and 43 per cent. respectively. Several workers, and especially the Hirschfelds, have shown that as one travels from west to east the prevalence of Group II. (A) decreases and that of Group III. (B) progressively rises. In Western Europe, A is found in about 45 per cent., in Russians and Arabs in 37 per cent., in negroes and Indians in 27 per cent. B, on the other hand, increases from about 15 per cent. in France, through the Balkans (20 per cent.), Malagasies (28 per cent.), negroes (34 per cent.) to Indians with 49 per cent. We have here an obvious suggestion of two original races of mankind, which have mingled in various degrees: it is possible that in some remote place a pure A or B variety still exists.

At present there is no evidence that these blood characteristics are associated with any other qualities, and it seems likely, like some other Mendelian characters, that they are negligible in the problems of selection and survival. It would, too, be an error of the ancients to suppose that the qualities of the blood dominated personality and conferred a general characteristic on the individual. There is much evidence of the essential similarity of parents and offspring. The greater success of grafting tissues from one animal to another if they are of the same family is a germane example. In blood tests brothers and sisters by no means always agree so far as the agglutination of their corpuscles is concerned: in other respects their bloods are probably more similar than those of more remote relations.

The History of the Photographic Lens.

DR. REGINALD S. CLAY performed a needed and useful service when he selected for the subject of the twenty-fifth annual Traill-Taylor Memorial Lecture, which he delivered at the meeting of the Royal Photographic Society on October 10 last, "The Photographic Lens from the Historical Point of View." It was a needed service, because a historical review of the origin and development of the photographic lens is necessary for a just estimate and balanced perspective of the many and diverse scientific factors that have to be taken into account in the production of modern photographic lenses. It was a useful service, because the fascinating and, at times, almost dramatic story that Dr. Clay had to tell brings out clearly the paramount importance of the pioneer work done in this field by British firms and scientific workers, and it must act as a useful corrective to the tendency, sometimes manifested in unexpected quarters, to underrate the value of British work in the optical field.

After touching lightly on the early history, Dr. Clay comes to "one of the great landmarks in the history of optics—the invention of the achromatic lens." John Dolland, after numerous experiments, exhibited to the Royal Society an achromatic prism in 1758 of crown and flint glass, and explained its construction. Of the authors who contributed, in this period, before the invention of photography, to the theoretical treatment of the lens, Dr. Clay instances, after Kepler, the following:

> Huygens, who, besides expounding the wave theory of light and the explanation of double refraction, also dealt with the spherical aberration of lenses, and showed how it varied with their aperture and focal length; Newton, who investigated the dispersion of light; Joseph Harris, who discussed the cardinal points, optical centre, oblique pencils, curvature of field, etc., in his "Treatise of Optics"; Herschel, who obtained valuable equations for the calculation of objectives free from chromatic and spherical aberration; George Biddell Airy, who investigated the conditions for eliminating astigmatism and distortion; William Hamilton, who evolved powerful mathematical methods which even yet have not been fully utilised; and, last but not least, Henry Coddington, who worked out the methods which, I believe, still form one of the most useful bases for attacking new problems in lens construction.

The next milestone marks the almost simultaneous announcements of the inventions of photography by Daguerre in 1838 and Fox Talbot on January 30, 1839, and we reach "the epoch from which we may date the great evolution of the photographic lens." After referring to the photographic lenses of Charles L. Chevalier, Dr. Clay comes to the work of Josef Max Petzval (1807–1891), who computed a new and most successful lens, corrected for spherical aberration over a small angular field, which was made by Frederick Voigtländer in 1840.

We may pass over much interesting record and come to a new chapter, opened in 1866 with the aplanatic lenses of Steinheil and Dallmeyer. Steinheil, "beginning to recognise the value of symmetry in reducing astigmatism and distortion," concluded that the astigmatism would be less if the refractive indices of the glass were more nearly equal; he therefore used two flints instead of flint and crown, putting the higher refractive glass outside. Dallmeyer also used two flints, and called his first lens a "wide-angle rectilinear lens," 1866. It worked at f/15, and he followed it by his symmetrical at f/7 and f/8. In 1874 Steinheil made a portrait lens of two cemented lenses working at f/3·5, and in the same year Ross brought out their portable and rapid symmetrical, calculated by F. H. Wenham. "This is of interest," says Dr. Clay, "as Ross and Co. (as the firm then was) was thus the first firm to employ a scientific man as calculator. Wenham was with them from 1870 till 1888."

The next step, which Dr. Clay describes as "the greatest step in the development of the photographic lens," was made possible by the new glasses—the barium crowns of the Schott glass factory at Jena. The problem and its solution is thus expressed:

> An achromatic lens of ordinary crown and flint, which we may call an "old achromat," could be corrected spherically, but not made anastigmatic. An achromatic lens made of the new barium crown and a flint could be corrected for astigmatism, but not spherically. To correct both, all three glasses must be used—old crown, flint, new barium crown. To take full advantage of this principle, it is obvious that each component can be made of all three glasses. It can then be achromatic, anastigmatic, and aplanatic. By combining two such components into a symmetrical lens, it can also be made orthoscopic, and can easily be given a flat field. This is the principle underlying the well-known Goerz lenses. Another way to achieve the result is to use two unlike combinations, one of which is made responsible for

correcting the spherical aberration and the other for correcting the astigmatism. This is usually the method adopted by Rudolph in the earlier of the Zeiss lenses and several of the recent lenses by other makers.

Hugo Schroeder and Stuart, of Ross and Co., were the first to take advantage of the new Jena glasses, and in 1888 they patented the "concentric" lens, composed of a flint and a barium crown. It was corrected for astigmatism, but had a lot of spherical aberration. Dr. Clay reviews briefly the series of Zeiss lenses—Planar, Protar, Unar, and Tessar—made by Ross under license, and in this connexion tells the following significant story:

> In 1911, when Zeiss had finished their factory at Mill Hill, they gave Ross notice to terminate the license, and themselves made the Tessar—the only one of which the patent was still running. This is rather an illuminating fact. It must be remembered that in 1892, when Ross started making the Zeiss lenses, Ross had a great name as makers of photographic lenses, while Zeiss's were practically unknown in that connexion, and undoubtedly Ross's reputation helped to make the new lenses known; yet no sooner are Zeiss ready to make their lenses over here than they terminate the contract! No further comment is necessary.

An interesting summary follows, which we have not space to notice in detail, of a brilliant series of lenses produced by Ross from 1892 to the present day. Dr. Clay says: "One other achievement of this firm I must refer to. When the Air Force began to take aerial photos in the war they found the Ross-Zeiss Tessar, of 8½-in. focus, suitable, but soon wanted great numbers, and also asked for a longer focal length lens with perfect definition over a small angular field, *e.g.* a 20-in. lens to be used with a 5 by 4-in. plate. This was wanted urgently, and in a single fortnight the lens was recalculated, and the 'Airo-Xpres' lens evolved in November 1918, working at f/5·6. Messrs. Taylor, Taylor and Hobson also made a variety of the Cooke lens, the 'Aviar,' for the same purpose."

We have not space to deal more than hurriedly with the fascinating record that Dr. Clay gives of the other work done in Britain in the development of the photographic lens to its present stage of wonderful achievement. An interesting account is given of the lenses introduced by the firm of Dallmeyer, and special attention is directed to the striking advance represented by their telephoto lenses. The original patent for the telephoto was taken out in 1891. Another English firm, R. and J. Beck, Limited, it is interesting to note, were the first to apply the iris diaphragm to photographic lenses, as early as 1882. In 1906 Beck introduced their "Isostigmar Universal," and in the following year their Isostigmar portrait lens. "These lenses do not obey the Petzval condition—that the sum of the power of the lenses, divided by their refraction index, should be zero—and were constructed by omitting this from consideration, as they believed it was not essential for a flat anastigmatic field"—a view afterwards confirmed by the investigations of W. Elder. The Isostigmar is of interest, as it covers a field of 85 to 90 degrees at f/16, the first wide angle with such an aperture. Beck also introduced another simple idea—the use of magnifiers in front of a lens—made for their Frena camera in 1894.

We have left till the last not the least of the British achievements in the development of the photographic lens—the Cooke lens invented by W. H. Dennis Taylor and made and put on the market by Taylor, Taylor and Hobson, Limited. Dr. Clay says: "I do not think the great step which the Cooke lens marks is as well appreciated here as on the Continent. The introduction of this lens has formed the starting-point for a new method of lens construction which has had, and will continue to have, many fruitful applications." The germ of the invention is thus expressed by Dennis Taylor:

> It . . . occurred to the author that since the normal curvatures of images due to any lens, whether simple or compound, are fixed by its refractive indices and power alone, and are independent of the state of rays entering the lens, whether convergent, divergent, or parallel, then it should follow that the normal curvature errors of an achromatic and aberration-free collective lens should be neutralised by the normal curvature errors of an achromatic and aberration-free dispersive lens of the same power (and made of the same glasses), placed at a considerable distance behind the collective lens; while the combination would, *as a result of the separation* . . . yield a positive focus. . . .

The patents for the Cooke lens were taken out in 1893, 1895, and 1898. During the war the special Aviar lens, referred to above, was evolved, designed by Arthur Warmisham of Taylor, Taylor and Hobson. It is a split-divergent lens, which was a conception of the inventor of the Cooke lens, but the exploitation of the idea was left to Warmisham, who was able, by making a special study of coma, to improve upon the large aperture Cooke lenses, and secure a flat field of larger area than had hitherto been found possible.

In a brief review of Dr. Clay's lecture we have had perforce to omit much of important interest, but we may conclude by re-echoing the words of the author: "In this story I think we in Britain may claim that we have borne our share, in spite of all the praise that has been lavished on the Germans."

Obituary.

PROF. HEINRICH RUBENS.

HEINRICH RUBENS was born at Wiesbaden on March 31, 1865, and received his early training at the *Realgymnasium* at Frankfurt on the Main, where he gained the School Leaving Certificate, equivalent to Matriculation, in March 1884. In the summer term of that year he proceeded to the Technical High School at Darmstadt to take up the study of electro-technics. During the following winter term and the summer term of 1885 he continued his studies at the Technical High School at Charlottenburg, but soon recognised that his ability and interest lay in the domain of pure science, and for this reason he began the study of physics. After spending the winter term (1885–86) at the University of Berlin, Rubens passed on to Strass-