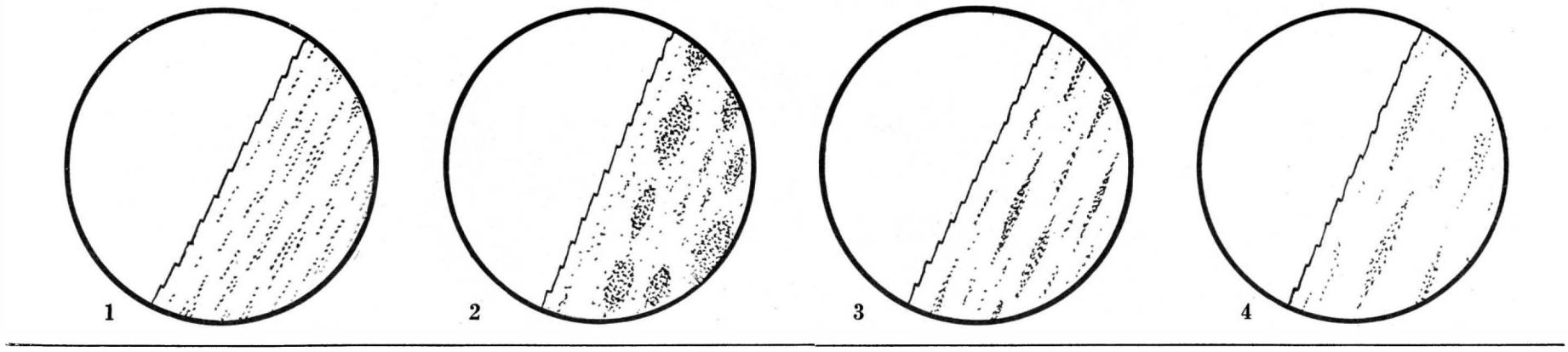


1. Chinese (black). 2. South African Bushman (black). 3. English (dark brunette). 4. Early Egyptian of about 4000 B.C. (light brown)

Highly magnified portions of shafts of human hairs of various colors and from individuals of various races, showing variation in the pigment-granule patterns

Human Hair Under the Microscope

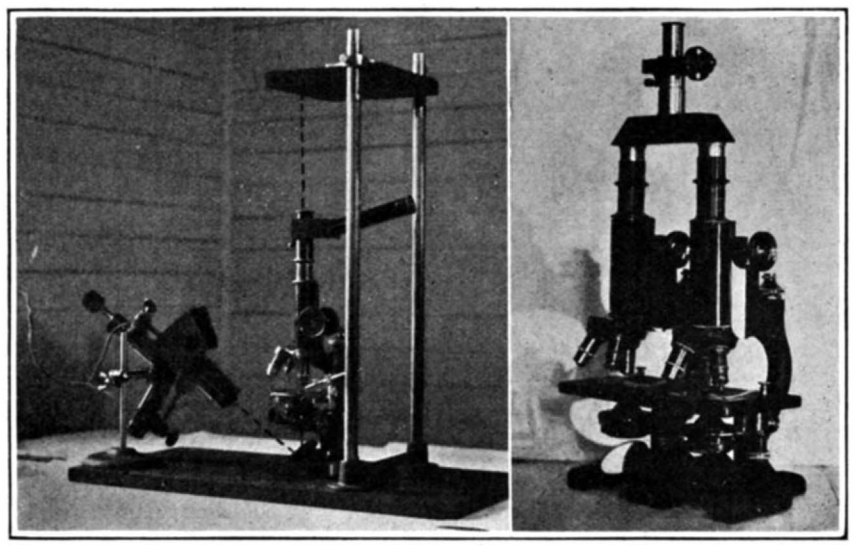
Recent Acquisitions to the Knowledge of Its Minute Structure, and Their Applications

By Leon Augustus Hausman, Ph.D., Cornell University

THE microscopic study of the structural elements in the human hair has, in recent years, begun to be of considerable value to investigators in several diverse departments of scientific research. Physicians and physiologists, detectives, anthropologists, archæologists, and others, are turning increasingly to the aid which the microscope can render in search of answers to some of their many questions. A few fragments of hair are found upon a murdered man's clothing, or in his hand. Are they his own, or some one's else? Of what race was this some one else? Man or woman? Hair dyed, or of natural color? Artificially waved, or naturally curly? Blonde, brunette, or red? Or the archæologist finds a mass of hair splinters in some ancient burial mound. Are they human or animal hairs? And if human, of what race? These are a few of the host of questions which a detailed study of the human hair under the microscope is helping to answer.

Grossly the human hair is a mere homogeneous shaft; minutely it is a complexly constituted structure, with definite elements found in definitely varying relationships. Fig. 13 shows the three structural units of the shaft of a typical hair. Through the center of the shaft runs a core or pith, technically known as the *medulla*, composed of shrunken, massed, distorted cells or chambers, more or less filled with air, and connected by a ramifying series of cornified filaments which usually completely fill the medullary column. Surrounding this structure is the *cortex*, or main shell of the hair shaft, made up of elongate, fusiform cells almost completely coalesced, and forming a nearly homogeneous and hyaline investiture. The outermost integument of the hair is termed the *cuticle*, and is composed of thin plates or scales of irregular outline imbricated like the shingles on a roof or the scales on a fish (Fig. 14). The varying physical make-ups of these three elemental structures of the hair and their varying relationships produce the many different textures which we observe in hair from various individuals.

A fourth element in the hair shaft hitherto of seemingly little worth in connection with analysis of hair samples is the pigment. This is usually distributed among and within the closely compacted cells of the cortex, in the form of granules of definite shape, size, color value, and color depth. Moreover, the patterns formed by these granules within the cortex have been found by the writer to vary in certain definite and predicable relationships in hairs of different color and from peoples of different race. In some hairs pigment is found also among the cells of the medulla, and in the case of reddish hair it is present in the cortex as a general diffuse color and not gathered into masses or granules.



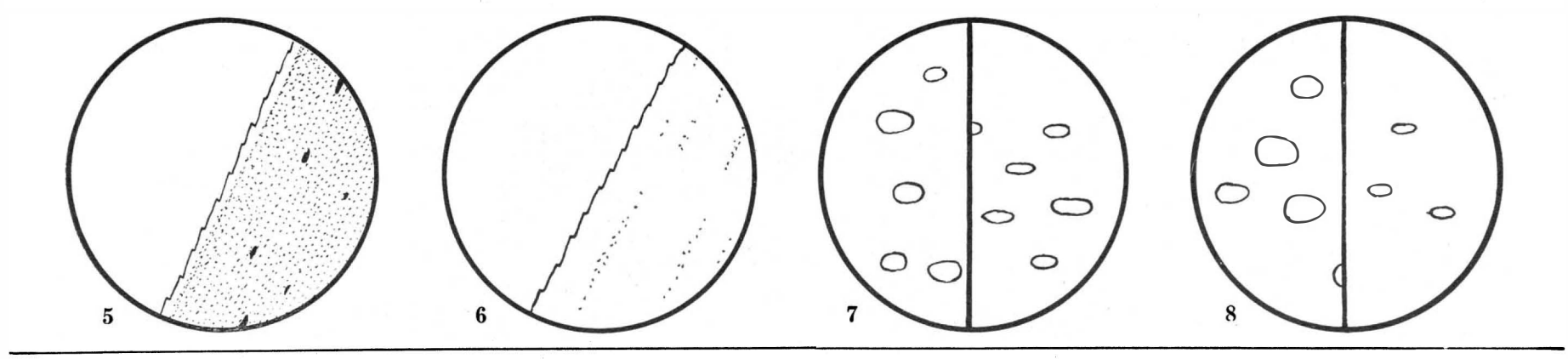
Left: Micro-mensuration apparatus. The greatly magnified image of the object under examination is thrown upon a scale located on the screen above, the course of the light rays being indicated by the dotted line. *Right:* Two microscopes fitted with the comparison ocular, which brings the two objects into the same field for delicate comparisons

Two of Dr. Hausman's microscopic attachments which he uses for the accurate study of minute fragments of human hair

Figs. 1 to 6 illustrate some of the strikingly different characters of the pigment granule patterns to be found in human hair. In order that these may be clearly seen and studied it is first necessary to subject the hair fragment under examination to several processes, the objects of which are: first, to clean the outer surface of the hair from oily substances, and second, to render the shaft as transparent as possible without distorting the elements which compose it. Under the highest powers of the microscope at present practicable the granule patterns can be clearly discerned and even the form and size of the individual granules made out. Two minute fragments of black hair, one from a Chinese, the other from an English brunette, would hardly reveal the secret of their derivation except under such study. The different and characteristic granule patterns of these two hairs are shown in Figs. 1 and 3. The typical granule pattern in the hairs of negroes is shown by the hair of the South African Bushman in Fig. 2. These granule patterns differ in the different races and tribes, but are in general in the shape of ovoid masses of varying sizes. Fig. 5 shows the appearance of so-called red hair. Here the majority of the pigment is diffuse in form, with larger masses of pigment than is usual in most cortices, distributed irregularly.

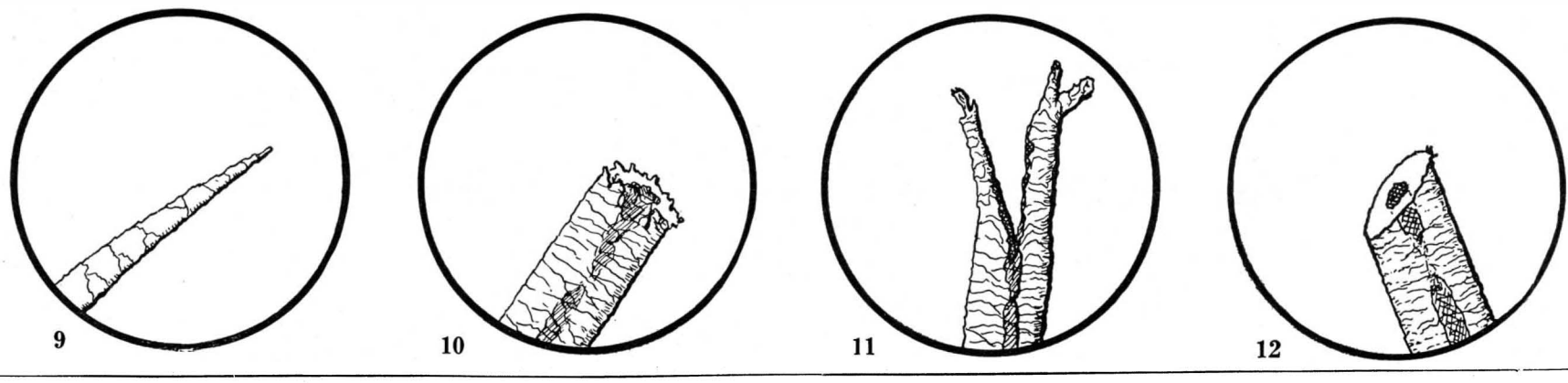
Not only are there marked and characteristic variations in the granule patterns, but also in the physical characters of the granules themselves. The most obvious of these are the variations in form and size of the granules. Figs. 7 and 8 illustrate the nature of these variations, as seen with the device known as the comparison ocular, shown in the photograph.

In making accurate determinations it is frequently necessary to record long series of measurements either of the granule patterns or of the individual granules themselves. For such nice mensuration the apparatus



5. English (golden red, pigment largely diffuse, with some few brown granules). 6. English ("tow-head"). 7. *Left:* American Eskimo; *Right:* Chinese. 8. *Left:* Negro, Bantu stock, Fingu tribe; *Right:* "tow-headed" Englishman

Two more shaft views; and the individual pigment granules from hairs of four diverse individuals, as seen with the comparison ocular



9. Characteristic appearance of the uncut, natural end of a woman's hair. 10. Usual appearance of a man's hair, the end cut with scissors. 11. Hair shaft with broken end. 12. End of hair shaved with razor

How the microscope reveals the treatment to which the hair has been subjected—a suggestion for the writer of detective fiction

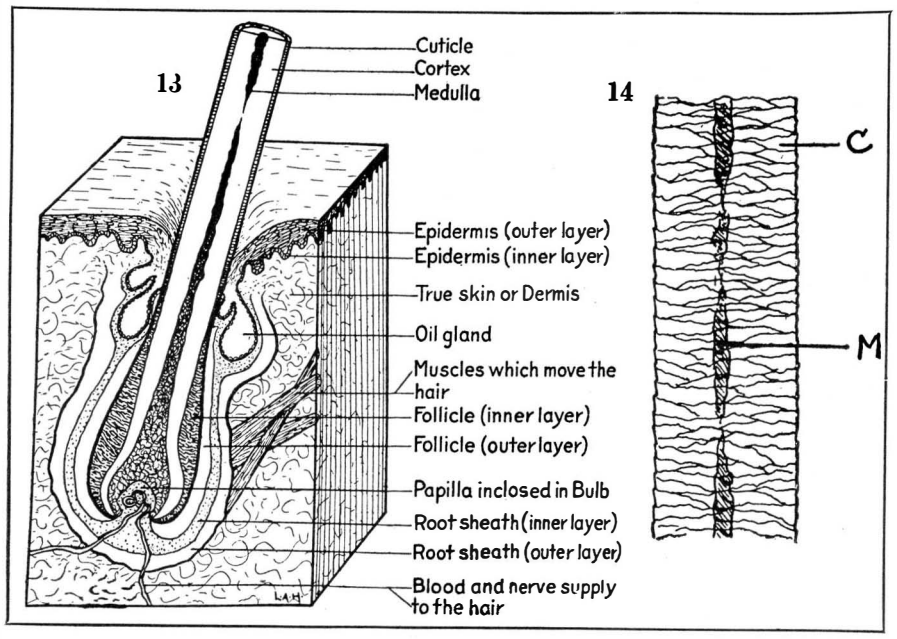
illustrated on page 112 is employed, and the greatly magnified image thrown upward on to a scale.

Not only are the forms and sizes of the pigment granules available as identification criteria, but also their color values and color depths. Some are dark brown, others yellow, others reddish. By the use of illumination, for the microscope, of standard color, direction, and intensity, accurate comparisons of color values of very minute fragments of hair shafts can be made. Because of the magnitude of the enlargements used for the study of pigment granules, photomicrography can not be successfully employed, except as a means of showing general features of hair coloration.

Work upon the pigmentation of hairs came about as a result of examination of a large series of animal hairs made by the author from 1915 to 1918. It was the possibilities of the forensic application of the study of mammal hairs in connection with the fur industries which led to a preliminary survey of samples of human hair of different color, and particularly from individuals of different races. At the present time it can be said that identifications of hair samples, and especially of minute fragments, are upon grounds of much greater trustworthiness than ever before. Minute criteria, of the sort discussed, have already proved their worth as aids in analyses, in forensic, archaeological, industrial, and purely scientific investigations.

The medulla and cuticular scales likewise show characters whose variations in form, size, and relationships also afford valuable aid in analysis. Fig. 14 shows the typical form of the cuticular scales and medulla of the average human hair. These two elements undergo certain fairly definite modifications in the hair of different races, in hair of different colors, and sometimes in the hairs from different individuals. Studies in individual hair variation, with regard to the microscopic structural elements of the hair shaft, will well repay those engaged in medico-legal work.

One of the earliest usable series of data for the separation of peoples into races on the basis of minute hair characters was that perfected by a French professor, Dr. Pruner-Bey, who about 1838 pointed out that the shape of the cross-section of the hair shaft is consistently characteristic of race. By an extended series of examinations and measurements Dr. Pruner-Bey showed that each of the various types of woolly, wavy, kinky, frizzy, or straight hair exhibited its characteristic form of cross-section. The straighter the hair the more nearly circular the outline of the cross-section; the curlier the hair the greater its ellipticity. Thus the straight hair of the Mongols and American Indians presents a circular, or nearly circular, transection, while the woolly hair of the negroid peoples of Africa shows an elliptical one. (See Figs. 17, 18.)



13. Shaft of a single human hair, represented in its place in the skin, a block of which has been cut out. 14. Typical form of the cuticular scales and the medulla of the average human hair

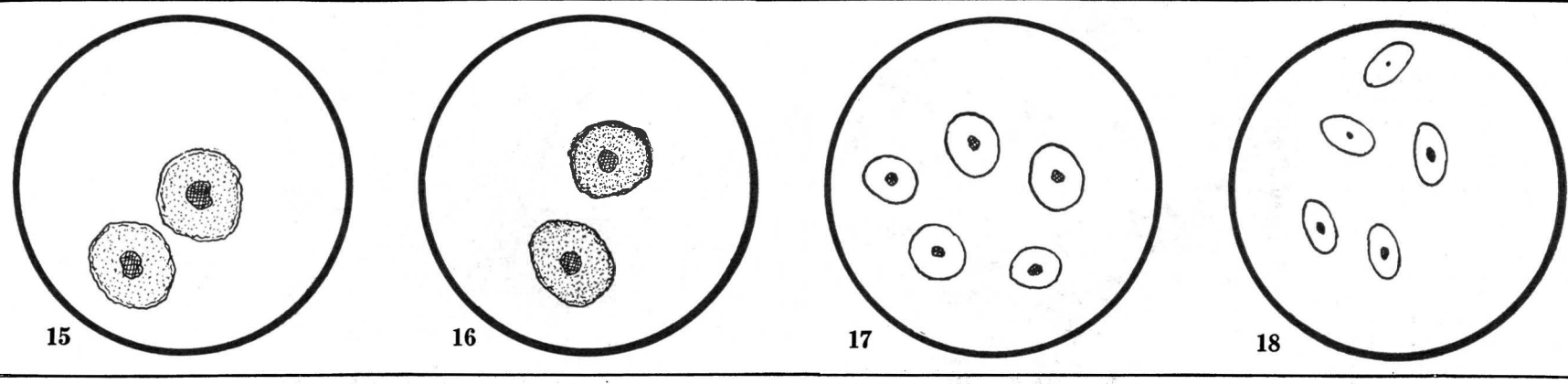
General structure and arrangement in the skin of human hairs

This basis for race classification has been long recognized as a rather precarious one. A slight displacement of the hair shaft under treatment away from a vertical position with regard to the edge of the sectioning knife results in the formation of a distorted transection, and may change a circular cross-section into an elliptical one, or increase the index of ellipticity in a slightly elliptical hair.

It is frequently helpful, or even vital, to know accurately to what sort of treatment a hair has been previously subjected. And here again the microscope can help us, for almost any sort of treatment of the hair registers its effects in some modification of the delicate structures composing the hair shaft. Hence it is that the microscopist can often determine whether samples of hair were taken from the head of a man or a woman, though it must be said that the recent fad of bobbing the hair has worked sad havoc with the reputability of this particular criterion! In general, however, the natural ends of a woman's hair present the appearance shown in Fig. 9, while those of a man's appear as in Fig. 10. If a hair shaft be bent and broken apart its fractured end shows a characteristic and easily recognizable form, shown in Fig. 11. A hair cut with a razor is shown in Fig. 12. These are some of the many separate bits of information obtainable through a microscopic examination of hair fragments. A tabulated series of observations of this sort is of great usefulness to the microscopist, who is called upon to search for answers to exceedingly nice questions, answers which lie, often, awaiting only the proper treatment and examination to make them render up their aid.

Trend of Automobile Design in Germany

A MARKED preference for 6-cylinder in the place of 4-cylinder motors is to be noted in the case of heavy types of car, while the 8-cylinder motor appears only in a few exceptional cases. Motors with overhead valves are being preferred on account of the greater reliability, higher efficiency and considerably lower fuel consumption due to the improvement of combustion chambers thus obtained. A new type of motor has been produced by subdividing the cylinder head and carrying the crank case up close to the combustion chamber, as well as by using steel cylinders and aluminum pistons. Thanks to an extensive use of steel, it has been possible, *e.g.*, in the case of the Mercedes motor, to reduce metal masses in the cylinder head, thus allowing such motors to be submitted to heavy overloads. Moreover, there is a wealth of improved carburetors intended to deal with inferior kinds of fuel (heavy oils), fuel economizers, ingenious combinations of the igniter, starter and lighting dynamo, new and improved accessories of all kinds, etc., and much space at the recent Berlin show was allotted to these devices.



15. Cross-sections of a reddish-brown hair, naturally pigmented. 16. Similar sections of hair dyed with henna. Note that in hair thus artificially colored the cuticle is stained. 17. Sections through hair shaft of American Eskimo. 18. Similar sections in the case of South African Bushman, showing increased ellipticity of the hair with increased curliness

Other details of hair analysis with which the microscope enables us to deal