# HAIR COLORATION IN ANIMALS

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IN some recent papers[1] the writer has endeavored to point out that an accurate knowledge of the histology of mammalian hair may be applicable not alone in the field of pure zoological science, but also in the standardization of furs and fabrics in the industries. The need of some sure means for the identification of textile and fur materials, and for their standardization, is increasingly recognized. The methods of identification which will prove most useful will be those which can be applied, with results of unimpeachable certainty, to any textiles, furs, or fur products, no matter how great a degree of modification away from their original color or texture they may have undergone. In the papers already referred to, attention is called to certain microscopic elements in the structure of the hair shaft which are of value in determining the species of mammal from which the hair was taken. These structural elements are the medulla, or central column of "pith" cells, and the cuticular scales, forming the outermost investiture of the hair shaft. (Fig. 1). The writer has suggested[2] that the pigment granules in the hair shaft, to which the color of the hair is primarily due, may also be used as determinative criteria for identification, when considered either alone or in conjunction with the other compositional units of the hair shaft structure. This paper will strive to show how the nature of the pigment granules in the hair shaft can be used in aiding in the identification of hairs. Detailed criteria of this sort may be useful in making determinations of very small fragments.

The various colors of animal hairs are due either to pigment materials within the shaft, or coloring matter deposited on the outside of the cuticle, and may be modified by the way in which light is reflected from the surfaces of the various structures of the hair shaft itself. Hair which owes its hue to the latter cause is comparatively rare, being found, for example, on the flanks and base of the tail in members of the weasel tribe, and appearing as a yellow tint, from deposits from skin glands. In the great majority of cases, however, it is the presence of pigment *within* the hair shaft which gives color to the hair.

[1]Hausman, L. A., The Microscopic Identification of Commercial Fur Hairs, Sci. Mon., Vol. 10, Jan., 1920, p. 70; Hairs That Make Fabrics, Sci. Am., Feb. 21, 1920, p. 184; Structural Characteristics of the Hair of Mammals, Am. Nat., Vol. 44, Nov.-Dec. 1920, p. 496.

[2]Hausman, L. A., Mammal Fur Under the Microscope, Nat. Hist. (Jour. of Am. Mus. Nat. Hist.) Vol. 20, No. 4, 1920, p. 434.

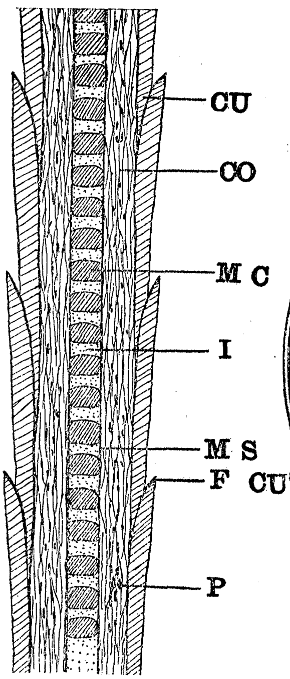


FIG. 1.—Ideal longitudinal section through a generalized mammal hair, CU. cuticular scale, CO. cortex, MC. medullary cells, I. interspaces between medullary cells, MS. medullary shaft, or column, F. CU. free edge of cuticular scale, P. pigment granules in cortex.

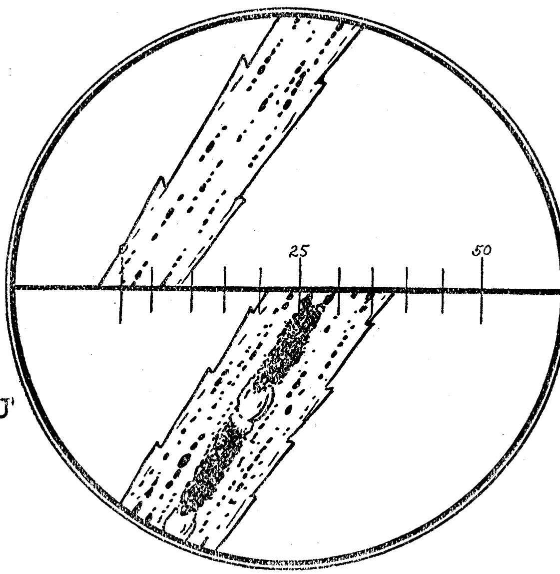


FIG. 2.—Fur hairs from the American otter (above), and the coypu, or "nutria" (below), seen in the comparison ocular. The scale in the center is that of the micrometer eyepiece. Each division equals 5 microns. One micron equals about 1/125,000 of an inch.

The pigment material within the hair shaft may be diffuse *i. e.*, not present in the form of distinct masses, and, if such is the case, the whole shaft is homogeneously stained, and the hair appears, even under the highest powers of the microscope, as a uniformly colored structure. Yellow, or amber hairs are usually pigmented in this way.

The most common cause of color in hair, however, is not external deposit, or internal diffuse stain, but the presence of pigment masses, occurring (1) in the cortex as separate granules, or (2) in the medulla, usually as amorphous masses, though sometimes as discrete granules. Fig. 1 shows a generalized mammal hair, to make clear the relationship of the structures, medulla, cortex, and cuticle.

The hair of the polar bear (Fig. 3) may be taken as typical of a pure white, i. e., colorless, hair. It will be seen that no pigment is present in the cortex of such a hair, which appears under the microscope as a transparent, glassy shaft. The medulla appears to be dark in color. This is due, possibly, to a slight amount of black pigment in the fused medullary cells, but more largely to the dispersion of light from the microscope mirror.

The addition of black pigment in the medulla, very commonly in the form of lenticular masses between the medullary cells, produces hairs of varying shades of gray, a common fur color among mammals. Fig. 5 illustrates the nature of the pigmentation in a hair of typical gray color, the drawing being made from near the middle of the fur hair[3] of the large blarina. An increase in the size of these medullary pigment masses gives to the hair a darker gray color, as illustrated in the hair of the Sewellel, Fig. 6. The size, mode of placentation and especially the form of the medullary pigment masses are in most cases characteristic of the species possessing them, and can be used as valuable aids in identifying hair samples. Gray hair, produced by these lenticular medullary pigment masses, is extremely common among the moles, shrews, voles and soft-fur bearing animals.

Brown pigment masses, composed of granules more or less perfectly fused, are also found between the medullary cells of certain hairs, imparting brown colors, as, for example, in the hair of the cottontail rabbit, Fig. 12. The intensity of the color varies according to the size of the medullary masses, and the depth of color of the component granules. Hairs colored in this way may vary from a light yellowish to a deep reddish brown. Hairs are occasionally found possessing granules in the medulla separate, and not fused. When such is the case the granules are grouped into aggregations of characteristic form and size. Such a condition is illustrated near the base of the fur-or underhair of the muskrat. (Fig. 18).

In a few cases the medullary pigments are also present in the form of separate granules, which are scattered about among the cells of the medulla in a rather uniform way. This gives a pigmentation character quite different from those already mentioned. These granules seem to be largely black, or of various shades of brown. Typical examples of such very distinctive pigmentation characters may be seen in the gray fur hairs of the Sennett kangaroo rat (Fig. 7), in the yellowish-brown hairs of the prairie dog (Fig. 11), and in the yellow hairs of the domestic guinea pig (Fig. 14).

The pigment materials found in the cortex of the hair are usually present in the form of disjunct granules, and are less often coalesced into masses than in the medulla. Furthermore, their patterns of arrangement are all built up along an axis parallel to the hair shaft. This is because the granules are deposited in and among the elongate, fusiform cells, or hair spindles, that go to make up the cortex. (See Fig. 1, CO.). The colors caused by the presence of cortical granules are the various shades of yellows, browns, reds, etc., to black, depending on the depth of color of the granules, and their numbers. The hair

[3]Two varieties of hair occur commonly in mammals: the *fur,* or *under*-hair, usually soft and thick; and the *protective,* or *over*-hair, longer, and stiffer. In the make-up of many furs the protective hair is removed.

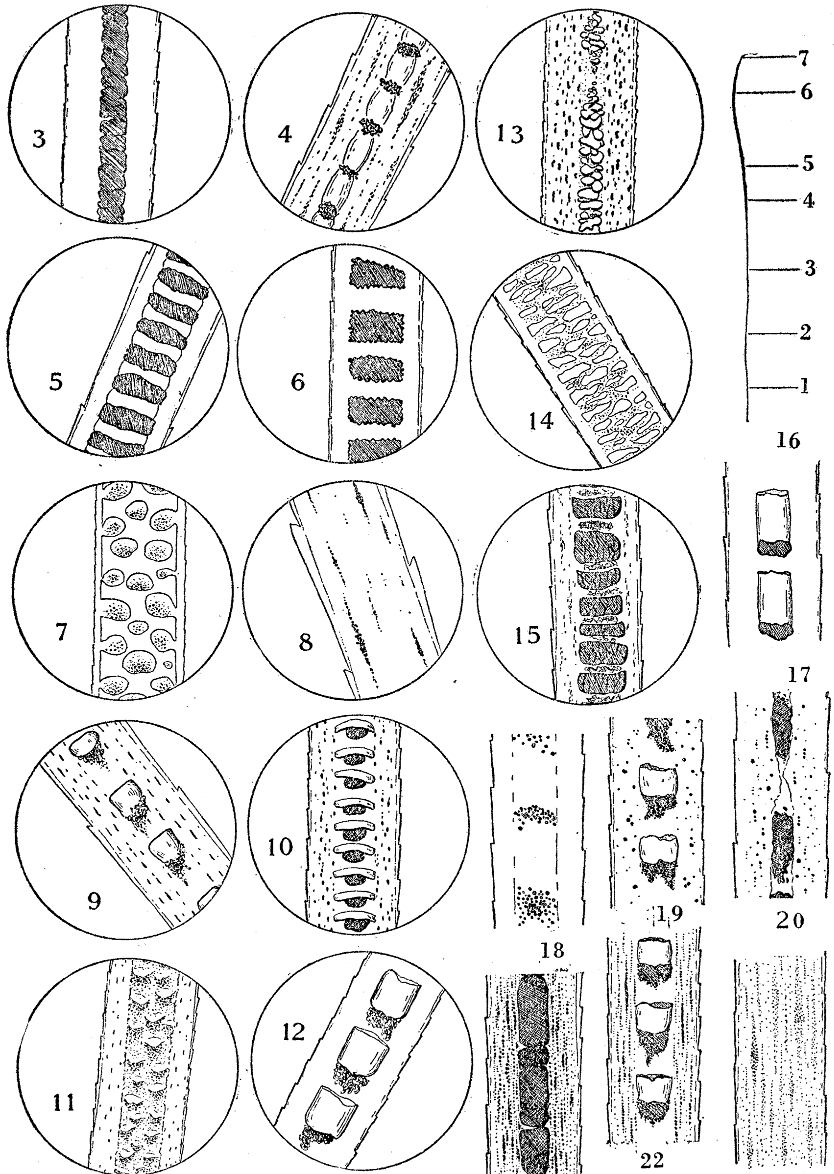


PLATE I

Explanation of Figures 3 to 23

Figs. 3 to 15 represent the conditions in the fur hair of the species, midway from the tip to the base, in each case, unless otherwise noted. For comparison, the diameter of each hair is given in micra.

Fig. 3. Polar bear (Thalarctos maratimus), 52 $\mu$, color white

Fig. 4. Black bear (Ursus americanus), 46 $\mu$., color, dark brown, almost black.

Fig. 5. Blarina (Blarina brevicauda), 38 $\mu$, color, gray.

Fig. 6. Sewellel (Aplodontia californica), 25 $\mu$., color, dark gray.

of the big brown bat (Fig. 8) is a typical example of a pure brown hair which owes its color solely to cortical granules. Fig. 23, from the tip of the fur hair of the muskrat, and Fig. 29, from the tip of the protective hair[3] of the same species, illustrate the same conditions of cortical pigmentation.

In most instances, however, the colors in hair are produced by a combination of cortical and medullary pigmentation, sometimes with the addition of diffuse color as well. In the hair of the black bear (Fig. 4), for example, the color is due to very dark brown cortical granules, plus black medullary masses. Light brownish or yellowish cortical granules, plus dark brown medullary masses, produces dark brown fur, as in the New York weasel (summer pelage), Fig. 9. Fig. 10, taken from near the tip of the fur hair of the large blarina, shows the usual pigmentation conditions in a dark grayish brown hair *i e.*, black medullary masses, and some few light brown cortical granules. Figs. 13 and 15, hair from the squirrel monkey and marmoset, respectively, illustrate the typical conditions found in yellow or yellowish hairs, *i. e.*, yellow granules both in medulla and cortex, or yellow granules in cortex, and yellow masses in the medulla.

These descriptions of pigmentation characters have been adduced thus in detail to show that the significant thing from the standpoint of fur identification is not the structural cause of the different colors, but that pigmentation characters can be used as aids in identification.

The pigmentation in the fur hair of a species often differs from that in the protective hair. There is likewise a change in the character if the pigmentation from the base to the tip of both varieties. The nature of these pigmentation differences in the hairs of the same animal can be well illustrated from the hair of the muskrat. Fig. 16 shows an entire muskrat fur hair, from base to tip. The numbers 1 to 7 refer

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Fig. 7. Sennett Kangaroo Rat (Perodipus sennetti), 40 $\mu$., color, gray.
Fig. 8. Brown Bat (Vespertilio fuscus), 8 $\mu$., color, brown.
Fig. 9. New York Weasel (Putorius noveboracensis), 10 $\mu$., color, brown.
Fig. 10. Blarina (Blarina brevicauda), tip of fur hair, 30 $\mu$., color, grayish brown.
Fig. 11. Prairie dog (Cynomys ludovicianus), 50 $\mu$., color, yellow-brown.
Fig. 12. Cottontail rabbit (Lepus sylvaticus), 10 $\mu$., color, brown.
Fig. 13. Squirrel monkey (Chrysothrix sciurea), 47 $\mu$., hair from wrists, color, deep yellow.
Fig. 14. Guinea pig (Cavia porcellus), 76 $\mu$., color, yellowish.
Fig. 15. Marmoset (Hapale jacchus), median band of yellow in the fur hair, 25 $\mu$., color, yellow.
Fig. 16. Muskrat (Fiber zibethecus) the entire fur hair, to serve as a guide figure. The numbers, 1, 2, 3, etc., refer to points represented by Figs. 17, 18, 19, etc.
Fig. 17. Muskrat-Character of pigmentation at point 1, Fig. 16.
Fig. 18. Muskrat-Character of pigmentation at point 2, Fig. 16.
Fig. 19. Muskrat-Character of pigmentation at point 3, Fig. 16.
Fig. 20. Muskrat-Character of pigmentation at point 4, Fig. 16.
Fig. 21. Muskrat-Character of pigmentation at point 5, Fig. 16.
Fig. 22. Muskrat-Character of pigmentation at point 6, Fig. 16.
Fig. 23. Muskrat-Character of pigmentation at point 7, Fig. 16.

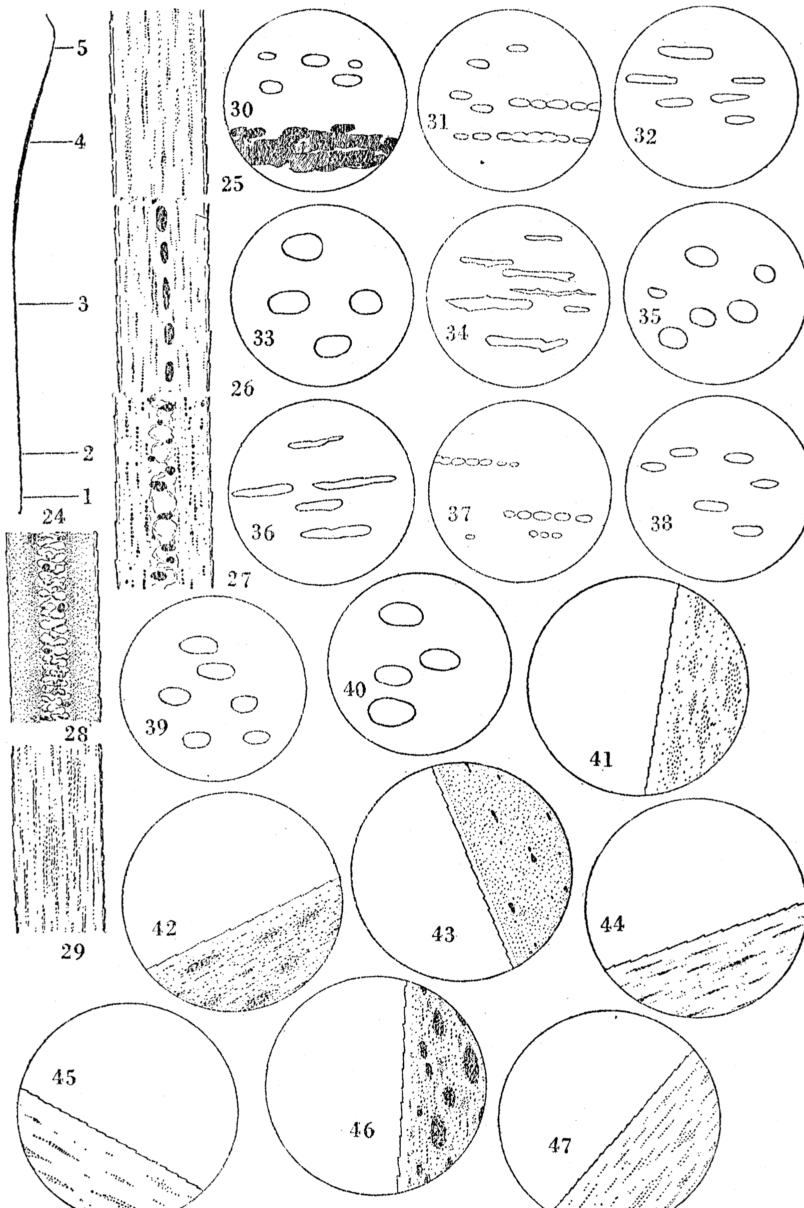


PLATE II

Explanation of Figures 24 to 47.

Fig. 24. Muskrat (Fiber zibethecus), the entire protective hair, to serve as a guide figure. The numbers 1, 2, 3, etc., refer to points represented by Figures 25, 26, 27, etc.

Fig. 25. Muskrat-Character of pigmentation at point 1, Fig. 24.

Fig. 26. Muskrat-Character of pigmentation at point 2, Fig. 24.

Fig. 27. Muskrat-Character of pigmentation at point 3, Fig. 24.

Fig. 28. Muskrat-Character of pigmentation at point 4, Fig. 24.

Fig. 29. Muskrat-Character of pigmentation at point 5, Fig. 24.

to localities illustrated by Figs. 17 to 23, respectively. It will be noted that there is a progressive increase in the density of the pigmentation from base to tip, as well as a change in the nature of the relationships between the black medullary pigment masses (Fig. 17), the brown medullary masses (Fig. 18 to 22), and the brown cortical granules (Figs. 19 to 22). A somewhat similar color change can be followed along the length of the protective hair of the muskrat, (Figs. 24 to 29).

The pigment granules themselves, particularly those present in the cortex, also show variations. These are variations in form, size, color value and color depth, and are susceptible of accurate comparison, as an aid in determining to species-source of the hair, or part of the body from which the hair was taken. As has been pointed out in the case of the muskrat, the character of these granules bears a relationship to their position in the hair shaft.

The value of the prosecution of the detailed study of pigmentation of mammal hairs may be looked for in the application it may have to problems connected with the artificial coloring of furs; in its value for the additional data which it yields for the identification of the species-source of hair samples, and especially in the possibility which

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Fig. 30. Coypu rat (Myocastor coypus), pigment granules, midway from tip to base in fur hair. Length, 0.775 $\mu$.

Fig. 31. Sea Otter (Latax lutris), pigment granules, midway from tip to base in fur hair, Length, 0.46 $\mu$.

Fig. 32. American Otter (Lutra canadensis), pigment granules, midway from tip to base in fur hair. Length, 1.18 $\mu$.

Fig. 33. Muskrat (Fiber zibethecus) pigment granules in tip of fur hair, Length, 0.91 $\mu$.

Fig. 34. Squirrel monkey (Chrysothrix sciurea), pigment granules, midway from tip to base in yellow hair of wrists. Length, 1.80 $\mu$.

Fig. 35. Fur Seal (Callorhinus alascensis), pigment granules near base of protective hair. Length, 0.76 $\mu$.

Fig. 36. Black bear (Ursus americanus), pigment granules midway from tip to base in fur hair. Length, 1.20 to 1.85 $\mu$.

Fig. 37. Brown Bat (Vespertilio fuscus), pigment granules midway from tip to base in fur hair. Length, 0.20 to 0.53 $\mu$.

Fig. 38. Chinese (Manchu), pigment granules in head hair, midway from tip to base. Length, 0.74 $\mu$.

Fig. 39. Eskimo (St. Lawrence Id.), pigment granules in head hair midway from tip to base. Length, 0.91 $\mu$.

Fig. 40. Fingo (Bantu), pigment granules in head hair, midway from tip to base. Length, 1.06 $\mu$.

Fig. 41. Papuan of New Guinea, pigment granule patterns in head hair, midway from tip to base.

Fig. 42. Fingo (Bantu), pigment granule patterns in head hair, midway from tip to base.

Fig. 43. English girl (hair, golden red), pigment granule patterns in head hair, midway from tipe to base.

Fig. 44. English girl (dark brunette), pigment granule patterns in head hair, midway from tip to base.

Fig. 45. Early Egyptian (floruit, 4,000 B. C.), pigment granule patterns in head hair, midway from tipe to base.

Fig. 46. South African Bushman, pigment granule patterns in head hair, midway from tip to base.

Fig. 47. Chinese (Manchu), pigment granule patterns in head hair midway from tip to base.

it affords of identifying minute fragments of hair, when these may be the only ones available in an investigation, as is sometimes the case in legal work.

It was the possibilities of the forensic application of the study of mammal hairs, which has induced the author to make a cursory survey of samples of the head hair of different races of man, to determine whether the pigmentation characters, so marked among the mammals, might not be equally well-defined in human hair. While the results of this tentative survey have not been conclusive, they are most suggestive.

The coloration of human hair appears to be due, in large measure, to either diffuse pigment (as is the case in "red" hair), or to granules in the cortex. The cortical granules are arranged in patterns, of distinctive size and form, for several of the chief races which were examined. Figs. 41 to 47 illustrate various forms of cortical granule patterns from the head hair of members of different races, and Figs. 38 to 40 depict separate pigment granules. The further study of pigmentation in human hair, may bring to light relationships of forensic significance.

For the study of their pigmentation, mammal hairs need to be prepared in the same way as for the study of the medulla, i. e., cleared and mounted in oils of various sorts, or Canada balsam.[4] They should be examined under the highest powers of the microscope, obtainable with oil-immersion objectives of greatest amplification in combination with 18, 20, and 25-power oculars.

An indispensable piece of apparatus for those who wish to make careful identifications is the comparison ocular. This is fitted to two microscopes, and each microscope exhibits half of its field in the comparison ocular, in such a way that two samples of hairs or other fibers, mounted separately on two slides, can be enlarged to equal magnitudes and brought close together for comparison within the same microscopic field. The utility of such a device will be at once apparent. Figure 2 shows a drawing, made from a photomicrograph, of one of the common fur hairs of commerce, and its imitator. The differences in the pigmentation of the two hairs becomes at once apparent when the hairs are thus brought together for comparison. A micrometer scale in the eyepiece aids in making measurements.

The development of micro-analysis has, during the past several years, been very great, and its utility in industrial fields, as well as in pure science, has been firmly established.

[4]For the technique of hair examination, see Hausman, L. A., Structural Characteristics of the Hair of Mammals, footnote 1.