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THE ADVANTAGES OF THE SCANNING ELECTRON MICROSCOPE IN THE INVESTIGATIVE STUDIES OF HAIR

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The advantages of using the Scanning Electron Microscope (S.E.M.) for mammalian hair studies far surpass the technique of light or Transmission Electron Microscopy (T.E.M.) microscopic studies. Determinations of surface characteristics such as scale count, hair diameter, surface debris, hair shape, scale structure and surface damage, whether physical or chemical may be significant in investigative crime studies.

Use of an optical light microscope gives very poor topographic resolution of hair features. While the transmission electron microscope gives better resolution, there is still the matter of replication of the surface of the sample to be investigated, which gives another possibility for error in investigation. The S.E.M. is not only a better tool for studies, since the depth of field and resolution of topographical work is better, but preparation is rapid and easy. Hair samples are mounted on metal stubs with either double-stick cellophane tape or conductive paint on the ends; the hairs are then metal vaporized with a thin-layer of aluminum, coating the sample with a featureless metal at a thickness of less than 200 Å, which is under the resolution of the S.E.M. This enables the sample to be observed without disturbing it; observations are made of the sample directly without replication.

The information on hair; development, growth, and chemical components and research projects on hair of mammals (primarily other than humans) fills volumes. The short article to follow will certainly not be able to cover all the information on hair, but will, perhaps, give a little insight into the characteristics of hair and the role the S.E.M. can play in bringing these characteristics into focus.

Histological studies have shown certain structural relationships of hairs to be usually predictable, though not invariable. The normally existing correlations are cuticular scales, medullae, cortical cells, and pigment patterns.

Since growth is managed by cells arising from a mass of rapidly proliferating tissue near the base of the hair follicles, hair growth patterns show up on the surface scale patterns. These cells grow by differentiating into a core of keratinized material composed of two interlocked parts—the hair proper and its internal root sheaths. During growth, the core passes upward through the wall of the follicle, the external root sheath. Root sheaths and dermal papilla are important in determining hair shape, size, and movement. Several glands and skin cells are involved (which will not be delved into, since the above description of hair growth is not the prime concern, but shows some of the things involved in influencing hair structure besides hormones, vitamins, gland functions, environment and genetic factors). Nutritive and traumatic factors can modify normal rhythm of hair growth. Thyroid hormones have a physiologically stimulating action on hair growth. Lack of adrenocorticotrophic hormones, disease, injury, or environmental stress cause a depression of hair growth. Of the eighteen orders of mammals, all grow differently structured hair, (Figures 1 and 2) which reveals either the outer structure, or the size, or the shape of the hair differently in each case. Some mammals grow hair in wave patterns; others grow hair continuously, as in sheep and humans.

In addition to growth mechanisms previously described, there are other individual and diagnostic pathological, chemical and abnormal con-

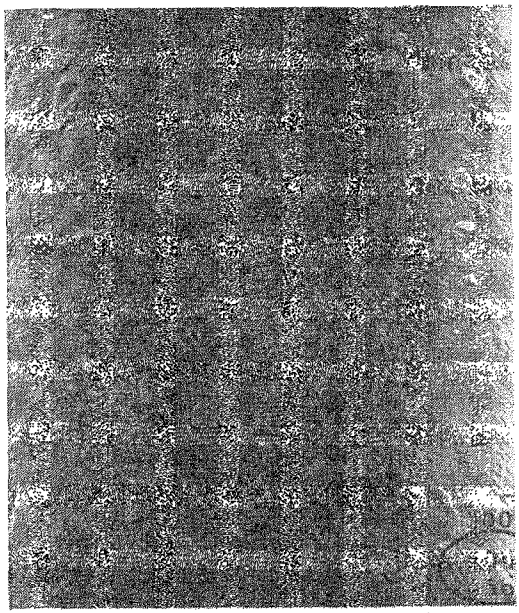

FIGURE 1.
Basal end of cat wisker showing small scales and broadness of hair. (Enlargement 300X).

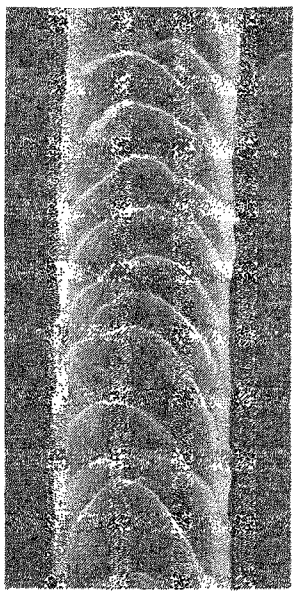

FIGURE 2.
Dog hair from a long haired Sheepard showing fine hair with narrow diameter and large smooth scales. (Enlargement 1000X).

ditions which affect surface characteristics of hair, and may be used as criteria for identifying hair of human individuals. Figure 3 shows chemically damaged hair from an individual taking drugs and in poor physical health. The scale structure in this instance did not develop properly and

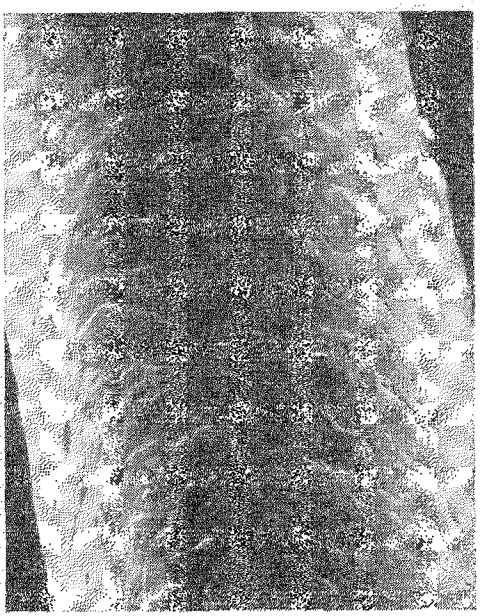

FIGURE 3.
Light brown hair of an adult female Caucasian showing chemically damaged hair structure. (Enlargement 1000X).

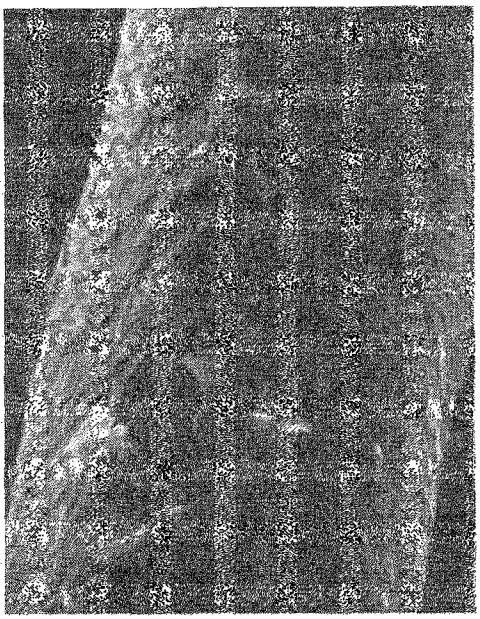

FIGURE 4.
Dark brown hair of adult female Caucasian showing physical damage. (Enlargement 1000X).

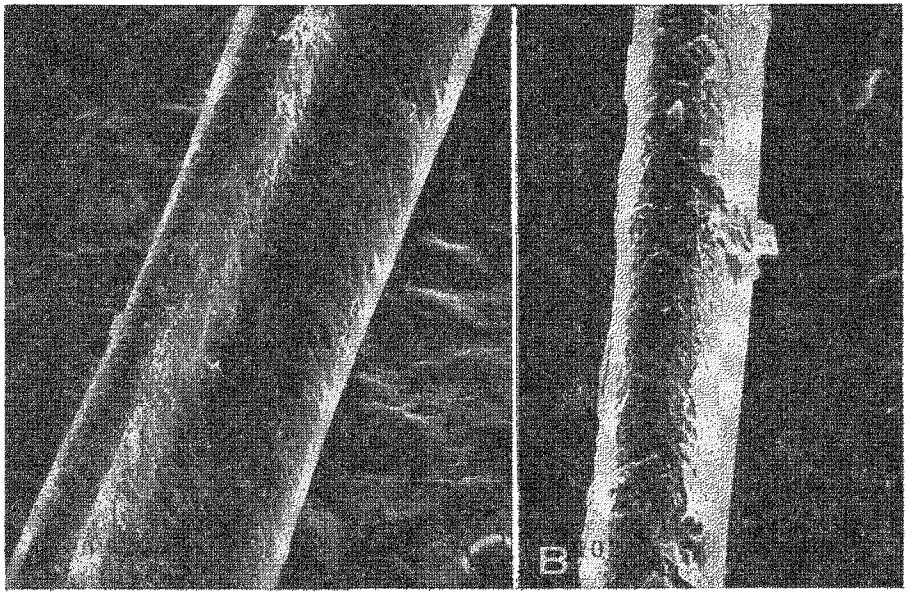

FIGURE 5.
Beard hairs from adult male. A. Caucasian; B. Negroid; (Enlargement 300×).

shows up very well as a surface characteristic. Figure 4 shows physical damage of hair which could have been caused by hard brushing or teasing of the hair.

The variability of human hair in each race is greater than the variability of hairs on a single individual's head. The hair of the Chinese is most nearly circular in cross-sections; coarser and straighter hair lends itself to a more circular shape. Negroid head hair is the most flattened being quite curly in nature, as tends to be the case with flattened ovaloid cross-sectioned hair. Western European and Asiatic Indian hair sections are intermediate in cross-section shape.

Human hairs have differently shaped and sized cross-sections of hair on various areas of their bodies. The male beard hair is more or less triangular shaped, instead of round or oval. (See Figure 5.) Pubic hair tends to be broad and flat (Figure 6), more on the oval side. The soft, downy body hair is quite round (Figure 7), yet the diameter range is from 15 μ for soft body hair to 70μ for the coarser male body hair. The range of the diameter of fine body hair to coarse head hair is about 15 μ to 190μ. The head hair diameter range is from 45 to 190μ, with the dividing line between large and small hairs being about 95μ. Scales, which are one-third the diameter of the hair, occur on hair shafts from 50–60μ; and narrow scales, which are one-sixth diameter, occur on 92–105μ scale counts can be taken rapidly on the S.E.M. and a permanent record can be made with comparative hairs mounted on the sample next to one another, as in Figure 5.

FIGURE 6.
Pubic hair from adult female Caucasian shows normal flat oval shape with tapered appearance due to twisting. Hair lacks pronounced scales. (Enlargement 300X).

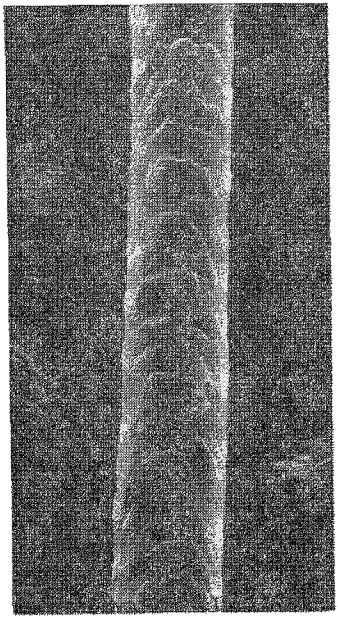

FIGURE 7.
Downy hair from forearm of adult female Caucasian showing large scales but small diameter. (Enlargement 1000X).

The pictures of hair samples were taken with a Polaroid camera attached to the Cambridge Mark I, Scanning Electron Microscope, using Polaroid Type 55 P/N film.

Stereo photographs can be taken on the S.E.M. simply by taking one picture of the sample at one angle, then tilting the sample an additional 2° to 10° to another angle, and taking another picture. This is the angle at which your eyes would normally see the sample, since all depth is seen by the brain interpreting two images from two angles in relation to the two eyes. The stereo image can be seen by focusing at a distance, holding the picture about 10 inches from the eyes, and viewing the stereo pair. Stereo glasses can also be used to view the image. Stereo photographs show the great depth of field not achieved with light optical instruments since the depth of field would not be the same and resolution would be very poor with the optical instruments in general use. With the stereo means, scaley structure and surface features not readily noticed or determined before literally pop into view. This, too, is a great advantage in hair identification.

SUMMARY

Hair identification is a complex and important problem in view of forensic investigation. It entails many tests and uncertainties still exist in drawing final conclusions to determine whether a single hair is identifiable from a certain individual.

The Scanning Electron Microscope alone may not be able to cause final conclusions to be drawn, however, with further tests and comparative studies, this type of study certainly will eventually lead to a more positive identification of hairs, since it definitely shows improvement over the optical means of identification regarding structural, surface morphology, coupled with other scientific data.

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