greens used in the safe lights of dark rooms.

Very little is yet known of the relation between visual acuity and the brightness of the object viewed. The ability to distinguish fine details is known to fall off rapidly with decreasing illumination, but we have not the data for the formulation of any laws.

Illuminating engineers require a mass of such data on the properties of the retina, for the eye is the sole means of judging whether lighting is good or bad and the conditions for best seeing have been only very roughly worked out thus far. We require to know what illumination levels and what contrasts are best and what are the effects of excessive contrasts and oblique glare in depressing the sensibility of the retina.

The precise measurement of color is an almost unworked but important field of applied optics. The preliminary part of the work only has been done. The underlying theory has been roughed out, methods have been devised and precision colorimeters designed. But our fundamental color scales have been but partly worked out and the various laws of color combination are practically unknown. The work urgently requiring attention in this field amounts to quite a number of man-years.

Within the necessary limits of this discussion only the more urgent problems in the more important fields of applied optics could be reviewed. The special problems of refractometry, photometry, radiometry, interferometry, spectrophotometry, polarimetric analysis and other fields can not even be enumerated here. It is hoped, however, that this brief outline may have impressed upon us all the necessity for concerted effort in solving the numerous problems which confront us. We trust that the formation of this society will, by promoting team work and well directed research, prove to be a powerful factor in the advancement of applied optics. This city has long been a leader in the production of optical materials, may it become the great source of optical ideas and the recognized home of optical learning.

P. G. Nutting

SCIENTIFIC NOTES AND NEWS

Dr. William W. Keen has been reelected president of the American Philosophical Society for 1916. The vice-presidents, Professors William B. Scott, Albert A. Michelson and