HAIR:

MICROSCOPICALLY EXAMINED

AND

MEDICO-LEGALLY CONSIDERED.

BY

WILLIAM J. LEWIS, A. M., M. D., F. R. M. S.,

HARTFORD, CONN.

READ AT THE ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF MICROSCOPISTS,
IN ROCHESTER, N. Y., AUG. 19TH, 1884.
REPRINTED FROM THE PROCEEDINGS OF THE SOCIETY.

BUFFALO:
BIGELOW BROTHERS, PRINTERS.
1884.

HAIR: MICROSCOPICALLY EXAMINED AND MEDICO-LEGALLY CONSIDERED.

By William J. Lewis, A. M., M. D., F. R. M. S.

Two hundred years have elapsed since the compound microscope was devised. At first, and for a long time after it became known, it was regarded as an ingenious piece of mechanism which afforded curious and wonderful revelations, or as an instrument with which the scientist could amuse his leisure hours, rather than a means through which might be unfolded lessons of practical utility. For me to say to this society that in the rapid advances of scientific pursuits, during later years, the microscope has become a powerful auxiliary of usefulness, is but to utter a truism. In every department of science it has become indispensable wherever accuracy is sought. The philosopher in his laboratory and the artisan in his work-room must resort to it frequently for its practical teachings. Its disclosures have revealed what otherwise were ever hidden mysteries; have brought to full view that which else had always been obscure; have confirmed or dispelled many a dubious theory, and have established or disproved asserted facts which had rested upon suspicion only. The wide range of its usefulness has brought it prominently before the halls of justice, where, in the hands of the really skilled witness, it has proved a true friend of the court and of the community.

In the field of forensic medicine, however, we necessarily must regard the microscope as being in the infancy of its service. I need only remind you that in this branch of our work no one subject, probably, has received such careful and thorough study as that of blood-stains; and yet, after years of pains-taking research and

experiment,—years of attentive labor by many of the brightest lights whose names and whose works have illumined the annals of science,—let me ask who, at the present day, aided by the most accurate instruments at our command, is able and willing to enter the witness-box and swear, *without reserve*, that a certain stain which has been submitted to him for an examination was made by human blood? If, then, in stains existing under many varying conditions and circumstances, but which are readily demonstrated to be blood, we are as yet unable to distinguish human from all animal blood with absolute certainty, we see how important it becomes to utilize all corroborative proof within our reach which may assist in determining the kind of blood under inspection. And where may we look for this additional information? Evidently in the clot or stain itself. It probably seldom occurs in a murderous assault that blood stains, found on the weapons used, are formed without entangling in their substance more or less extraneous matter; and this material is not unfrequently hair, or textile fibers of one sort or another, which, when examined by the microscopist, will disclose presumptive proof. Such evidence may assist in delivering into the hands of justice the perpetrator of a crime who might otherwise successfully elude detection, or it may with equal force establish the innocence of a suspected person. What the microscopist may do to assist in determining questions of this nature, it is the purpose of this paper to briefly touch upon; and more especially to consider that feature to which we have alluded in speaking of hair and filamentous substances generally in their relation to legal medicine.

If the object under observation is hair, it becomes at once necessary to determine, if possible, whether it is human or animal; and if found to be of the latter kind, whether it is of its original, natural color, or has been stained by the dyer. To become practically familiar with the many varieties of fur, such as are in common use as articles of wearing apparel, and to recognize the changes wrought in hair by dyes to which it has been subjected, opens up an important and extensive field to the forensic microscopist, and one which as yet has received comparatively little attention.

The importance of closely inspecting weapons, and of carefully

examining hair found upon them, may best be shown by a few illustrative cases.

In a case quoted by Dr. Taylor, a hatchet, having clotted blood and hair adherent to it, was produced as evidence against an accused person under whose bed the weapon had been found. This, with other circumstantial evidence, had turned public opinion strongly against the prisoner; but when the hair was examined it was found not to be human, but to have been taken from the body of some animal. This circumstance led to a more complete sifting of the evidence, and the prisoner was acquitted. It turned out that the prisoner had killed an animal with the hatchet, and had carelessly thrown the weapon under his bed. (*Taylor's Med. Jurisp., Vol. I., p. 508.*) Some years since a little girl was murdered in one of our large cities, and the appearance of wounds which had been inflicted upon her head indicated that the weapon used was some blunt instrument. A club stained with blood was found near by. The counsel for the accused person endeavored to show that the club had been used by the prisoner for the purpose of killing pigeons. The club was submitted to examination, and there were found in the clots thereon, and in the splintered portions of the weapon, certain hairs which were identified by others and myself as fine hairs from a human head. By comparison they were in every respect precisely like hair taken from the head of deceased. In the case of an alleged murder in Connecticut, where the charred bodies of two women had been found in the *débris* of their dwelling which had burned to the ground, I was employed by the State to make an examination of certain pieces of half-burned cloth, some partly singed hair, and numerous other fragmentary substances. I found considerable blood in unburned portions of the cloth, but owing to the high temperature to which it had been exposed, the corpuscles could not be sufficiently restored to determine, even approximately by the aid of micrometry, whether they were of human or animal origin; and it was not known whether there was an animal in the house at the time of the fire or not. I found, however, some hair which had been matted together by blood previous to its being heated, and was able in that case to show that the hair was from the head of an adult dark-complexioned person. One of the most im-

portant features developed during this trial was the ability to show that the blood in the meshes of the hair was *ante-mortem*.*

In distinguishing the various fibers from which woven textures are made; in detecting, as is often possible, the characteristic action of certain dyes on textile fabrics; in demonstrating the peculiar twist of warp or consistence of woof in a given specimen,—we may, by means of comparison with textures from an established source, be able to form decided opinions relating to identity. In this paper, however, which necessarily must be brief, I shall not enter at all upon the many changes which fibrous materials undergo in the process of manufacture. Nor shall I more than allude to the important medico-legal questions relating to human hair, such as whether it has been pulled out by violence, or fallen out by natural processes; whether it has been bruised or cut; nor shall I discuss the characteristics which frequently enable us to determine from what part of the body it comes. All of these points are treated in our medico-legal text-books. I shall mainly confine my remarks to the salient points of difference between human and animal hair, and the distinguishing features of hair from those of the more common filaments which may be mistaken for it by the ordinary means of sight and touch.

The principal filamentous substances which may be mistaken for hair are the finer fibers of jute, linen, silk, and cotton. These under a good glass are easily contradistinguished, and may be best disposed of in this paper by giving a short description of each, rather than by pointing out the special features wherein they differ from hair.

Jute (*Plate I., fig. 7*), the liber fibers of the *Corchorus capsularis*, an East Indian plant, when observed under a power of from one hundred and fifty to two hundred diameters, is at once seen to be of vegetable origin. The single fiber consists of a firm woody texture, with conical ends. The central axis is composed of long vegetable cells with blunt conical tips, separated from each other by

* The blood, here referred to, was shown to have escaped from the victim during life, by presumptive evidence introduced during the trial; the author does not wish to be understood as believing there are any characteristic microscopical distinctions between so-called *ante-mortem* and *post-mortem* blood.

delicate joint-markings at very regular intervals. The long, pliable character of the jute fiber, with its smooth regular surface and glossy appearance, enables it to be used quite extensively in the manufacture of so-called artificial hair, and also in many woven fabrics such as fancy table covers and mats. It is usually artificially colored before it comes into the hands of the microscopist, and may prove a valuable accessory to identification either of a person or a fabric.

Linen (*Plate I., fig. 5*), the liber fibers of the *Linum resitatissimum*, employed for centuries in the manufacture of cloth, presents a strong woody consistence, round and attenuated to a point at the ends. Distinct joint-markings are seen at unequal distances. Linen fibers enter into the structure of many of our domestic garments, both in a dyed and uncolored state. Under favorable conditions it retains its microscopic characteristics for hundreds of years, and is not likely to be confounded with any other fiber employed in the manufacture of textile fabrics.

Silk, an animal substance, secreted by the spinning organs of certain insects, presents, under an objective magnifying about two hundred and fifty diameters, the appearance of solid cylindrical or somewhat flattened filaments, free from markings of any kind. The boundary lines are clearly defined, and it is not liable to be mistaken for any of the fibers above mentioned.

Cotton (*Plate I., fig. 8*), the long, downy filaments from the capsules or pods of *Gossipium*, is one of the most familiar objects with which the practical microscopist is acquainted. His first efforts in mounting frequently present good specimens of cotton, regardless of what the object may have been intended to represent. The beauty of many a diatom mount, or of a desmid, has been spoiled by the unintentional presence of a cotton fiber on cover-glass or slide. But it is well to be able to recognize it in all the disguises it assumes in the course of manufacture and wear. Cotton consists of long, ribbon-like bands, with somewhat thickened borders, and with a characteristic twist which would alone distinguish it from the filaments already mentioned. The flattening is due to a collapsing of the fiber when it dries, there being no thickening layer. There is little danger of cotton being mistaken for ordinary hair, though it may be for down or wool. Quite recently I examined a knife which was

supposed to have been used by an accused person as the weapon in an alleged murder. On its blade were stains resembling dried blood, and in one of these stains were a number of hair-like filaments, which, under an ordinary pocket magnifier, closely resembled soft, downy human hair. Further examination showed them to be cotton.

In cases of forensic microscopy, the importance of a careful examination of all minute fibers found upon weapons cannot be too strongly insisted upon. A case is related where a razor was found which belonged to a prisoner, and on which were some small fibers imbedded in blood, which, examined under a high magnifying power, proved to be cotton. In cutting the throat of his victim the murderer had also cut through the cotton strings of her night-cap. The similarity of the cotton fibers on the razor belonging to the prisoner and those of the deceased woman's night-cap was fully established. (*Tidy's Legal Med., Vol. I., p. 272.*)

In another case, a knife which had been used to inflict a fatal wound, and which had been wiped afterward, contained in its depressions and irregularities, as well as between the layers of the handles, coagula of recent blood mixed with rust. One remarkable circumstance brought out by the microscope appeared to connect the weapon with the prisoner. In a small coagulum found on the knife, dried and fixed to the blade, were some woolen fibers of a peculiar purple-brown dye. These corresponded exactly to the fibers of the woolen jacket which the prisoner wore. (*Taylor's Med. Jurisp., Vol. I., p. 509.*)

In examining hair for the sole purpose of determining whether it came from man or a lower animal, we shall find sufficiently characteristic differences in that portion known as the shaft, and we shall therefore limit our remarks to that part only, which, in fact, is often the only portion of the hair we are able to obtain in medico-legal practice. The appearance of the hair-shaft varies considerably in different persons, as it does also in the same person upon different parts of the body; but there is, nevertheless, the same general structure, which enables us to identify it with little difficulty when under the microscope. Before entering upon the features distinguishing human from animal hair, it will save repetition if we first briefly refer to the general structure of the hair-shaft.

When we examine a hair, properly mounted, under a low or medium power, we can usually discern at once its two principal anatomical parts, the cortex and medulla. The medulla, forming as it does a dark central axis in the hair, gives it the appearance of a tube,—an illusion which led some of the earlier observers into error. A thin transverse section of the shaft at once corrects this impression, and shows the medulla to be composed of cells of variable size and shape. These cells usually contain dark, coarse spots, which were at one time supposed to be deposits of pigment, but have since been shown to consist of air. This can be easily demonstrated by allowing a longitudinal section of hair to soak in some volatile oil, when the air will be displaced by the oil, and the spots disappear, and again reappear upon evaporation of the oil. The size and shape of these medullary air cells, as we shall see later on, form one of the most noticeable distinctions between animal and human hair.

The linear portion or cortex, which surrounds the medulla, is made up of flat and generally nucleated cells, the borders somewhat overlapping each other. By treating a human hair, preferably a white one, with caustic soda or potassa (*Plate I., figs. 1 and 6*), the cell walls become plainly visible; and by desiccation in warm nitric or sulphuric acid the individual cells may be obtained, showing oftentimes with beautiful distinctness their elongated nuclei,—and frequently, in dark hair, pigment markings. The cortex of a human hair, especially, is hard, tough, and yet elastic. This permits of brushing, combing, and of even much rougher treatment, without injury to its normally smooth contour. We would remark, in passing, that this is a point of some value in forensic microscopy, as we frequently find dents of more or less depth in hair taken from weapons which have been used in assaults. Such dents or other injuries to the cortex, when observed in hair remaining on the victim's head, may lead to a presumption as to the kind of weapon used.

With these remarks, we may now inquire into the characteristic distinctions which exist between human and animal hair. For the purpose of convenience they may be considered under the following heads, viz.: 1st. The relative proportions of the cortical and medullary structures. 2d. The size, shape, and arrangement of the

medullary cells. 3d. The size, shape, and arrangement of the superficial cortical cells. 4th. The size and shape of the hair shaft.

First.—*The relative proportion of the cortical and medullary structures.*

In animals, the medulla almost always forms a much larger proportion of the hair shaft than in man, though there are a number of exceptions to this general rule. In hair from certain *Quadrumana*, the monkey for example (*Plate II., fig. 6*), the relative proportion of medulla is about the same as in the hair from man (*Plate I., figs. 1, 2, and 6*), though its appearance is different. The stronger and denser the hair, the greater is the thickness of cortical structure; while conversely, the lighter and more pliable and spongy the hair, the greater is the proportion of the medulla. This rule is well illustrated in such typical examples as the pig's bristles, intended more for protection than warmth, with hard, horny cortex and proportionately small medulla; and on the other hand, the soft and pliable though coarse hair of the deer (*Plate II., figs. 7a and 7b*), with its thin, delicate cortex and full, spongy medulla, evidently constructed as much for warmth as for protection from violence. So universal is this rule, that, with a full knowledge of the life history of a given animal, we can form an opinion as to the relative proportion of cortical and medullary structures with considerable accuracy, even before we have made a microscopic observation.

Second.—*The size, shape, and arrangement of medullary cells.*

In human hair we find the medullary cells of variable size, irregularly round; that is, in such diverse shapes as globular cells assume when in close and crowded aggregations (*Plate I., fig. 6*). They differ in general appearance from the corresponding cells in most hairs of animal origin. They are smaller, more crowded, and unless specially prepared, less distinct than the medullary cells in animal hairs of the same diameter. In hair from most of our domestic animals, we find the size, shape, and arrangement of these cells to be so totally unlike those in human hair, as to be contradistinguished at a glance, when properly mounted and viewed under a good glass by transmitted light. In the *Rodentia*, for example, these cells are mostly arranged in pretty regular longitudinal lines, the medulla in

the finest hairs being composed of but a single row of more or less distinctly separated cells.

Third.—*The size, shape, and arrangement of the superficial cortical cells.*

In human hair these are thin, flat, and usually fusiform, superimposed flatly one on another, and overlapping so as to give the appearance of very fine, irregular, transverse striæ on the surface of the hair, and a delicate serrated edge on the outer borders (*Plate I., fig. 2*). The projection of these superficial cortical cells is only equal to the thickness of a single cell. On the other hand, in animal hair, where the cortex at all resembles that of human, the striæ are coarser, more distinct, the lines more widely separated, and the edges generally more deeply serrated. In many hairs the projection of the superficial cortical cells is so great that instead of the striated appearance, we have a rough surface thickly studded with obliquely projecting points or spurs; or we may find the scales arranged in handsome whorls at regular intervals, as in the hairs of some bats.

Fourth.—*The size and shape of the hair shaft.*

Hairs from different parts of the same person or animal vary much in size. So also do hairs from the same animal, when collected at different seasons of the year, vary considerably both in length and thickness. As a means of identification, the diameter of human hair is important when considered in connection with a considerable number of measurements made from hairs from a known source. Measurements taken of the diameter of a hair for the purpose of ascertaining whether it is of human or animal origin are of little or no use; but measurements made of the thickness of the cortex and diameter of the medulla, whereby the relative proportion of each may be obtained, are of considerable value. I present with this paper a table of such comparative measurements of hairs from quite a number of animals. This table gives the thickness of cortex and medulla, and diameter of hair-shaft, of both the coarse and fine or downy hairs.

Coarse Hairs.				Fine Hairs.		
Thickness of Cortex.	Diam. of Medulla.	Diam. of Hair Shaft		Thickness of Cortex.	Diam. of Medulla.	Diam. of Hair Shaft
mm.	mm.	mm.		mm.	mm.	mm.
.0172	.0378	.0722	....British Fox.....	.0048	.0098	.0194
.0096	.0324	.0516	..... Sable.	.0028	.0136	.0192
.0118	.0362	.0598	...Zulu Antelope...	.0068	.0080	.0216
.....	.....	.....	....English Otter...	.0026	.0038	.0090
.....	.....	.....	..... Raccoon. ...	.0040	.0060	.0140
.0150	.0130	.0430	.....Bison.....	.....	.....	.0200
.0300	.0380	.0980	..... Hyena*.....	.0070	.0080	.0220
.0016	.0424	.0456	.....Mouse	.0016	.0084	.0116
.0070	.0800	.0940	...Gray Squirrel...	.0050	.0090	.0190
.0020	.1080	.1120	...Northern Hare..	.0030	.0110	.0170
.0120	.0340	.0580	.....Silver Fox	.0050	.0070	.0170
.0150	.0330	.0630	.....Lioness.	.0050	.0100	0200
.0080	.0200	.0360	..... Mole.....	.0030	.0150	.0210
.0180	.0200	.0560	....Brown Bear....	.0040	.0120	.0200
.....	.....	.....	....N. A. Otter....	.0020	.0060	.0100
.0130	.0200	.0460	Australian Opossum.	.0040	.0080	.0160
.0160	.0800	.1120	.....Zebra.....	.....	.....	.....
.0170	0990	.1330	... Wapiti Deer ...	.0030	.0110	.0170
.0020	.2020	.2060	.....Reindeer.....	.0040	.0360	.0440
.0030	.1360	.1420	.....Am. Deer.....	.0070	.0310	.0450

The shape of hair varies in persons and in animals. Hair from the human scalp is cylindrical and with smooth contour, while animal hairs are of various shapes,—some oval, others branched, and many constricted in diameter at regular intervals along the shaft. Of the latter kind we may mention that of the mouse, in which we find the hair is round, and contains a number of rows of medulla cells which gradually diminish at the constricted part and increase in numbers as we examine the larger part, and so on through the entire length of the shaft, producing several symmetrical contractions and expansions in the hair.

In conclusion, I wish to say that as, by following the general line of investigation indicated in this paper, we are able to distinguish human from animal hair, and from the few illustrative cases cited we have seen the great importance of such contradistinctions, allow me to express the hope that we may in future give more careful study to the examination of hairs and fibers entering into medico-legal case which may be referred to us as microscopists, and not confine our *exclusive* attention to examinations of blood-stains in the hope of being able to distinguish human from all animal blood, to the neglect of such other presumptive evidence as may be within our reach.

* Hairs from the Hyena are very variable in size, there rarely being two of the same diameter in the same microscopical preparation.

1.

2.

3.

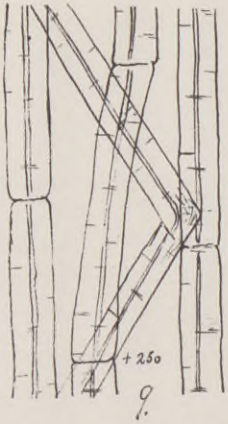
4.

5.

6.

7.

8.



9.

PEN SKETCHES OF HAIRS AND FIBERS

EXPLANATION OF PLATE I.

Fig. 1. Human hair prepared and focused to show imbricated cortical scales.

Fig. 2. Human hair showing medulla before the air is expelled, and illustrating relative proportions of cortex and medulla.

Fig. 3. Transverse sections of human hair.

Fig. 4. Sheep's wool.

Fig. 5. Linen fibers.

Fig. 6. Human hair treated with caustic soda, showing medullary cells with their nuclei and the elongated nuclei of cortical cells.

Fig. 7. Jute.

Fig. 8. Cotton fibers.

Fig. 9. Flax.

EXPLANATION OF PLATE II.

Fig. 1. Fine and coarse hair from Mouse.

Fig. 2. Hair from Skunk.

Fig. 3. Hair from Brown Bear.

Fig. 4. Fine hair from Raccoon.

Fig. 5. Hairs from Gray Squirrel.

Fig. 6. Hair from Red Monkey.

Fig. 7. Hair from Deer. 7a longitudinal sec. 7b trans. sec.

Fig. 8. Hair from Beaver.

Fig. 9. Hair from African Wild Cat.

Fig. 10. Hairs from Australian Opossum.

Fig. 11. Hairs from Silver Fox. 11a, longitudinal sec. of coarse hair. 11b, transverse sec. of coarse hair.

Fig. 12. Hair from Leopard.

Fig. 13. Hair from Buffalo.


+350
1.


+250
2.


+250
3.

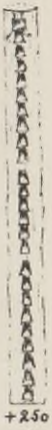

+350
4.


+150
5.

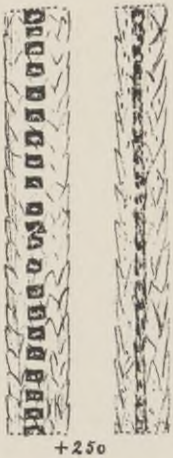

+150
7b.


+250
6.


+150
7a.


+250
8.


+250
9.


+250
10.


+250
11a.


+250
11b.


+250
12.


+250
13.

PEN SKETCHES OF ANIMAL HAIRS