Hair : with special reference to hypertrichosis / by C.H. Danforth.

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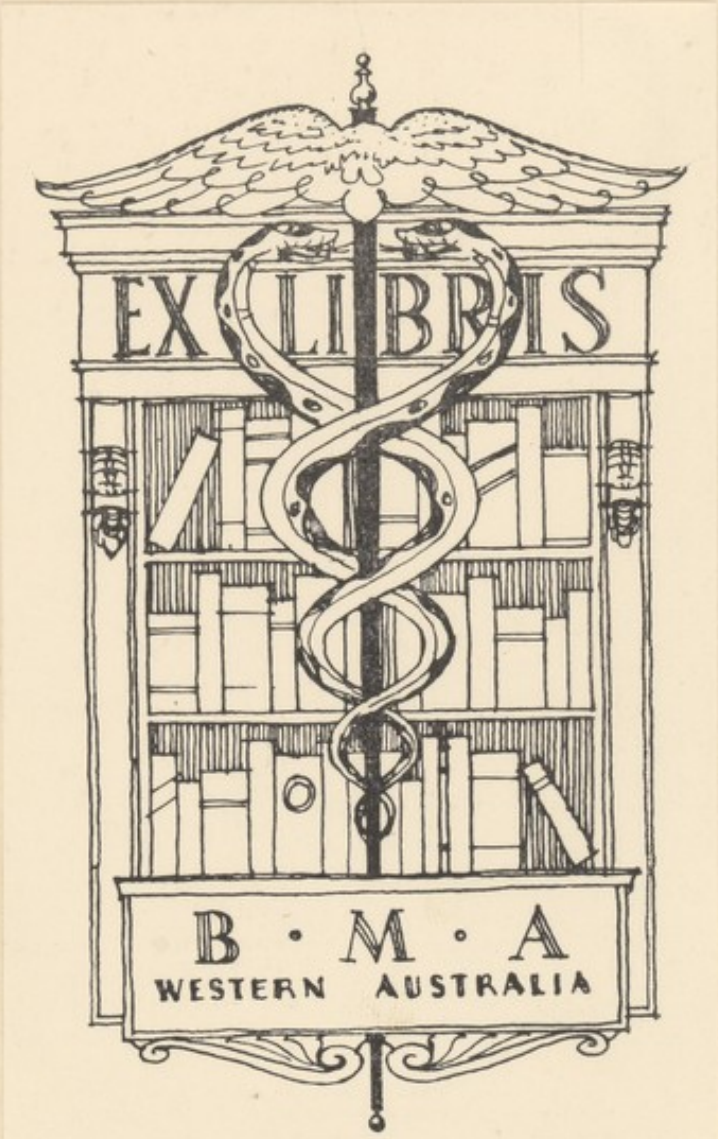

F. Wood Jones. from the Author
1927.

HAIR

With Special Reference to Hypertrichosis

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FOREWORD

This book is the outcome of a study begun several years ago at the Washington University School of Medicine. The work was stimulated and generously assisted by a grant to the dermatological department of the school for the study of hypertrichosis, but it early became evident that the problem of excess growth of hair was not likely to be solved without a more thorough understanding of the morphology of hair and a better knowledge of its normal growth processes. Consequently, most of the efforts have been directed toward these ends. The principal results have been published by Trotter, Cady, and the author, chiefly in the American Journal of Physical Anthropology and in the Archives of Dermatology and Syphilology. Since the study involved a rather extensive review of the literature, and since there is no comprehensive treatise on hair in English, it seemed desirable to bring together our own results and try to coördinate them with those of other workers. In doing so, no attempt has been made to cover the field exhaustively, the purpose being rather to present a general outline of the available information relating to the pilary system and to indicate some of the more obvious lacunae in our knowledge of that subject. The publications in this field are so numerous that anything like a complete bibliography is quite out of the question for a book of this size. It is hoped, however, that the articles listed will be found representative of the best morphological, physiological and clinical papers, and furnish a key to practically the entire literature on the subject.

C. H. Danforth.

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CHAPTER I

PHYLOGENY OF HAIR

The production of hair is one of the fundamental characteristics which differentiate the mammals from other classes of vertebrates. Hair is as peculiar to the mammals as feathers are to the bird. It is present and, with few exceptions, well developed in every member of the class, while it is entirely lacking in all other vertebrates. It was a recognition of the value of hair from the systemist's standpoint that lead Oken to propose the term *Trichozoa*—hair animals—for his highest class of vertebrates. Although Oken's term never came into general use, the fact remains that it is as descriptive of the class as is the word *Mammalia,*[1] which supplanted it.

It is natural that a character so distinctive and of such morphologic importance as mammalian hair should attract the attention of many investigators. During the period of intense morphologic interest, which extended through the last decades of the past century and the first few years of the present one, it was a subject of frequent research. In this period, most of the leading morphologists of the time concerned themselves to a greater or lesser extent with questions relating to the origin and homology of hair. Their problems, however, were not solved, and while several attractive theories were put forth, not one of them has ever been able to command an unqualified acceptance. At the present time, the most acceptable view would seem to be that of Botezat, who regards hair as a structure *sui generis,* for which there is no known antecedent in lower forms.

POSSIBLE PRECURSORS OF HAIR

But this is not a view that was held a few years ago, nor is it universally subscribed to at the present time. Most morphologists who have studied hair have been able to detect in it resemblances, real or fancied, to cutaneous structures in lower vertebrates. These supposed resemblances afford starting points for a number of hypotheses which have been evolved in an attempt to trace the phylogenetic history of the

1. Bonnet (1892) proposed the term *Pilifera* (hair bearers) as more sharply defining the class than does the term *Mammalia.*

hair. Since most of these theories were developed at about the same time, it does not seem expedient to discuss them from a chronologic point of view. They may perhaps better be considered with reference to their relation to each other.

The placoidal scales, or dermal teeth, of elasmobranch fishes and the true teeth of amniotes have much in common and are generally conceded to be homologous. These structures also bear some resemblance to hair, as has been emphasized by Emery, who at one time compared hairs to scales, and by Brandt, who compared them to teeth. Beard, however, was probably the first to point out the resemblance between teeth and hair. He found that the horny teeth of some cyclostomes arise in a manner somewhat suggestive of hair development. In these teeth, true enamel is replaced by horn, and odontoblasts are entirely lacking. Such horny teeth are degenerative according to Beard, and this suggested to him the possibility that hair, which in some measure partakes of the nature of cornified epithelium, might also be the product of a degenerative process. The idea, with some variation, has been elaborately developed by Brandt, who presents a kind of phylogenetic tree to show the relationship between scales, hair and teeth. The salient features of Brandt's theory are brought out in Figure 1. Despite the fact that the proponents of the view have been able to point out some interesting similarities between teeth and hair, on the whole their claims seem rather far fetched, and have received little support from other morphologists.

A different possibility as to the origin of hair is that suggested by Leydig who was impressed by certain resemblances between hair and cornified epidermal excrescences which appear on the heads of some male fish during the breeding season. There are grounds for homologizing these "pearl organs" with epidermal outgrowths that occur in occasional amphibians and even reptiles, but the majority of investigators have been inclined to regard them as more or less incidental by-products with no phylogenetic significance. The fact that "pearl organs" occur in only a few species, and those presumably not closely related to the main line of evolutionary descent, has weighed rather heavily against Leydig's view that they are the forerunners of hair.

Evidence that the hairs of mammals are derived from the sense organs characteristic of the skin in fishes and aquatic amphibians was presented in a series of papers by Maurer. This theory proved attractive from the first, and early gained the support of a number of leading morphologists, including Gegenbauer and Romer. The discussion, reported for the thirtieth annual meeting of German anatomists (1921),

shows that the theory is still favorably regarded in Germany. The strength of Maurer's claim lies in the remarkable similarity, almost identity, in the earliest stages in the development of cutaneous sense organs and hair. The accompanying illustrations (Figs. 2, 3, 4, 5 and 6)

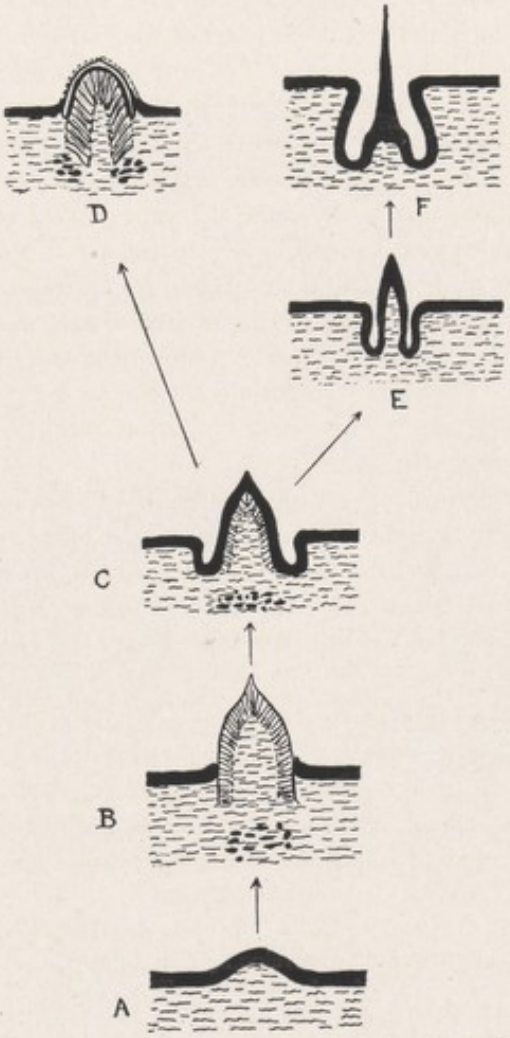

Fig. 1.—Diagrams illustrating the phylogenetic relationship between teeth and hair according to Brandt (from whose paper the figures are copied with slight modifications). *A*, hypothetical section through the skin of the presumed ancestral vertebrate; *B*, dermal tooth of a Selachian; *C*, dermal tooth of a pre-amniote showing inner bony and outer cornified elements; *D*, mammalian tooth (ready to rupture); *E* and *F*, late stages in the evolution of hair.

will serve to show the nature of these resemblances. The opponents of the view, among whom may be mentioned Keibel, Krause and Wieders-

heim, point to the deficiency of transitional stages between the lateral sense organs of amphibia and the hair of mammals, and also to the fact that, at least in contemporary amphibians, the whole cutaneous part of the lateralis system disappears when the animal leaves the water. A further objection that has been brought out against the view concerns

Fig. 2.—Section through the skin of a larval Triton. (Free-hand copy of a figure by Maurer.) The epithelial cells grouped around the one designated by *X* represent the earliest indication of a developing cutaneous sense organ in this amphibian.

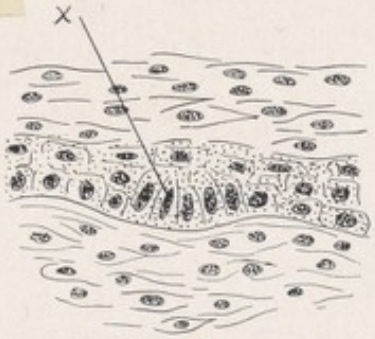

Figure 3

Figure 4

Figs. 3 and 4.—Early stages in developing hair of the mouse (Maurer). In Figure 3, *X* indicates the site of a future hair. The similarity between this and the sense organ rudiment shown in Figure 2 is the foundation on which Maurer builds his theory. Figure 4 shows a slightly more advanced hair rudiment on the right and one considerably more advanced on the left. The latter shows the characteristic epithelial down-growth with the beginning of a connective tissue papilla at the end.

the question of innervation. The ichthyopsidan sense organs from which Maurer would derive mammalian hair are invariably supplied by branches of cranial nerves, even when the sense organs themselves are situated far back on the trunk or tail. The hairs of mammals, on the other hand, have no such special nerve supply. In view of these rather

serious objections, it has been urged that while the resemblances which Maurer had pointed out do exist and are striking, they are after all to be regarded as incidental and not to be credited with any particular morphologic significance.

Most of the remaining theories as to the origin of hair connect it in one way or another with reptilian scales. One of these hypotheses (which nevertheless has some relationship to the views of Maurer in that it would derive hair from sense organs of lower forms) is that put forward by Oppenheimer, who sees in tactile spots of reptiles the probable source of hair. These tactile spots (Fig. 7) occur on the

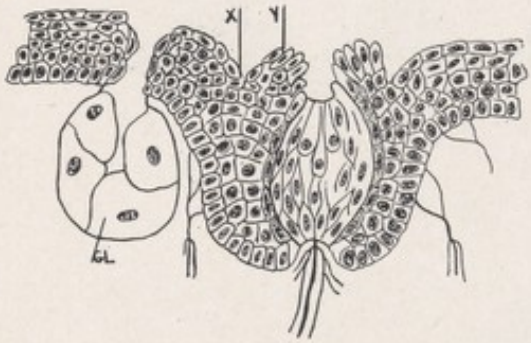

Figure 5

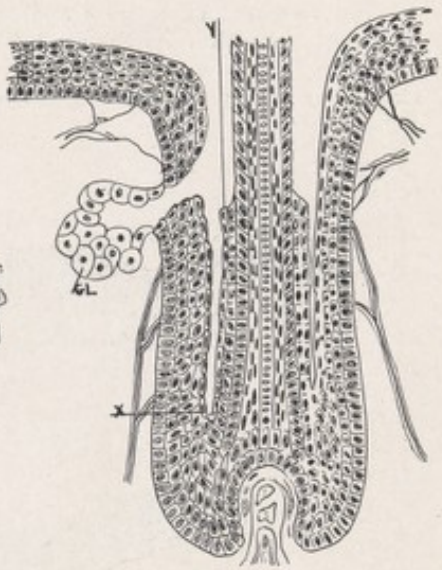

Figure 6

Fig. 5.—Schematic vertical section of a cutaneous sense organ of Triton (Maurer).

Fig. 6.—Similar section of mammalian hair. (Maurer.) The two figures are presented to show Maurer's view as to the homology of hair and cutaneous sense organ. The hair shaft represents the sense organ itself, the inner root sheath, *Y*, is the mass of cells shown at *Y* in Figure 5, and the outer root sheath is the product of a further invagination of the surface epithelium at *X*. This invagination carries the mouth of the cutaneous slime gland, *GL*, down into the follicle, where it becomes the sebaceous gland of the mammal.

scales, mostly toward their free distal ends (Fig. 10). Histologically, they bear a considerable resemblance to the earliest stages in a developing hair. While each spot has a rather constant topographical relation to a scale, it is not, strictly speaking, to be regarded as a part of the scale. More recently, small bodies, which in all probability are homologous with these tactile spots, have been discovered in mammalian skin along with the hair which they in no sense replace. If this discovery and its

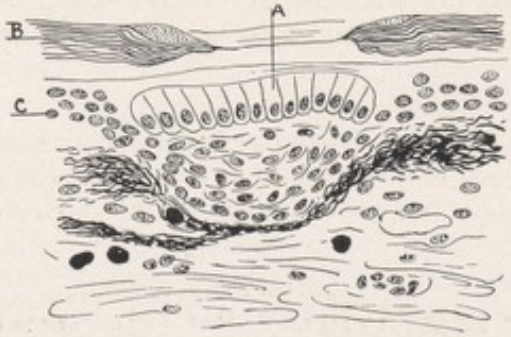

Fig. 7.—Sense organ on a scale of the lizard Hatteria. (Oppenheimer.) A layer of cylindrical epithelium (*A*) beneath a modified area of the stratum corneum (*B*) rests upon a thickening of the stratum germinatinum (*C*). The latter has some resemblance to an early stage of hair growth.

Figure 8 Figure 9

Figure 10

Figs. 8, 9 and 10.—Three stages in the development of reptilian scales. (Maurer.) In Figure 8 are shown slight elevations of the connective tissue beneath a practically unchanged epithelium. In the stage represented by Figure 9, definite elevations have been produced by extensive prolification of the connective tissue, the epithelium remaining practically unchanged. Figure 10 shows a later stage in which the connective tissue core of the scale is prominently indicated. An epithelial sense organ is shown near the tip. Figures 8 and 9 are from an embryo of Platydactylus. Figure 10 is from an embryo of the glass snake (Anguis).

interpretation are fully substantiated, it will probably prove fatal to the view that hairs are derived from the scale-borne sense organs of reptiles.

HAIR, FEATHERS AND SCALES

For those who have not been inclined to postulate a primary sensory function for hair, one of the simplest and at the same time most plausible views is that hair, feathers and scales are morphologically equivalent.

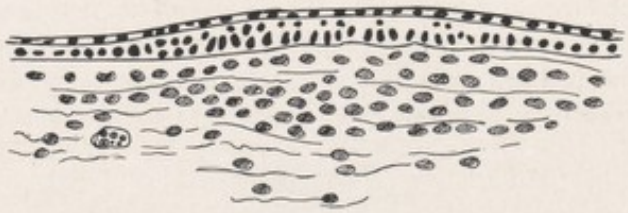

Fig. 11.—First stage in development of a feather in the pigeon. (Davies.) The site of the future feather (down) is indicated by the aggregation of mensenchymal nuclei which precedes any appreciable alteration in the epithelium. Compare with Figures 12 and 13.

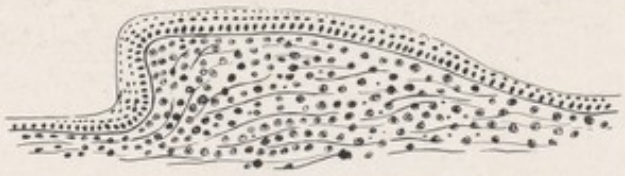

Fig. 12.—Later stage in the development of a feather. (Davies.) Growth manifestations are confined chiefly to the connective tissue.

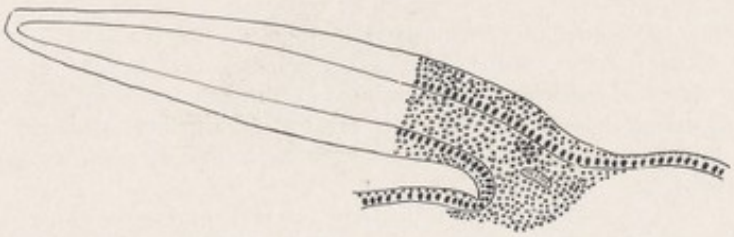

Fig. 13.—A young down feather. (Davies.) It is to be noted that the connective tissue papilla extends throughout the whole length of the shaft.

It may be objected, however, that there is little plausibility in the idea that the small and numerous hairs should individually represent either feathers or scales, which are relatively much fewer and of far greater size. More significant is the objection based on easily demonstrable embryologic grounds that hairs (except some spines) and feathers develop in a different manner. In the former, development is initiated

by the epithelium; in the latter, by the connective tissue. These differences are brought out in the illustrations (Figs. 3-6, 8-10 and 11-14) showing early stages in development of the cutaneous appendages. Further difficulty is experienced in attempting to homologize the parts of a hair with the parts of a feather. Poulton's suggestion that the hair shaft represents the axial part of a feather, the inner root sheath the appendicular part, is based on the belief that the essential elements of both hair and feathers must have been present in the reptilian ancestors of birds and mammals. The scales of these ancestral forms are pictured as covered with a felted fibrous growth which aided materially in the maintenance of a relatively constant body temperature, and may even have been one of the requisites for the development of

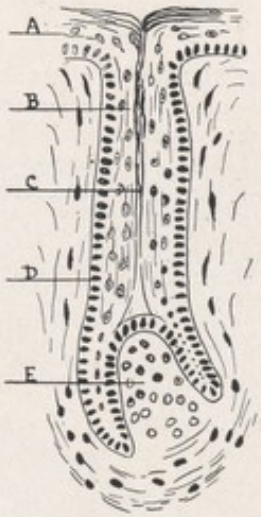

Fig. 14.—Formation of permanent feather germ after shedding of the first down. (After Davies, with slight modifications.) *A*, surface epithelium; *B*, horny layer of follicle; *C*, follicular canal through which the feather will grow; *D*, germinal layer of follicle; *E*, papilla. The general similarity of the feather in this stage to a developing hair in its follicle is superficially rather pronounced.

homothermic animals. How such primitive scales might have been modified into feathers in one line of descent and into hairs in another line is indicated diagrammatically in Figures 15 and 16, which are copied from Poulton's sketches.

While Poulton did succeed in pointing out a possible homology between a part of the feather and a part of the hair sheath, he did not adequately account for the difference between the vascular medullary pulp of the feather and the purely epithelial medulla of hair. Even if the latter difficulty is explained away on the ground that feather pulp

is really a greatly elongated papilla, while the medulla of the hair represents the site of a former papilla, the fundamental difference in the mode of development of the two structures remains as an obstacle which may be regarded as insurmountable.

In view of these serious difficulties in the way of considering hairs as individually equivalent to typical feathers or scales, the possibility has been suggested that each hair represents only a part of the scale.

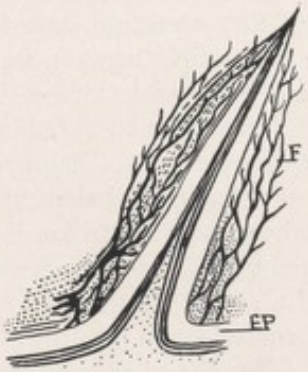

Fig. 15.—Schematic representation of hypothetical primitive scale and, in a measure, a hair of Ornithorhynchus. (After Poulton, slightly modified.) *EP*, surface epithelium; *F*, superficial feltwork which is assumed to be homologous with the vane of a feather.

Fig. 16.—Differentiation of the primitive scale in the direction of a typical hair, and corresponding to an early stage of a hair in Ornithorhynchus (Poulton). *EP*, surface epithelium; *EX*, invagination of epithelium forming outer epithelial sheath of the follicle; *F*, the original superficial feltwork corresponding to the inner epithelial sheath; *P*, papilla.

This is the view advocated by Keibel, who maintains that both hairs and feathers are to be homologized, not with the whole scale, but with special parts of it. Whether or not hairs and feathers correspond to comparable parts, Keibel is unable to decide. Feathers arise from, or in the middle of, certain scales on birds' legs (some pigeons and fowls), and hairs have a similar origin with reference to the scales in

some of the armadillo group of mammals. If these avian and mammalian scales could be definitely homologized with the scales of reptiles, then the simultaneous presence of the greater part of a scale and the feather or hair that grows from it would lend strong support to Keibel's view, but unfortunately for the theory, there is doubt as to the homology of the particular scales involved in each case.

Not wholly inconsistent with the view of Keibel is that of Pinkus, the discoverer of the so-called hair disks which may be seen in human skin. These disks, when they occur, are invariably placed immediately behind the hairs in the acute angle between the oblique hair shaft and the skin. Such disks are in general more easily demonstrable macroscopically than by any microscopic means, but there seems to be no question as to their actual existence. They are said to have a special nerve supply and a constant topographical relation to the hairs. On the other side of the hair, where the shaft makes an obstuse angle with the skin, there is often found a thickening of the dermis which has many of the characteristics of a scale. These relations led Pinkus to regard the latter thickening as equivalent to the base of the scale and the hair disks as the tactile spot (Figs. 7 and 10), which Oppenheimer had supposed to be the origin of the hair itself. According to Pinkus, the whole hair region ("hair district") includes the scale rudiment behind, the hair with its appendages in the middle and the hair disk in front. All of these together occupy the site of a single reptilian scale with its tactile spot. If this is correct, the mammalian hair represents a new formation, since in the scale the spot which corresponds to it is wholly undifferentiated. Such a view requires the assumption of descent from some form with excessively small and numerous scales or a tremendous subsequent multiplication of their morphologic equivalents.[1] In any event, there is need of further comparative and embryologic study of the hair region before a final evaluation of Pinkus' theory can be reached.

ARRANGEMENT OF HAIR AND SCALES

As already indicated, there has been some hope of getting evidence on the origin of hair through a study of the arrangement of individual hairs. Maurer, for example, attempted to connect the appearance of hairs in rows with the fact that the cutaneous sense organs of amphibians are also in rows. According to the theories that hairs are derived from scales, or parts of scales, the arrangement should be that of the original scales themselves. The most extensive work along these lines has been done on those mammals in which there are regions in which both hairs and scales are present, as on the tail of the rat. It is not fully established that even these mammalian scales are homologous with the scales in

1. This aspect of the subject is discussed more fully in Am. J. Anat. **36**:47-68, 1925.

reptiles, but there is a rather widespread belief that they are. In such regions it is common, as pointed out by de Meijere and others, to find a group of three, or less often five, hairs protruding from beneath the free margin of each scale. In these groups, the middle hair is usually the largest (Fig. 17). Similar groups of one large and two small hairs are of common occurrence, even in regions in which there are no scales. This fact suggests that the observed groups indicate the sites of ancestral scales which have disappeared. On such an assumption, hypothetical scale patterns have been marked out on the human fetus and on other animals. But interesting as these relations are in themselves, they have only added to our uncertainty as to the origin of hair. It has been maintained, on the one hand, that promammalian scales early became differentiated into two types, one of which was only slightly modified from the reptilian form, while the other first became greatly reduced in size and then later converted into hair. It might be expected that these small scales would be overcrowded and brought into subordinate position

Fig. 17.—Arrangement of hair and scales on the tail of the opossum. (Based on figures from de Meijere.)

with reference to the larger ones, hence the observed position of hair germs beneath the free margin of persistent scales. On the other hand, some of the adherents to Maurer's theory have claimed that as sense organs became converted to hairs no downgrowth of the bulb could take place over the thick scale plate, and consequently hairs could only come into being in the soft places between the scales. This would account for the topographical relation of scales and hair groups. In the light of these various possibilities, it seems improbable that further study of hair arrangement will by itself throw much additional light on the actual phylogenetic origin of hair.

If it had turned out that a hair is morphologically a tooth, a scale, or a sense organ, that fact might have been of practical as well as theoretical importance, in that there would then have been a firmer foundation on which to base further studies of hair growth and function. But as it is, we are forced to admit that every attempt to explain the

phylogenetic origin of hair has failed. If it be assumed that hairs are essentially scales, then how may we account for their striking resemblance to sense organs? Conversely, if they be thought of as modified sense organs, may we ignore their resemblance to scales and teeth? The difficulty is not wholly avoided by assuming that hairs are new formations or structures without homologues in lower forms, for the student who makes such an assumption has to face most of the difficulties encountered by the supporters of each of the other views, since he must explain not one or two sets of resemblances, but all the similarities that have been pointed out by proponents of the various theories. This kind of uncertain and contradictory evidence from phylogenetic and morphologic investigations is not uncommon in other fields of research than that on hair, and might well lead to the suspicion that the fundamental trouble is inherent more in the philosophy of morphology than in the technic of acquiring pertinent morphologic data.

THE CURRENT MORPHOLOGIC CONCEPTS

For this reason, it may not be out of place at this point to consider some of the underlying postulates of morphology with reference to their bearing on hair. It would probably be generally admitted that the basal concepts of morphologists and, for that matter, of all classes of students of biology, are necessarily ill-defined. So long as life itself is unexplained, there must be at least one undetermined factor in every vital process, and consequently in the development of every structure. But, in general, just as the systematist feels that the only true classification is based on descent, so the morphologist considers true homology as likewise determined by relationship. Homologous structures are those that, phylogenetically, have been derived, the one from the other, or both from a common prototype. This concept is fundamental in practically all speculations on phylogeny. Equally important, especially when embryologic studies are involved, is the concept often referred to as the "biogenetic law," which postulates that in a general way the developing individual, or part, passes through phases which correspond to successive stages in the phylogeny of the species, that every individual recapitulates, in epitomized form, the morphologic history of past generations, in short, that "ontogeny repeats phylogeny." A further assumption of no small importance is that transitions have been made gradually, if not in direct response to changing environment, at least as an indirect result of it. Probably some such group of postulates has been behind every attempt to trace phylogenetic relations.

How far these postulates are valid may be open to question. If the preceding paragraph has been successful in indicating with reasonable accuracy the prevailing point of view of morphology, it will have to be

admitted that the general outlook has been little influenced by the accumulated data from the last thirty years of work in experimental embryology and genetics. And yet there can be no doubt that the findings in the younger sciences should be of great value in elucidating the unsolved problems of the older ones. But for reasons which it might not be hard to find, morphology, instead of being stimulated by modern developments, has been more or less paralyzed. Consequently, nearly all work relating in any way to the phylogeny of hair has been carried out along lines established long ago. Since no recent morphologist has attempted to bring the philosophy of his science up to date and to supply new working hypotheses, there can be little hope of doing more here than to offer a few suggestions that may help to harmonize the apparently conflicting data that have been accumulated in the various attempts to solve the riddle of hair phylogeny.

In the older concepts of morphology, there is a tendency to take into consideration only gross structure, with little emphasis on germ plasm. It is, of course, well known that the parts of an individual develop not from the corresponding parts of the parent, but that each and every part in both parent and offspring is the product of interacting forces, which come into play during development from an undifferentiated ovum originally lacking in all the morphologic characteristics of the adult. Since it is only in a figurative sense that one may speak, for example, of the hair of a child as derived from that of its parent, so it is only in a still more figurative sense that one may speak of the hair of mammals as derived from structures in lower vertebrates. What will be generally agreed to is that the similarity in the hair of parent and child is due to similarity in the forces which have resulted in the production of hair in the two cases. Such of these forces as are inherent in the germ plasm are the hereditary hair determining factors. It is theoretically possible that an individual's hair might in some way react on the hair determiners in his germ plasm, and thus affect succeeding generations, but phenomena of this sort have not been demonstrated with certainty, and there is a considerable body of opinion which holds that they do not exist. In any event, the development of a particular individual is conditioned by the determiners in the germ plasm from which he arose, and focusing attention on this fact may lead to a different outlook from that gained by concentrating wholly on morphologic structures themselves.

HOMOLOGIES RELATIVE, NOT ABSOLUTE

Since morphologic structure is regulated by many factors, some of which may vary or be replaced by other factors, homology must in general be looked on as relative and not absolute. Thus in the field in

which we are interested there are, as has been pointed out, resemblances between hairs and teeth. In addition to these morphologic resemblances, those who would homologize the two structures might well have pointed out that certain developmental disturbances in the pilary system are associated with disturbances in tooth development. These structural and functional similarities are probably not without meaning, nor, on the other hand, are the structural and functional resemblances between hair and feathers. In the light of present information, what that meaning seems to be is that some of the factors responsible for hair production are also involved in the formation of teeth, and, likewise, that some of the hair determining factors are effective in producing feathers or scales. From this point of view, structures are homologous with each other in proportion to the number of comparable germinal factors by which they are conditioned, and it is quite conceivable that a structure may be at once homologous to a greater or less extent with two or more structures which are not homologous with each other. The acceptance of some such view in relation to hair would greatly reduce the number of seeming paradoxes that have been brought out in the controversy over its phylogeny.

Turning now to the "biogenetic law," data which indicate that it should be considered with caution are not lacking. It must be admitted that in a general way developing embryos pass through stages which in certain respects are more or less remotely suggestive of what may be presumed to have been ancestral forms. While this is not the place to enter into an extended discussion of the theory of recapitulation, it may be recalled that the "reminiscences" are for the most part hazy and often do not occur. This is particularly true of structures that appear late in development. As an example, the terminal segments of the digits in almost all mammals have hair, as no doubt they did in the ancestors of man, but they now lack it in the adult human being and in all stages of his development as well. In other words, the hairless condition of the terminal part of the digit is attained without showing any evidence of recapitulation and the same is true of the middle segment in many persons. Likewise, there can be little doubt that the appearance of extra digits is not a reversion, but something new. Nevertheless, so far as evidence is available, it may be stated that in the embryology of polydactylous forms, recapitulation fails to appear, since one does not find first the normal number of digits indicated and later the supernumary ones, but instead the full complement from the beginning. Without multiplying cases further, it may be suggested that the degree of "recapitulation" depends wholly on the time at which modifying or inhibiting factors come into play. Since the evidence from both plant and animal genetics seems to be that such factors may become effective at any

stage, it might be expected that "recapitulations" would show wide variation in completeness and not infrequently fail to appear. On such grounds, one could not feel secure in arguing that because two structures are not altogether similar in their early stages, they are of necessity not homologous. Applying this idea to our present problem, the lack of agreement between the earliest stages of the hair and of the scale need not prove an insurmountable obstacle to regarding the two as partly homologous.

Another point which cannot be ignored is that we have learned of late that a single mutation in one of the factors responsible for a structure may profoundly modify its morphologic appearance, so that rather wide gaps may occur between a parental state and the henceforth hereditary filial condition. So far as has been determined, even the most marked mutations bear no direct relation to environmental factors. While it may properly be objected that most of the data on mutations have been furnished by domesticated forms, and that all the requirements for a "good" new species have rarely been met by any artificially developed strain, the possibility of such origin in nature is strongly suggested and calls for caution in accepting a view that is not in accord with such facts as are known. In all essential respects, the problem of the origin of species and the origin of phyla is one and the same, and there would seem to be some scientific support for the suspicion that in certain classes of structures, now different in form but identical in origin, transitional stages may never have existed.

If, then, we may think of structure as the expression of interacting factors, which may individually vary by much or little, if we may think of the "biogenetic law" in terms of germ plasm rather than of gross anatomic form, and accept homology as relative and not absolute, it may still be possible to harmonize facts which seem inconsistent in the light of a system of more rigid morphologic concepts. We cannot as yet, however, present a clear picture of the phylogeny of hair. Perhaps no such picture is possible, but the subject affords an attractive field for future research. For the present, we must content ourselves with regarding mammalian hair as akin to lateral line organs, tactile organs of reptiles, placoidal scales, teeth, claws, dermal scales and feathers. It is more closely related to some of these structures than to others, but with none of them is it fully homologous.

CHAPTER II

THE HAIR OF MAMMALS

All kinds of mammalian hair have sufficient similarity to justify the belief that they have had a common phylogenetic origin. Whether hairs were originally protective or sensory has frequently been discussed, but there is considerable likelihood that at first they were neither wholly the one nor the other. Among living mammals, the protective function of hair is obvious, and at the same time there can be no doubt that many hairs, particularly the highly specialized tactile ones, play an important rôle in sense perception. The wide gaps that exist, for example, between movable sensory hairs and fine down or coarse spines are bridged by intermediate forms. That one or another of the various types of hair represents the persistence of an unmodified remnant from the covering of an early mammalian prototype, is not supported by adequate evidence. In the light of what knowledge we have, it seems more probable that the earliest mammals, or their immediate ancestors, possessed cutaneous appendages related to the integumentary organs of several other classes of vertebrates, but having in generalized form many of the characteristics of hair as we now know it. From some such primitive hair, it may be presumed that the more or less diversified types which we find today have been evolved, sometimes side by side in the same line of descent, sometimes in different lines.

DEVELOPMENT OF HAIR

Hairs are essentially highly specialized epidermal outgrowths, characterized by marked keratinization, and usually containing pigment considerably in excess of that found in the surrounding unmodified epithelium. So far as embryologic studies have been able to determine, their development generally begins with a thickening of the ectoderm, followed by a modification of the subjacent mesenchyme (Figs. 3 and 4). The ectodermal thickening grows obliquely downward and, for the most part, forward, to a depth roughly proportional to the size of the hair to be produced. Its basal portion gives rise to the hair bulb, the remaining portion to the epithelial part of the follicle and to the accessory glands. The mesenchyme forms a papilla projecting into the end of the hair bulb, the surrounding connective tissue part of the hair follicle and the arrector pili muscles. According to Fibroes, it also con-

tributes collagenous fibers to the formation of the hair itself. In a few cases (e. g., specialized quills of the European hedgehog and sensory hairs of the sheep), it has been reported that future hairs are foreshadowed by concentrations of mesenchymal nuclei which appear simultaneously with, or even preceding, the occurrence of ectodermal thickenings. This raises a question as to where development of the follicle is actually initiated, and whether or not it is always dependent on the same factors. Although this is an important consideration from the point of view of morphology of the hair, it has not yet been possible to settle the matter in a satisfactory manner.

The hair shaft is produced within the follicle by a multiplication of cells in the hair bulb. As these cells increase in number they are pushed upward in the core of the follicles, which in turn tends to disintegrate, forming a canal. At the same time, the young hair cells assume their definitive arrangement in the shaft and become cornified. Elongation of the shaft is effected through the continued addition of new cornified cells from below. After it is once well started, growth of the hair is generally more or less uniform and continuous until the definitive length has been nearly attained. At the beginning and toward the end of a growth period, the number of cells entering into the formation of the shaft for a unit of length is less than during the intermediate period, as indicated by the fact that nearly all hairs are pointed at their tips and, when full grown, narrowed toward the roots. While some hairs are, through the greater part of their length, approximately cylindrical, giving a circular cross section, deviations from this form are common, the most frequent involving a slight flattening of such nature as to give the hair an elliptical outline in cross section. The extreme deviation is met in the flat, bilaterally symmetrical hairs of *Ornithorhynchus.*

Since the hair follicle generally grows obliquely forward under the epidermis, the tip of the hair most commonly points backward or downward. But this is true only in a general way, since there are many variations and even reversals in the direction of the hair stream in different animals (Fig. 18). The direction of hair in mammals, including man, has been studied extensively by Walter Kidd, who sees in the hair stream an indication of physiologic response to such external factors as pressure and gravity. The supposed transmission of these acquired relations to the offspring he designates as "use inheritance."

When the hair has attained its full size, cells in the matrix of the bulb cease to divide, and the bulb itself becomes cornified. The connective tissue papilla partially atrophies, and a "resting" stage ensues, toward the end of which by multiplication of undifferentiated cells, the

hair bulb is pushed toward the surface. Ultimately a new bulb forms, possibly through proliferation from the "epithelial bed" in the side of the follicle, the connective tissue papilla regenerates, and another hair is developed. The old hair, if it has not already fallen, is generally crowded out by the new one. The duration of this cycle varies with different hairs and with different animals. In many cases a tendency for hairs of the same kind to pass through the cycle simultaneously is evidenced by seasonal moults.

STRUCTURE OF HAIR

A generalized hair in its follicle is represented in Figure 19. The hair shaft itself consists of cuticle, cortex and medulla, the latter frequently being absent. When the medulla is not present, its usual position is marked in a few instances by cavities extending for some

Fig. 18.—A lioness, to show a relatively simple plan of hair arrangement (Kidd). Arrows with single barb represent the direction taken by hair that retains its presumed primitive arrangement; those with extra barbs indicate regions in which a change in direction has taken place.

distance along the shaft, but usually hairs without medulla have a solid cortical core. Rarely, if ever, does the medulla extend the full length of a hair. It is ordinarily absent for some distance back from the tip and frequently again near the root. In the shaft of the hair, the medulla may be interrupted for short distances, through which the hair consists of cuticle and cortex alone.

The cuticle is a thin, unpigmented layer composed of more or less overlapping scales whose free margins are directed toward the tip of the hair. Within the follicles these scales interlock with the cuticle of the inner hair sheath, the scales of which point in the opposite direction and thus help to hold the hair securely in place. In general, cuticular scales are relatively smaller in coarse hairs. Even in the same hair, an inverse relation between the size of the scales and the diameter of the shaft is often apparent in passing from one end of the hair to the other. Two hairs standing side by side but of different size may show

a marked difference in the character of their scales. Nevertheless, while the form of the scale may be considerably influenced by the size of the hair shaft and possibly of other mechanical factors, there are characteristic specific differences, as Hausman has pointed out in a recent series of articles. In some cases, each scale completely surrounds the hair, the successive scales fitting over each other like a series of hollow

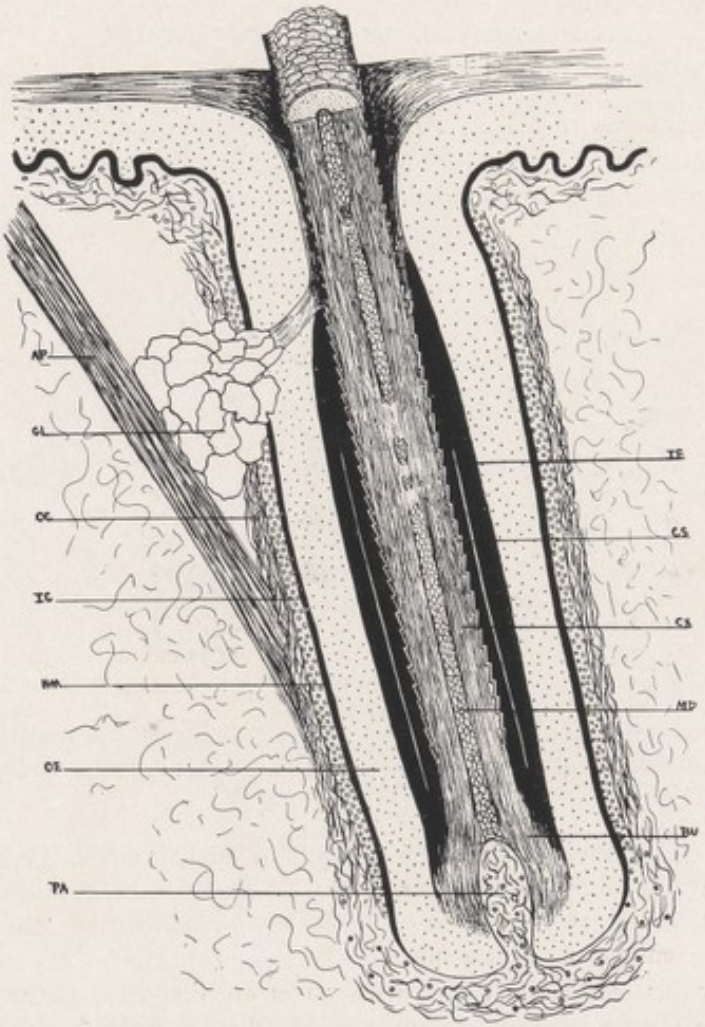

Fig. 19.—Diagram of a hair in its follicle. The follicle and the part of the hair beneath the surface are split longitudinally. Contacts between adjacent layers are suggested. *AP*, arrector pili muscle; *GL*, a sebaceous gland; *OC*, longitudinal fibers of the connective tissue sheath; *IC*, circular fibers of connective tissue sheath; *HM*, hyaline membrane; *OE*, outer epithelial sheath; *PA*, hair papilla; *IE*, internal epithelial sheath, divided through part of its extent into outer (Henle's) and inner (Huxley's) layers, the latter with cornified scales which articulate with those of the hair cuticle; *CS*, cuticular scales of the hair shaft; *CX*, cortex of the hair; *MD*, medulla of the hair; *BU*, hair bulb.

truncated cones; but more frequently individual scales do not reach all the way around the hair shaft, in which case they are imbricated in a manner not unlike the arrangement of scales on a fish. The genetic relations of the several classes of scales is a matter that needs further study. The following classification is that employed by Hausman, and the accompanying illustrations are from his papers.

CLASSIFICATION OF CUTICULAR SCALES

1. *Imbricate.*—Individual scales not completely surrounding the shaft, classified according to the free margin as: ovate (Figs. 20 and 21; *a* and *i*), acuminate (*b*), elongate (*c*), crenate (*d*) and flattened (*e*).
2. *Coronal.*—Individual scales completely encircling the hair shaft, classified according to the free margin as: simple (*f*), serrate (*g*) and dentate (*h*).

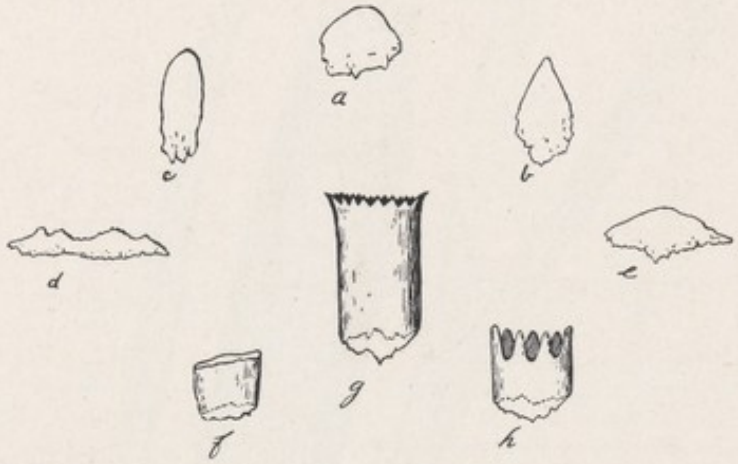

Fig. 20.—Types of cuticular scales. (After Hausman.) *a-e*, imbricate; *f-h*, coronal; *a*, ovate; *b*, acuminate; *c*, elongate; *d*, crenate; *e*, flattened; *f*, simple; *g*, serrate; *h*, dentate.

The cortex, constituting the main body of the hair shaft, is composed essentially of compact keratinized cells which have been compared to those of the stratum corneum of the skin. When isolated, these cells are found to be for the most part fusiform or elongated. According to Friboes, they are intermingled with fibers of connective tissue origin. The cornification is so complete that in the absence of pigment the cortex is usually translucent to a marked degree. Pigment, however, is commonly present, appearing in several forms that, according to Gortner, may probable be grouped in two general classes, the melanoproteins, which are acid-soluble, diffuse and nongranular, and the acid-insoluble melanins, which appear in the form of definite granules. Either one or both may be present in a given hair, but the granular form is not often lacking.

The medulla is far less dense than the cortex. Its cells are fewer, larger and more loosely held together. Pigment is often present. As a rule, among the medullary cells there are real or virtual spaces filled by replaceable gas, probably in most cases air. Such spaces are not often directly demonstrable except by optical effects, but in a favorable specimen it is easy to watch a film of fluid make its way along the medulla of a hair placed in a suitable solution under the lens. The medullary cells

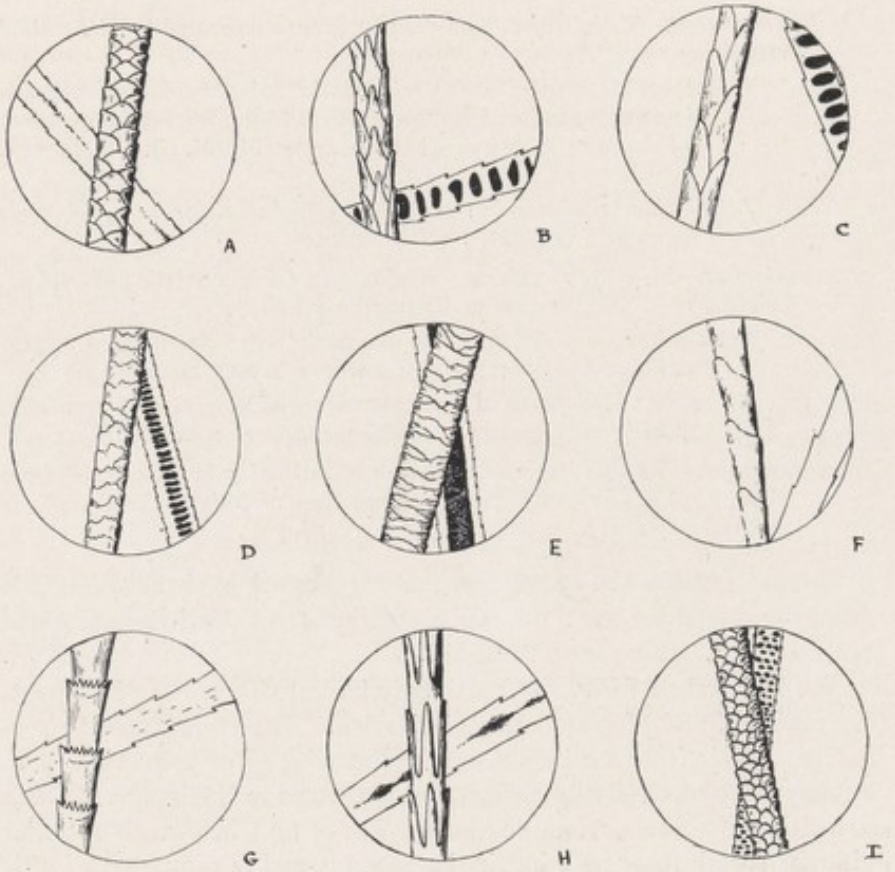

Fig. 21.—Representative mammalian hairs. (After Hausman.) In each circle one hair is shown in surface view, the other in optical section. The magnifications are not all the same. *A*, civet, showing ovate imbricate scales and a medulla apparently on the borderline between continuous and fragmental; *B*, star-nosed mole, scales acuminate imbricate, medulla discontinuous and intermediate between ovate and flattened; *C*, golden mole, scales elongate imbricate, medulla ovate discontinuous; *D*, camel, scales crenate imbricate, medulla flattened discontinuous; *E*, Tragulus, scales flattened imbricate, medulla nodose (?) continuous; *F*, Porto Rican bat, scales simple coronal, medulla lacking; *G*, intermediate bat, scales serrate coronal; *H*, European otter, scales dentate coronal, medulla elongate discontinuous (?); *I*, kangaroo rat, scales ovate imbricate, medulla of the ovate, compound discontinuous type.

proper tend to be grouped along the central axis of the hair, where they may form either a continuous or an interrupted core. In some cases, there may be several parallel or anastomosing and mostly discontinuous columns of medullary substance. In such instances, there need be no medulla in the actual center of the hair. The classification employed by Hausman in dealing with fur hair is essentially as follows:

CLASSIFICATION OF MEDULLAS IN FUR HAIR

1. *Discontinuous.*—Medullary cells in discrete groups separated by "interstitial medullary spaces."
    1. Simple: Groups of medullary cells in a single column. Depending on the ratio of the longitudinal to the transverse diameter of the masses, they may be: (*a*) ovate (Fig. 21, *C*), (*b*) elongate, (*c*) flattened (Fig. 21, *D*).
    2. Compound: Groups of medullary cells in two or more columns: (*a*) ovate (Fig. 21, *I*), (*b*) flattened.
2. *Continuous.*—Medullary column continuous (characteristic of spines, bristles, most other coarse and many finer hairs).
    1. Homogeneous: Diameter of the medullary column more or less uniform except at the ends, where it may taper.
    2. Nodose: Diameter of the column variable, giving a somewhat moniliform appearance to the medulla as a whole.
3. *Fragmental.*—Medulla interrupted irregularly, differing in this respect from discontinuous types of medullas where the "medullary chambers" are regularly disposed.

Hausman makes the suggestion that the evolution of the medulla is "from the discontinuous through the continuous to the fragmental and finally . . . to no medulla at all."

The hair follicle (Fig. 19), as already indicated, consists of elements of ectodermal and of mesodermal derivation. The former closely surrounds the hair from the bulb nearly to the point of exit from the skin, and may be subdivided into an inner and an outer epithelial sheath, both of which are more or less continuous above and below. The outer epithelial sheath rests on a hyaline membrane, and is composed of cells which are comparable to those of the stratum germinativum in unmodified epithelium. The inner epithelial sheath is immediately surrounded by the outer, from which it is not always clearly distinguishable. Toward the bottom of the follicle, it may be subdivided into two concentric laminae, the outer being designated as Henle's layer, the inner as Huxley's layer. Resting on Huxley's layer and immediately in contact with the hair is a thin cuticle composed of scales, whose free margins point downward and interdigitate with those of the hair cuticle.

No wholly satisfactory comparison between the epithelial layers of the follicle and the surface epithelium has been made, but it has been

pointed out that if the skin were stretched so that the hair bulb would be brought to the surface and the follicle spread out flat, a gradual modification of the epithelium as it approached the hair bulb would become apparent. Near the periphery of the zone represented by the lining of the original follicle, a subdivision of the stratum germinativum into layers representing the outer (deep) and inner (superficial) hair sheaths could be noticed. Somewhat nearer the follicle, the latter would in turn be found to subdivide into a deeper layer of Henle and a more superficial layer of Huxley. Most superficial of all, in a restricted region immediately around the hair bulb, would be a zone of cornified cuticular scales which would now point in the same direction as those on the hair, with which they would form a continuous series. Pushing this comparison still further, the cortex of the hair shaft would seem to correspond to the upper part of the stratum germinativum and possibly the inner hair sheath, while the medulla would represent the lower part of the stratum germinativum, corresponding perhaps to cells of the outer hair sheath. "Prickle-cells like those in unmodified epithelium are found in the medulla of the hair." Such homologies for the parts of the follicle and its contained hair cannot be accepted at present without reservations, especially since there is a good deal of evidence that the inner sheath really grows up from the region of the bulb; but if subsequently established, they may prove of practical significance.

The dermal sheath of the follicle consists of an outer layer of connective tissue fibers arranged longitudinally, an inner layer of circular fibers, and a basement membrane on which the epithelial cells of the outer hair sheath rest, or from which they are separated only by a hyaline membrane of their own production.

The correspondence between the connective tissue around the hair follicle and that beneath the unmodified epithelium is fairly close. The outer layer may be compared to the stratum reticulare and the inner layer to the stratum papillare, except that around the hair follicle no papillae are found.

APPENDAGES OF THE HAIR FOLLICLE

Closely associated with the hair is a sebaceous gland which develops from the same epithelial rudiment and empties into the follicle near the surface, its oily secretion often filling the depression around the root of the hair and ascending by capillarity along the shaft. While a few sebaceous glands occur in places where there are no hairs, as on the margin of the lip, there can be little doubt that there is an intimate developmental and functional relation between the two structures. The true sweat glands have also been thought to have an intimate relation to hair. This idea is based on both morphologic and embryologic

grounds. Jerina quotes Römer to the effect that each hair group has only a single sweat gland. The same view is shared by several others who have been led to the opinion by topographical relations found particularly among monotremes. Diem has shown that in many cases sweat glands develop as outgrowths of the hair follicles. Whatever the relations between hair and sweat glands may be from a phylogenetic and embryologic point of view, there is evidence that they have a certain amount of functional correlation.

One other characteristic structure in connection with most hairs is the arrector pili muscle. This consists of a few smooth fibers that lie in the corium and are inserted on the under side of the hair follicle below the sebaceous gland. Thus located, their contraction pulls the follicle into a more vertical position and causes the hair to stand on end. These little muscles are under the control of the sympathetic nervous system. In some places, they are lacking.

CLASSIFICATION OF HAIRS

The foregoing paragraphs are intended to present a generalized picture of the anatomy and relations of the ordinary type of hair. There are many deviations from this form associated with specialization in various directions. Unfortunately, no wholly satisfactory classification of hairs has been proposed. This is, no doubt, largely due to the complete series of intergrades that can be found between any two hairs, however different they may appear when compared with each other. The accompanying rough tabulation is included in order to afford a general survey of the varied characteristics of hair.

The tactile hairs that occur in any individual animal are few in number and their distribution is limited for the most part to lips, cheeks and supra-orbital regions. Less commonly they occur on the elbows and knees and even on the back, sides and flanks. Ontogenetically, they are the first hairs to appear and are often the largest hairs of the body. They have deep-seated as well as specialized follicles. Some of them, such as those on the upper lip of the cat, establish connections with the subjacent striated musculature and come under voluntary control. Others are nonmotile. Hairs in the same region of different species of animals may be motile in one case, in the other, not.

The follicle of a tactile hair is shown in Figure 22. The outstanding characteristic of such a follicle is the presence of numerous small or somewhat enlarged blood sinuses in the inner layer of the connective tissue sheath and outside the hyaline membrane. These sinuses, with their walls and interstitial substance, form a little mass of true erectile tissue surrounding the root of the hair and designated as the corpus cavernosum or corpus spongiosum pili. A large individual sinus in

the upper part of the body of the corpus spongiosum and encircling the hair root occurs in some forms. This is the "circular sinus." By increasing the turgescence of the follicle, not only is the hair itself made a more efficient conductor of pressure from light contacts, but the nerve endings are also placed in a more favorable position to pick up these impulses. The corpora spongiosa are presumably entirely under the control of the sympathetic nervous system. There is, in addition, a rich sensory nerve supply to the follicle itself, especially to its inner layer, where there are medullated fibers which are said to terminate in small end-organs called Merkel's corpuscles, and nonmedullated fibers which have free terminations (Fig. 23). These structural and functional characteristics make the tactile hairs sense organs of great delicacy, although their importance to the well-being of their possessor has often been greatly exaggerated.

TYPES OF MAMMALIAN HAIR

1. Hairs with specialized follicles containing erectile tissue. Large, stiff hairs that are preeminently sensory. They have been variously designated as, feelers, whiskers, sensory hairs, sinus hairs, tactile hairs, vibrissae, etc. They occur in all mammals except man, and are grouped by Botezat essentially as follows:
   - (1) Active tactile hairs—under voluntary control.
   - (2) Passive tactile hairs—not under voluntary control.
     - (*a*) Follicles characterized by a circular sinus.
     - (*b*) Follicles without a circular sinus.
2. Hairs with follicles not containing erectile tissue. The remaining types of hair, most of which are more or less defensive or protective in function. In many cases, the follicles have a good nerve supply endowing the hair with a passive sensory function as well. These hairs are grouped here according to their size and rigidity.
   - (1) Coarser, more or less stiffened "overhair."
     - (*a*) Spines. Greatly enlarged and often modified defensive hairs, quills.
     - (*b*) Bristles. Firm, usually subulate, deeply pigmented and generally scattered hairs. "Transitional hairs" (Botezat), "Leithaare" (Toldt), "protective hair," "overhair." This group also includes mane hairs.
     - (*c*) Awns. Hairs with a firm, generally mucronate tip but weaker and softer near the base. "Grannenhaare" (Toldt), "overhair," "protective hair."
   - (2) Fine uniformly soft "underhair."
     - (*a*) Wool. Long, soft, usually curly hair.
     - (*b*) Fur. Thick, fine, relatively short hair—"under hair," "wool hair."
     - (*c*) Vellus. Finest and shortest hair—"down," "wool," "fuzz."

The classes of hairs designated in the table as spines, bristles and awns represent a series with progressively lesser rigidity. The former, as exemplified by those of the porcupine and spiny anteater, are clearly special hairs of considerable defensive value to their possessors. There is no indication that the spines which occur in different mammalian families have any close genetic relation to each other but rather is it more probable, as Gegenbauer has said, that in these cases we see

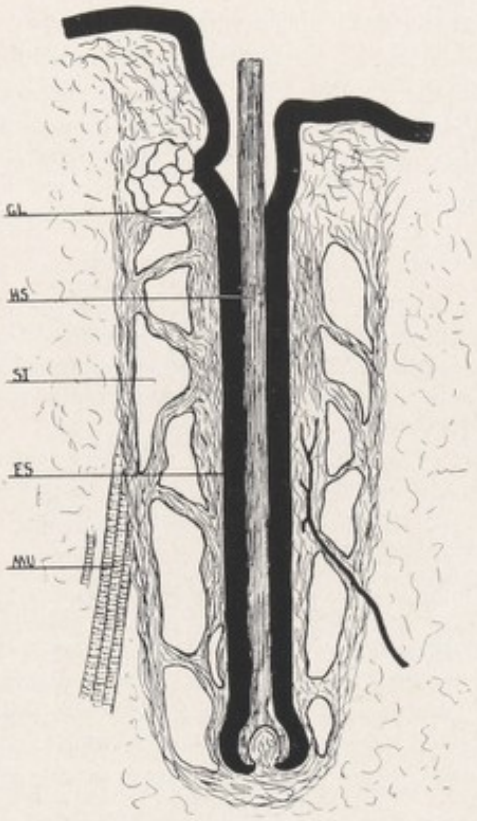

Fig. 22.—Diagram of a tactile hair showing blood spaces in the corpus cavernosum. *GL,* sebaceous gland; *HS,* hair shaft; *SI,* blood sinus, in the corpus cavernosum; *ES,* epithelial sheath; *MU,* striated muscle (characteristic of tactile hairs under voluntary control).

instances of parallelism or convergence, spines having arisen independently in several different lines.

When we come to the bristles, some difficulty is experienced in assigning to them any definite function. They are the long, rather stiff and slender pointed hairs generally sparsely scattered through the pellage. These are the hairs which, in view of their size, usual large number, flattened, imbricate scales and well developed, continuous

medullas, most closely approach the true tactile hairs, from which they differ in the complete lack of a corpus spongiosum. The nerve supply to the follicle is well developed but less elaborate than that of the true tactile hairs. Botezat designates this class as "transitional hairs," and expresses the opinion that they represent the primordial mammalian hair

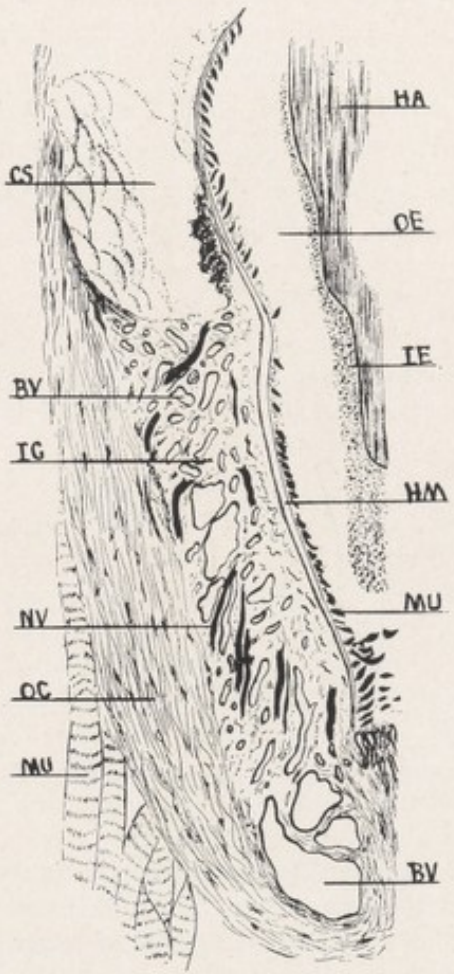

Fig. 23.—Part of the follicle of a tactile hair in the cat (Botezat). *CS*, circular sinus more or less flaccid with the wall to the left thrown into folds; *BV*, blood vessels in the corpus spongiosum or inner connective tissue sheath; *IC*, inner connective tissue sheath (corpus cavernosum); *NV*, nerve fiber; *OC*, outer connective tissue sheath; *MU*, voluntary muscle fibers inserted in the outer sheath; *HA*, hair shaft; *OE*, outer epithelial sheath; *IE*, inner epithelial sheath; *HM*, hyaline membrane; *MU*, a tactile meniscus (Merkel's corpuscle).

type which has given rise in one direction to the several forms of tactile hairs and in the other direction to the more purely protective hairs. Toldt, who finds that in many mammalian pelts there are repeated small

areas, "hair districts" (not the "hair districts" of Pinkus) in which there is one bristle and many progressively smaller hairs (Fig. 24), regards the bristle (Leithaar) as the principle hair in the sense of de Meijere. In commercially prepared fur, these hairs are pulled out or cut off.

The awns are considerably more numerous than the bristles, there being, from Toldt's point of view, several of them to each "hair district." They are characterized for the most part by a firm, dilated and often somewhat flattened tip borne on the end of a less rigid and otherwise furlike hair shaft. Toldt is able to find among the awns of a relatively restricted area every grade of transition, from typical fur to well developed bristles. Like the latter, they have a definite nerve supply.

Fig. 24.—Series of finely graded transitions in hairs from the fox, Vulpes vulpes (Toldt).

According to Botezat, medullated nerve fibers enter the connective tissue sheath in the region of the neck of the follicles of smaller awns and both the neck and lower part of the follicles of larger ones.

The remaining three types of hair continue the series of progressively reduced forms. So far as is known, they have no direct nerve supply. The first two may be regarded as purely protective in function, the last as for the most part rudimentary. Wool might properly be designated as a form of fur. Fur hairs are generally fine, soft and abundant. Their scales tend to be relatively large and the medullas more or less reduced or even absent. Ontogenetically, fur and vellus are the latest hairs to appear. Whether or not they continue to be developed de novo in adult life does not seem to have been determined with absolute certainty, but most evidence is against the idea that they do.

It is doubtful whether anything like a true morphologic entity can be assigned to the several types of hairs. The tactile hairs represent a relatively distinct group, but the other forms are less clearly differentiated. It would be of both theoretical and practical interest to know whether a follicle which would normally produce a fur hair could be made to produce a typical awn or bristle, but direct evidence on this point does not seem to be available. Changes in the character of hairs with age, transitional forms, and hairs that, like some awns, represent essentially different types at the two ends, suggest the possibility that follicles may not be wholly specific in regard to the type of hair they produce. If they are not, an interesting question arises as to why one finds different types of hair growing side by side. In this connection, a more thorough study than has heretofore been made of Toldt's "hair district," if it actually exists, is much to be desired.

The amount, the relative proportions of different types, and the pigmentation of hair show wide variations among the different species of mammals. The number of hairs depends on two different conditions: the extent of hair-bearing skin and the thickness of hair in a unit area of skin.

FACTORS INFLUENCING THE AMOUNT OF HAIR

In most mammals, the amount of skin that is really without hair is very small, but in some the hairless areas are greatly extended. The maximum reduction is found among the whales and dolphins, where the total number of hairs in *Phocaena,* for example, may be as few as two pairs, or in some individuals only one pair of probably useless tactile hairs situated near the mouth. Among other mammals with greatly reduced hair, *Sirenia* is a close rival of the whale. Many thick-skinned animals, such as the hippopotamus, rhinoceros and elephant have lost most of their hair. It is noticeable that the species that have little hair either inhabit warm regions or are supplied with a thick layer of subcutaneous fat, and that such hairs as persist are generally bristles and not fur or down. It has often been assumed that a warm climate is sufficient to cause a direct reduction in the amount of hair, and conversely that cold stimulates hair production. While such views have a certain inherent plausibility, careful scientific data in support of them are far from adequate. In this connection, one must not lose sight of the fact that animals that are not protected against cold can live only in a warm climate, and that some form of protection is requisite for a life in cold regions. There is a wide difference between adaptation through selection and direct physiologic adaptation. That the latter may occur is possibly indicated by seasonal differences in the pelts of some animals. For example, the wild boar is said to have only bristles in the summer, but both bristles and wool in the winter. There are many, for the most

part poorly authenticated, records of change of hair with change of climate. It is claimed that swine at higher altitudes become woolly, and hairless Mexican dogs are said to grow hair after five years in London. Some recent studies of Sumner on the response of mice to continued cold may lead the way to a more accurate knowledge of the immedate and remote effects of temperature on growth of hair.

Knowledge of the relation of increased fat to decreased pilosity also rests on an unstable basis. It has been suggested by those who believe that there is such a relation and think that it has a functional foundation that (*a*) fat under the skin compressed the follicles, causing the hair to atrophy through pressure; (*b*) that the fat absorbs the nutriment, thereby in a sense starving the hair out, which would explain the early disappearance of fine hairs with short follicles, or (*c*) that the fat exercises an unfavorable effect on the sweat and sebaccous glands, thus indirectly affecting the hair. While it is not impossible that some of these factors do affect the amount of hair, it is not easy to find any convincing evidence pointing in that direction. The difficulties in the way of establishing a relation between subcutaneous fat and hair are about the same that are encountered in attempting to establish a similar relation between temperature and hair. In either case, the first desideratum is to determine whether any relation that may exist represents a direct causal connection or is in the nature of a circumstantial correlation. Most writers on this phase of the subject have seemed to imply a belief that modifications acquired by an animal on entering a new environment are transmitted directly to its offspring. This is as yet an unproved assumption.

Closely related to the amount of hair is the relative proportion of the different kinds of hair. There seems to be a widespread phylogenetic tendency among mammals for the finer grades of hair, particularly fur and wool, to disappear or become reduced to vellus. For bristles, this tendency is much less pronounced. Consequently, as a general thing the more sparse the hairiness, the higher is the proportion of bristles to awns and fur hairs. In many mammals, including the higher apes, the hairy covering consists largely of hairs of the general character of elongated softened bristles. The prevailing reduction of fur in the covering of animals not exposed to very much cold is a familiar phenomenon.

HAIR COLOR

The pigmentation of hair has always been a matter of interest. There are many points in connection with coloration that have not yet been cleared up, but considerable information has been acquired relatively recently through genetic and combined genetic and chemical experimentation. The view sometimes maintained that granular pig-

ment is in reality formed in the connective tissue and subsequently transferred to the hair, has been pretty well disproved by microscopic studies. The theory that individual animal hairs change color has also failed to receive adequate support, changes in the color of pelt having been shown to be due in reality to recurring molts. There seems to be little doubt now that the pigment granules are produced in situ by the cells of the hair bulb itself and undergo little subsequent change. This is probably also true of the soluble pigment. So the coloration of a hair, apart from fading, may be considered as in all probability the result of factors acting on hair-forming epithelial elements. The investigation of these factors has yielded some interesting results.

It has been shown that in many of the domestic and laboratory animals, certain grades of color are dependent on the number of pigment granules rather than on their intensity. Specific hereditary "dilution factors" have been found to reduce the pigment granules quantitatively without affecting them qualitatively. When these factors operate in conjunction with those which would otherwise produce black hair, the color becomes slate or maltese. The "dilution factors," which generally behave in heredity as recessives, may be transferred by appropriate crosses to animals of different colors, giving corresponding light or dilute shades. Dilution factors undoubtedly affect soluble pigments as well as the granular form, but here the exact mode of their action is less evident.

Apart from apparent differences in color due to varying amounts and arrangement of pigment, there are also qualitative differences in the pigment itself. Probably all colors due to granular pigment can be resolved into shades of brown, "black" for example being in reality a very dark brown. On this basis, it has been maintained that the different hair colors represent stages in the oxidation of a single pigment base, the color of a hair indicating the stage of oxidation reached in that particular instance. If this is the case, it follows from the variety of definite colors which exist that there is a considerable number of heritable factors which regulate the precise amount of oxidation that shall take place for each hair color. Most of the evidence seems to point in this direction, but the possibility still exists that a single animal species may produce several slightly different melanin bases.

Besides the hair pigments, it has been found that there are two types of whiteness, the dominant and the recessive, or albinotic. The latter is apparently due to the inhibition of certain heritable factors since it is easily demonstrable by breeding experiments with rabbits or mice that the albinos correspond to all the known color classes except that they are unable to actually develop the color which they have in potential form.

Albinos seems always to carry the color factors unchanged. It is not quite certain whether or not white hair actually contains granules of the unoxidized chromogen base.

The dominant form of whiteness generally associated with spotting behaves in heredity as the exact opposite of recessive whiteness, since a pair of animals with this trait may produce not only offspring like themselves but pigmented young as well. Chemical study of the skins of young rabbits at the time when hair is beginning active growth shows, according to Onslow, the presence of an antityrosinase that prevents the oxidation of tyrosin, which is believed to be one of the important chromogen bases. A few drops of the extract from skin with white hair of the dominant type suffices to prevent the oxidation of extracts from dark skins. In control tests, when the extracts were not mixed, the oxidation of the dark skin was complete.

Various factors which affect the amount and distribution of hair pigment may act at different times on one and the same hair, giving the well-known banded, ticked, or agouti appearance common to many wild animals. This hair pattern is due to another hereditary factor which may be combined at will with the several intensities of black and brown, giving a considerable variety of color effects.

The whole question of pigmentation of animal hair is one that has received a great deal of attention, and relating to which there is a considerable volume of literature. This abridged reference to the subject is made in order to suggest how great is the number of independently hereditary factors that may enter into a relatively simple phase of hair development. It is not meant to suggest, however, that the production of hair pigment involves a complicated reaction. The contrary is probably true. But the process may be controlled, modified or restricted by a surprisingly large number of factors which studies in genetics have shown to exist and which chemical analysis has begun to identify.

There are many obvious lacunae in our knowledge of mammalian hair, but most of the deficiencies are those which we find in other fields of biologic endeavor; they inhere largely in our inability as yet to recognize, analyze and evaluate the determining factors in organ development and maintenance. Whatever is lacking to a comprehensive knowledge of the sequence of developmental stages and structural characteristics of mammalian hair can be supplied with relative ease, but the knowledge of the factors which control these manifestations can at best only keep pace with the advance of an understanding of vital processes in general.

CHAPTER III

GENERAL CHARACTERISTICS OF HUMAN HAIR

Man is unique among the mammals in his complete lack of tactile hairs. So far as is known, every other mammal possesses them. They are the first to appear in the embryo and persist after all others have been lost through disease or phylogenetic reduction. But with man they are found, if at all, only as transient embryonic rudiments. This absence of true tactile hairs may be mentioned as one of the few qualitative differences between man and all other mammals. In most respects, human hair conforms fairly well in character and distribution to the hair of other members of the class, especially the anthropoid apes.

HAIRLESS REGIONS OF THE BODY

The human species is by no means the most nearly hairless animal, for, as already mentioned, most cetaceans and many representatives of other orders are less well provided. But in man, the great majority of hairs never develop beyond more or less rudimentary vellus. This peculiarity is a rather highly characteristic human trait since, with few if any exceptions, other mammals are relatively poorer in down than in the coarser forms of hair. The total amount of really hairless skin in man is small, being confined to a few special areas. Hair does not normally occur on any invaginated ectoderm except close to the nostrils and in the external auditory meatus. It has been reported in a number of instances as growing from various mucous membranes, but most, and probably all, these cases may be attributed to the presence of dermoid cysts. The other regions in which it is characteristically absent are the margin of the lips, areolae of the nipples, the umbilicus, the immediate vicinity of the anal and urogenital openings, including the labia minora and prepuce, the soles, the palms, and the terminal parts of the fingers and toes. The hairless area on the foot extends well up on both the lateral and medial margins, including the lower part of the fossae between the malleoli and Achilles tendon behind, and the terminal segments of the toes and second interphalangeal joints in front. The hairless region of the hand is comparable, morphologically, to that of the foot, the bare region of the heel being apparently represented by a more or less triangular area extending several centimeters along the flexor surface of the forearm somewhat to the ulnar side. As with the toes, the skin

of the fingers back to and including that over the terminal interphalangeal joints is without hair. It is doubtful, too, if hair ever occurs over the proximal interphalangeal joints of the fingers or four lateral toes.

The regions indicated in the preceding paragraph as hairless are believed to be entirely free from hair or hair rudiments in all races and at all age periods. There is no indication that this pecularity is in any way modified in disease or in cases of the most marked hypertrichosis. In certain persons, an extension of the hairless areas to cover the middle

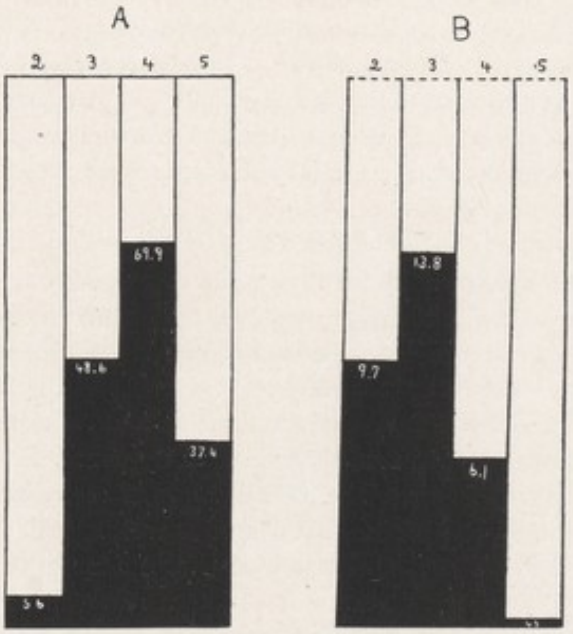

Fig. 25.—The frequency of the presence and absence of hair on the middle segments of the digits in 442 white soldiers (Am. Jour. Phys. Anthrop.) *A*, represents the fingers; *B*, the toes. The columns headed 2, 3, 4 and 5 indicate the digits commonly designated by those numbers. The black areas show the percentage of cases in which the respective digits had hair on their middle segments, the light areas the percentage which lacked it. *B*, corresponds to the base of a polygon ten times as high as *A*.

segments of the fingers and toes has been reported by Danforth. In these cases, which include nearly all negroes and Indians that have been examined, as well as about one-fourth of white Americans, the absence of hair is not merely apparent but real, as shown by embryologic and histologic studies. This absence of hair from the middle segments may involve all the digits (except the thumb and great toe, which are presumed to lack a middle phalanx) or it may extend to only part of

them. Of the fingers, the index is the one which most often has no hair on its middle segment. This is followed in turn by the little, middle and ring fingers. It is noteworthy that if hair is absent from the middle segment of the ring finger it is almost invariably absent from the corresponding segments of all the others. In the foot, where the frequency of absence of hairs on the middle segments of the toes is in the sequence of the fifth, fourth, second, third, there is a similar relation in reference to the third digit. In the white race, these areas are bare on the toes about ten times as frequently as on the fingers (Fig. 25). The middle segments of the fingers and toes, which may probably be regarded as morphologically only two regions, and those homologous, represent the only parts of the body which, so far as has been ascertained, show any present phylogenetic tendency toward an increase in the amount of hairless skin.

REDUCTION IN HAIRINESS

Other parts of the body are covered with hair in greater or less abundance. For given regions, there may be a wide range individually and racially in the degree of hair development, but whether or not the total number of hairs to the unit area varies appreciably seems to have been ascertained for only two regions, the face and the fingers. Dr. Trotter states that no constant sexual or racial difference in the actual number of facial hairs has been found. In this region, the differences in apparent hairiness of different persons seems to depend primarily on the size of hairs rather than on any marked variation in their number. A study of facial hair taken by itself would lead one to suspect that if the human race is becoming less hairy it is doing so not by a reduction in the number of hair follicles formed, but by a more and more complete suppression of the growth of the hairs that are present. There is considerable evidence pointing in this direction, and one might easily imagine that this is the only process involved were it not that study of digital pilosity indicates that in some parts of the body there may be other factors. On the middle segments of the fingers, the actual numbers of hairs in a definite area varies widely, as has been determined by careful examination of the living and by microscopic sections. Here one may find on the middle part of the ring finger, for example, of one person a single well developed hair with no trace of any other follicles, while in exactly the same place in another subject there may be as many as twenty or twenty-five hairs of various sizes.

The two contrasted types of hair reduction, involving in the one case actual diminution in the number of follicles and in the other a deficiency in the growth of the individual hairs might be referred to as actual and apparent reduction. The two types have not been adequately studied. They may occur more or less independently in the white race but are

associated in the negro and Indian, a fact that is possibly of some significance. Whether actual reduction as compared with the apes has occurred in other parts of the body than the fingers and toes, is open to question. A comparative microscopic count of the hairs of human fetuses at the age of about 6 months and of several fetal apes and monkeys of approximately the same stage of development was made by Meyer-Lierheim, the results of which are summarized in Table 1. It appears from these figures that man has more numerous hairs on his head than either of the three anthropoids examined and more on his back than either the chimpanzee or the gibbon. As compared with the macaque man seems to have considerably less hair, but a square centimeter of surface on a human fetus represents a comparatively much smaller area than does a square centimeter of surface in the fetus of a medium sized monkey, so even here the relative difference may be small or even in favor of man. There can be no doubt, however, that as compared with many of the lower mammals the human species has a considerably reduced number of hairs. It has not been established that

TABLE 1.—*Comparative Microscopic Count of Hairs of Human Fetuses and Fetal Apes and Monkeys of Same Stage*

Region Examined	Number of Hairs to a Square Centimeter of Skin				
	Man	Orang	Chimpanzee	Gibbon	Macaque
Head	880	383	400	546	1,240
Back	688	937	420	440	1,406

this reduction was brought about primarily through an elimination affecting exclusively some special type of hair, such as the bristle or awn. The tactile hairs have disappeared, but as to the exact nature of other losses, nothing definite is known. The problem is complicated by possible independent factors making for the partial suppression of hair growth without necessarily any elimination of hair follicles. From the point of view of comparative morphology, this is a matter requiring further study.

HAIR OF THE FETUS

In development, the first definite hair rudiments in the human embryo appear on the forehead at the end of the second or during the third month of intra-uterine life, and by the end of the fourth month very fine, soft, and unpigmented hairs mark the region of the eyebrow and its immediate vicinity. Only slightly later (in fetuses of 120 mm., according to Frédéric) hair appears on the upper lip and scalp, followed at once by hair on the lower lip. During the next two months, the number of hair rudiments increases and their distribution spreads, the backs of the hands and feet becoming hairy, according to Friedenthal, at about the

end of the sixth month. It is frequently stated in the textbooks and maintained by Spuler that new follicles continue to appear even after birth, but owing to the natural wide variation in the size of closely adjacent follicles, it is easy to mistake a tangential section or a small follicle for a newly developing follicle, and there may be some question as to the accuracy of these statements. Scars usually fail to develop hair follicles, but substitution tissue following a transplant, at least in animals, may have follicles which, however, are possibly drawn on from the periphery. Whether or not this supposed late appearance of new follicles is a reality is an important question that awaits more critical investigation.

That the eyebrows should be the first hairs to appear in the human fetus and that they should be almost immediately succeeded by hairs on the upper lip are points of considerable interest, since it is precisely in

Fig. 26.—Gibbon embryo of 5 cm. to show developing sinus hairs (Frédéric).

these places and in this order that the first sinus hairs appear in fetal apes. The fact that the eyebrows and the mustache occupy comparable positions to tactile hairs in the apes, that they are the first hairs to appear in the embryo, and have certain superficial resemblances (Fig. 26) has been used as an argument for considering these particular human hairs as morphologically comparable to the sinus hairs of lower forms. This rather widespread view has not been borne out by careful investigation. Frédéric's study of developmental stages showed that the hairs of the mustache and those of the eyebrows, both of old men and of fetuses, have nothing in common with sinus hairs except their early appearance and topographical position. There is nothing in the follicular structure of human hairs to suggest kinship with tactile hairs. Frédéric himself concluded, rather cautiously, that it is not altogether impossible that the eyebrows and mustache have descended from sinus hair but that there is no well founded evidence that such is the case. From the point

of view suggested earlier in this book, the hairs of the eyebrow or mustache might be thought of as perhaps partially homologous with sinus hairs, development of the different forms being due to germinal complexes having some, but not all, factors in common.

That the human species has not entirely lost the tendency to produce tactile hairs has been maintained recently by Broman, who finds on the

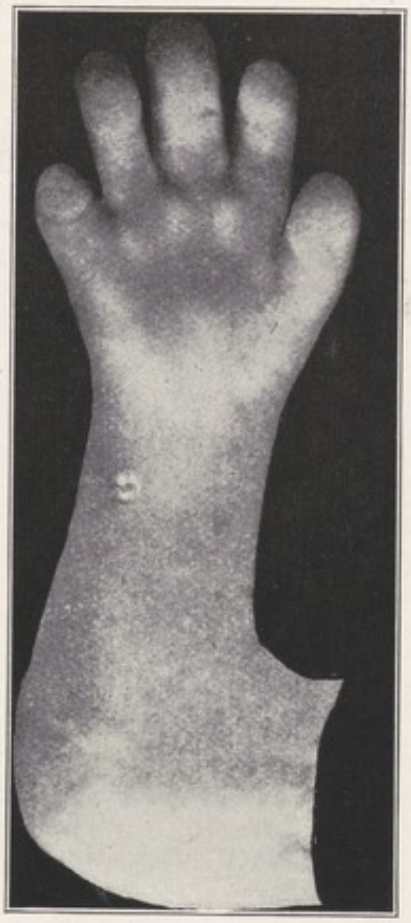

Fig. 27.—Right forearm of a 28.5 mm. human embryo (Broman). The elevations on the ulnar side above the wrist are interpreted as indication of a transient tendency toward the formation of tactile hairs, since they occur at a point where such hairs are developed in the cat (Fig. 28).

arm of a 28.5 mm. embryo (probably about seven weeks old), little elevations (Fig. 27) at a site corresponding to the position of "carpal vibrissae" of certain other forms as, for example, the cat (Fig. 28). Similar elevations are found on the nose and face. These ephemeral structures Broman considers as transient manifestations of vestigial

tactile hairs. Should his observations be confirmed, they would have considerable interest from a phylogenetic point of view.[1]

STAGES IN DEVELOPMENT OF FETAL HAIR

Apart from the question of presence or absence of sinus hairs or their homologues, human hair development presents little of special interest as compared with that of other animals. Stöhr, some of whose figures are copied herewith, divides the process of development of fetal hair into four stages.

His initial period or "hair germ" stage covers the period from the first indication of thickening in the ectoderm to the formation of a compact nodule of cells projecting into the corium. Figure 29 is from a

Fig. 28.—Left forearm of a 17 mm. cat embryo (Broman). The elevation on the ulnar side above the wrist is the site of tactile hairs which develop later.

developing follicle near the end of the first stage. At this time a slight suggestion of asymmetry in the follicle may be noted, indicating its future obliquity. Only the ectoderm is concerned in the initiation of follicle growth, but by the end of the first stage the corium shows some reaction in the form of the accumulation of nuclei beneath the epithelial downgrowth.

The second period in hair development Stöhr calls the "hair peg stage." This begins when the epithelial downgrowth assumes a more or less cylindrical form, and continues to the time when its deep extremity

1. Dr. Adolph Schultz of Baltimore has reported observations confirming those of Broman.

is indented by the developing hair papilla. A follicle toward the end of the second stage is shown in Figure 30. By this time, several indications of organization are apparent. The "hair peg" shows some differentiation into neck and bulb but only slight specialization of the cells. The regions of the future sebaceous gland and the epithelial bed are vaguely indicated. Nevertheless, the whole structure is still a solid mass of cells, the core being filled and continuous with a strand of somewhat specialized cells indicating the site of the future subepitrichial hair canal. The surrounding mesenchyme is organizing into a connective tissue sheath which is especially thickened just beyond the end of the epithelial downgrowth. A few round nuclei close to the latter represent the true hair papilla. Several nuclei in the mesenchyme below the rudiment of the sebaceous gland may probably be interpreted as forerunners of the arrector pili muscle.

Then follows the third stage, which lasts until the hair proper appears in the follicle. In this stage, illustrated by Figure 31, the "hair peg" is

Fig. 29.—Skin of the forehead of a 5 months fetus showing early stage in the development of hair. (After Stöhr).

dilated at the end into a bulb encasing a well developed connective tissue papilla. The transition from the second to the third stage must be effected rapidly, since it is only exceptionally that one sees a developing follicle in the intermediate condition. In the third stage, one finds a more marked differentiation in the follicle. The sebaceous gland, not well shown in the figure, is further developed, and the epithelial bed, supposed to be the source of new hair shafts following molting later on, has attained to considerable proportions. In the bulb, indications of both Henle's and Huxley's layers are present, and the cells from which the hair itself will form are definitely indicated. The connective tissue sheath and the hyaline membrane, derived in part from the mesenchyme and in part from epithelium, are now present. The arrector pili muscle is definitely indicated, except in connection with follicles for hairs which characteristically lack it. "Arrector muscles are absent from the lanugo of the nose, cheeks and lips, and also from the eyelashes (cilia) and nasal hairs (vibrissae)." In the third stage, the axis of the "hair peg" is still filled with cells.

The fourth period, designated as the "sheathed hair stage," begins with the definite appearance of the hair shaft at the end of the third stage and continues until the hair ruptures, pushing its tip above the surface of the skin. This stage is characterized by the breaking down of cells in the axis of the follicle and under the epitrichial layer of the epidermis forming the hair canal. The phenomenon appears before the hair itself is much developed and considerably in advance of any apparent need for such an opening. At the same time, there is a partial degeneration of the inner epithelial sheath followed by superficial corni-

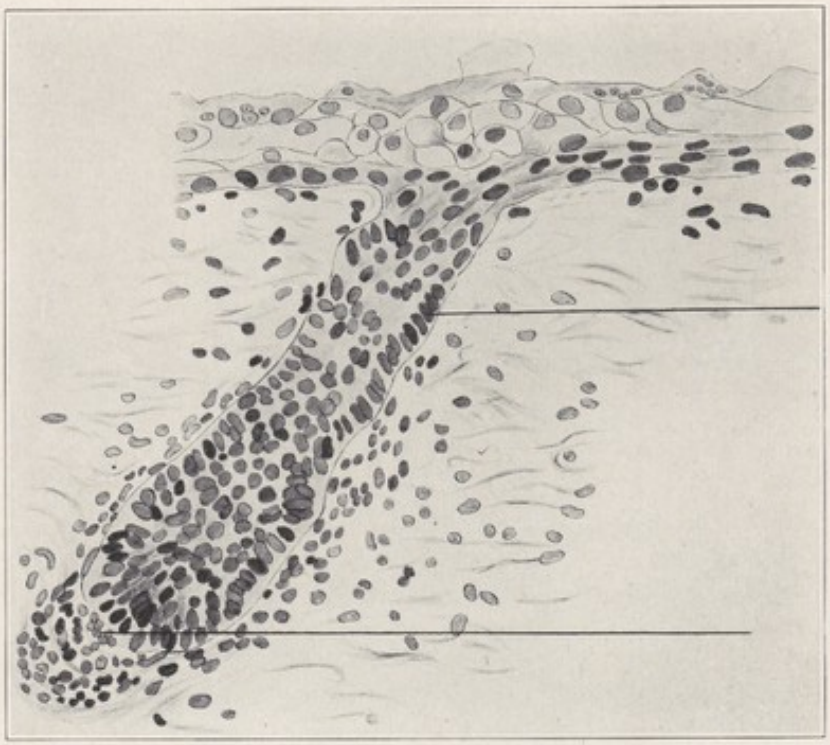

Fig. 30.—A hair follicle at about the end of the second stage. Magnification about 300 (after Stöhr). *P*, anlage of papilla; *S*, first indication of the sebaceous gland.

fication and the formation of the cuticular layer. This stage is represented semidiagrammatically in Figure 32. When the tip of the growing hair reaches the epitrichium, it is deflected horizontally in the hair canal. Continued growth finally results in a bowing of the distal part of the hair shaft and a consequent rupture of the epitrichium.

THE LANUGO

The first hairs are formed and reach a considerable development during the period extending from the third to the seventh month of intra-

uterine life. They are fine, slender, slightly, if at all, pigmented, and with some of the characteristics of wool. Many of them are longer than the vellus by which they are subsequently replaced. The cortical scales are large, and a medulla is lacking. It will probably make for greater clarity if the term lanugo is restricted to hair of this type. At their first

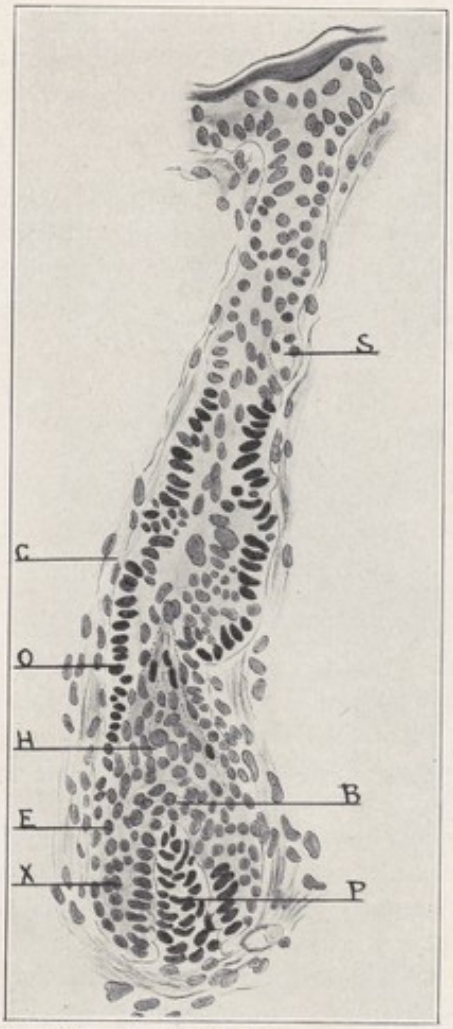

Fig. 31.—Hair follicle from the back of the nose representing the third stage. Magnification about 300 diameters (after Stöhr). *C*, connective tissue sheath; *O*, outer epithelial sheath; *H*, hair rudiment; *E*, Henle's layer; *X*, Huxley's layer; *S*, sebaceous gland (only indicated); *B*, bulb; *P*, papilla.

appearance, these hairs occur singly, but soon many of them are found in groups of two, or rarely five, as a result of two or more new hairs forming about an older one. Most, and perhaps all, of the first hairs are shed before birth. The process of shedding (Fig. 33) has been

worked out in detail by several investigators and consists in a series of changes in the follicle initiated by a cessation of growth in the hair bulb and a more or less complete atrophy of the papilla. There is no certainty that the process is the same in fetus and adult. It is doubtful that the first hairs have any function. One rather fanciful suggestion that

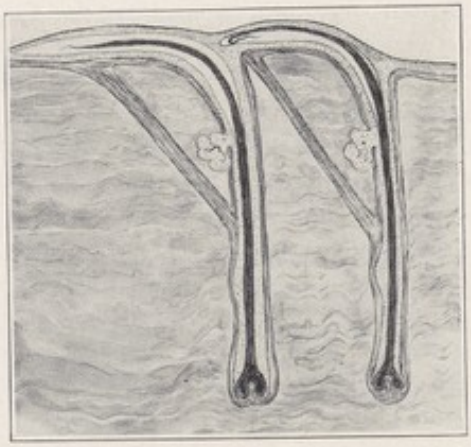

Fig. 32.—Diagrammatic representation of hairs immediately before rupture. The young hairs are still covered by the epitrichial layer which is on the point of rupturing.

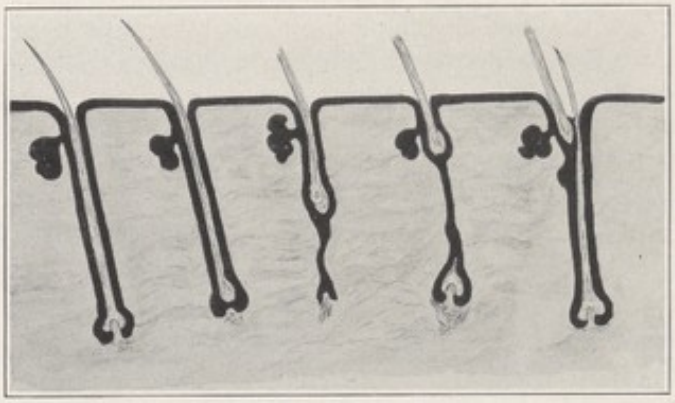

Fig. 33.—Diagram of stages in maturation and replacement of fetal hair. Epithelium, sebaceous glands and epithelial sheath in the follicle are solid black; connective tissue is gray.

has been advanced is that since they are shed into the amniotic fluid they should be regarded as a form of excretion. Another possibility, more acceptable from a morphologic standpoint, is that they represent a phase of the recapitulation process. Even this is perhaps rather far fetched,

and it seems quite as satisfactory to regard this first feeble production of hair as the early expression of a function that has not reached its height.

By the time of birth, the hairs of the eyelashes, eyebrows and scalp, while still soft and partaking more or less of the character of lanugo, show a much more vigorous growth than did the earlier generations in these regions. Particularly in dark infants, the hair shafts may be well pigmented at this time. Frequently, there is also present at birth a considerable amount of conspicuous hair in other places, such as the face, ears, body and especially the shoulders. This persistent lanugo on the body, along with most or all of the hair of the scalp, is shed during the first few months. That of the eyebrows and scalp is replaced in general by the coarser and more typical hair of those regions, while over the rest of the body the replacing hair, if not finer, is at least relatively shorter, and after a few generations resolves itself into the typical form of vellus or down hair, which is fine, short, generally unpigmented, and usually without medulla. There is little precise information on the growth, duration of life and sequences in stages of the hair during early childhood.

AGE CHANGES IN THE PILARY SYSTEM

The gradual changes that take place in the hairy covering during late fetal life and childhood are continued through the period of maturity to old age. This is especially true of certain persons in whom, as Friedenthal has remarked, the pilary system seems never to reach a stage of equilibrium. Particularly in men, the hair over the body, in the eyebrows, on the face, in the nostrils and on the ears increases and becomes more apparent long after adult life has been reached. In both white and negro women, Trotter found a steady increase in the average length and diameter of hairs of the lip and cheek from youth to senility. It is a strange aspect of these changes that only a part of the hairs of any region are affected, many of them remaining as small as those of the fetus.

The first few generations of hair may be referred to as the primary hair. This is the covering of the fetus and to a large extent of the new-born. It is customary, but perhaps somewhat confusing, to class together as "wool" the primary hair of the fetus and the vellus of the adult. While the two forms have much in common; small dimensions, deficient pigment, small or absent medulla, relatively large cuticular scales, and are even regarded by some as identical, it seems better to retain the distinctive terms primary hair, in the restricted sense, as referring to the early hairs of the fetus, which perhaps under the stimulus of something derived from the maternal circulation, hypertrophy into lanugo, and secondary hair as referring to the fine hair of the postnatal

life. Convenience of usage, however, should not obscure the important fact that the morphologic type which characterizes the very first hairs of the fetus is still found virtually unchanged right through to the end of life.

The coarse, longer and more heavily pigmented hair which develops, especially at and following puberty, represents a third phase which most German and English speaking authors designate as terminal hair, in the sense that it is the presumed ultimate stage of hair development. Terminal hair characteristically has a well developed medulla through the greater part of its length and flattened or crenate cuticular scales. It ranges in character from the bristle to the awn. Hairs representing all stages of transition between bristles and the finest down may be found on any ordinary subject.

In his discussion of human pilosity, Friedenthal recognizes three stages in the development of the hairy covering. The first or "wool hair covering," that of the fetus, is characterized by the universally distributed primary hairs arranged in groups of from one to three, or rarely, five. The next, or "child hair covering," lasting until about puberty, consists for the most part of "wool" (secondary) hair arranged as before except that the coarse eyebrows and eyelashes are all placed singly. The hair of the head is coarser and shows a tendency toward the group arrangement. Finally, the "permanent hair covering" of the adult is characterized by the addition to the "child hair covering" of terminal hair which varies in amount according to the race, sex, and even the individual. The greater part of the body, at least in the female, is still covered by vellus.

ARRANGEMENT AND DIRECTION OF HAIR

The arrangement of hair is a matter of considerable interest. Its phylogenetic interpretations have already been mentioned. Friedenthal maintains that while the arrangement of down may be such as to suggest scales, the single hairs or groups of hairs being placed at the intersections of two imaginary sets of oblique parallel lines, the resemblance is after all only superficial, since the real explanation of the arrangement of the groups is to be found in the distribution of elastic tissue fibers in the corium. If this is correct, the similarity which Friedenthal has shown to exist between the arrangement of primary (and secondary) hair in man and the arrangement of hair in American monkeys presumably has its immediate cause in a similarity in the elastic tissue arrangement in these monkeys and young human beings. Terminal hairs in man occur singly at first but may subsequently appear in groups, and occasionally show a tendency to become arranged in rows. This point is stressed by Friedenthal, who regards it as significant from an evolu-

tionary standpoint that the young human being should have an arrangement of hair suggestive of the lower primates, while the adult has an arrangement more closely resembling that of the higher apes.

Another phase of hair arrangement which has attracted a good deal of attention is the matter of the direction of hair in different parts of the body—the hair streams or hair slopes. Since nearly all hair follicles have an oblique position in the skin, the tip of each hair points in a characteristic direction, which is obviously determined by the direction of the follicle from which it grows. What in turn determines the direction of the follicle is not answered so easily. The hair slopes in man

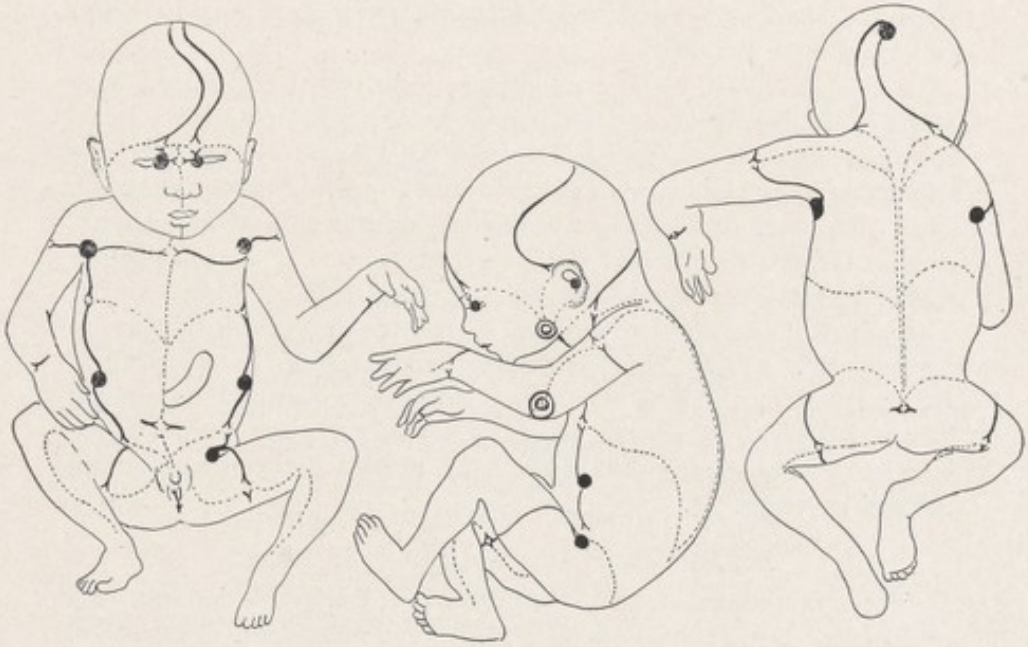

Fig. 34.—Diagrams show the direction of hair in a 7 months fetus (Friedenthal). Solid black lines represent divergence of hair streams, dotted lines convergence. Hair whorls are represented by solid black circles and "convergent whorls" or tufts on elbow and neck by concentric circles.

depart widely from those of the simpler forms where the majority of hairs point from before backward. Most of the early investigators worked on the fetus and young infant, but some studies, notably those of Kidd, have been based on the adult. A few slight changes take place between the two age periods.

Incidentally, there is also found more or less individual variation in the direction of hair. Several of the more constant phenomena of hair direction have been noted and are indicated in the illustrations (Figs. 34-37). All the hairs over a given surface usually point in essen-

tially the same direction. Such an area of parallel hairs is called a hair stream or hair slope. Two adjacent hair slopes may be at their common boundary either convergent or divergent, the former condition tending to produce a crest, the latter a natural parting or feathering. At the end of either of these lines, there is at least a potential whorl or cross (Fig. 35).

One of the earliest suggestions as to the cause of the hair slope is attributed by Eschricht to Osiander, who discussed the matter in 1816. Osiander seems to have believed that the direction of the hair follows the direction of the subjacent arteries. This was easily disproved as was

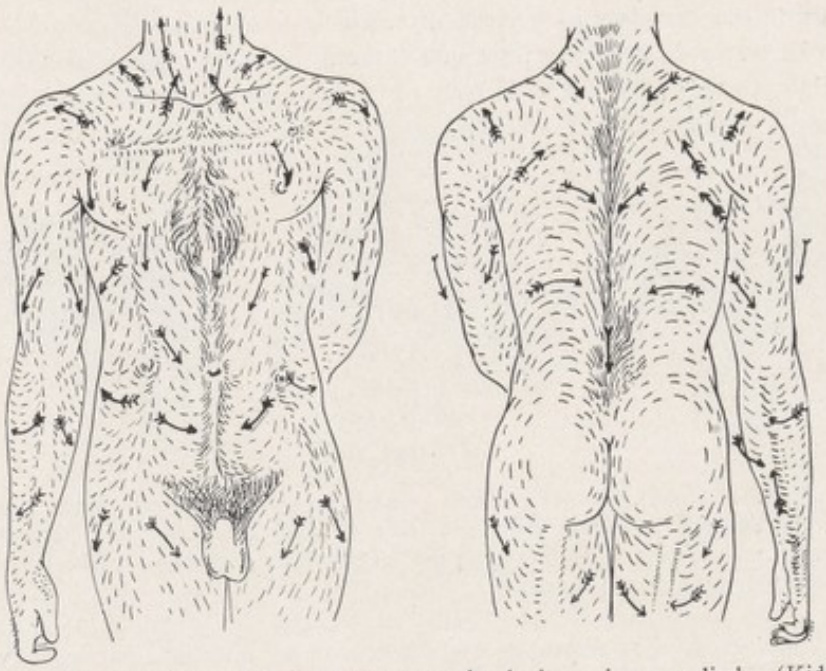

Fig. 35.—Direction of hair streams on the body and upper limbs (Kidd). Arrows with single barbs represent the presumed primitive arrangement; others show areas in which this arrangement has been modified.

also any suspicion of a definite association between hair direction and nerve distribution. According to Voigt (1856), the direction of hair is determined by the tension resulting from the unequal growth of different parts of the fetus, very much as the slope of a nutrient foramen is said to result from unequal growth of bone with reference to surrounding tissues. This theory has a certain degree of plausibility as applied to certain parts of the body and may be a factor of limited importance. According to Friendenthal and others, the direction of the follicle is determined by the tension of the elastic tissue elements in the skin. This suggestion probably comes nearest to offering a satisfactory mechanical

explanation but is not wholly adequate, since there is some lack of coincidence between direction of hair and elastic tissue pull. Schöne was unable to reverse the direction in the mouse by autoplastic transplants in which the skin flaps were turned end for end.

SUPPOSED ADAPTIVE CHANGES IN THE HAIR SLOPE

In this connection, the ingenious speculations of Kidd cannot be passed over. According to Kidd, the direction of hair is determined primarily by mechanical forces, which may be in the nature of external pressures and friction, and even gravity, or the internal pull of muscles and subcutaneous tissues. The arrangement of the hair may be modified during the life time of a person, in which case the modifications tend to be transmitted to the next generation. In his book on the subject, Kidd presents a considerable body of evidence in support of this kind of "use inheritance," but much of it is contradictory and on the whole

Fig. 36.—Three cases of natural parting in young subjects (after Kidd). *A*, the commonest arrangement with hair directed downward and parting to the left; *B*, parting to the right of the median line; *C*, parting to the left and continued down to the eyebrow.

unconvincing. For example, there is commonly a natural parting of the hair on the head (Fig. 35), and Kidd in examining seventy infants and young children found that forty-five of them showed a left lateral, seventeen a central, and six a right lateral parting. Two others had an unusual arrangement. These natural partings correspond in position and perhaps in frequency with the usual partings made in combing the hair, and lead to the inference that "probably most of them, certainly some, are produced in the individual by the inherited effects of dressing the hair in ancestors." The force of this and similar instances of the supposed inheritance of acquired modifications is considerably diminished by the equally striking cases which it seems impossible to explain in this way. For example, there is a frequent break in direction of the hair near the medial extremity of the eyebrow, attributed by Kidd himself to the effect of the subjacent corrugator muscle. The incidence of this

common condition was determined by Kidd from 200 consecutive cases, in which it was found that the break or parting was more marked on the right side in only fourteen instances. It was equally well marked on both sides in thirty-three subjects and more marked on the left in 153. In other words, despite the fact that it has never been the custom to part the eyebrows, there is as strong a tendency for the hair of the left eyebrow to show a natural part as for the hair on the left side of the scalp, and consequently the assumption seems justified that neither the one nor the other is due to any past ancestral custom, but that some other explanation must be sought for both. That the modes of hair dressing, on the other hand, have been influenced by the natural proclivities of the hair might be urged with some degree of plausibility. In passing, it may be noted that the natural parting of the hair in the eyebrow may represent a

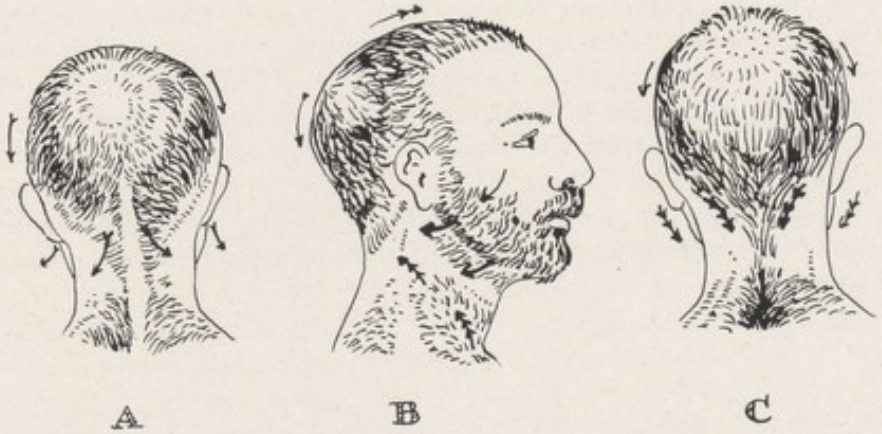

Fig. 37.—Three sketches showing direction of hair on the head and neck (after Kidd). *A* and *C* show two different natural arrangements in the back of the neck; *B* shows especially the reversed direction of hair in the anterior triangle.

continuation of the line of parting on the scalp. Kidd presents a figure (36 C) which strongly suggests such an interpretation, but he does not comment on this possibility. It would be of interest to determine the correlation between a left parting of the hair on the scalp and that of the left eyebrow.

One instance of the failure of the hair direction to become adapted to new conditions may be cited. The natural direction of hair in the submaxillary region is downward, while in the lower part of the neck it is upward, the two streams meeting in a line well within the beard covered area of most men (Fig. 37 B). Despite the frequent irritation that comes from shaving against the natural direction of the hair on the part of a considerable proportion of men for many generations, this peculiar

arrangement, apparently not shared by apes, still persists as a characteristic human trait.

On the ulnar side of the arms, the prevailing direction of the hair toward the elbow has frequently been emphasized, and since the time of Darwin and Wallace explained as an adaptation brought about through natural selection. This particular arrangement is presumed to have been acquired first in forms which during rain crouch with hands clasped back of the neck, the hairs of the arm and forearm forming a natural thatch which sheds the water freely from the slightly protruding elbows. In man, the arrangement is assumed to be a useless heritage from an apelike ancestor in which this habit was developed. The plausibility of this explanation is reduced by the fact that in the arm there is a fairly good agreement between the direction of hair and of subcutaneous connective tissue bundles.

In spite of much unreliable and conflicting evidence, the possibility that the direction taken by hair on different parts of the body is such as to be more or less advantageous to the individual, cannot lightly be dismissed. According to Kidd, the hair arrangement in man deviates markedly in many particulars from that of any of the apes, and some explanation for the differences is needed. A satisfactory hypothesis will have to account for whatever differences may exist between the direction of hair follicles and lines of tension in the skin of the same region.

CHAPTER IV

REGIONAL CHARACTERISTICS OF HUMAN HAIR

The hairy regions of the body are covered at one time or another by vellus of the character already described (Fig. 38). In its typical form, the vellus is essentially the same as the primary hair of the fetus, and ontogenetically, although probably not phylogenetically, precedes all other types of hair. The tendency, which is widespread among mammals, for hairs to occur in groups is well exemplified by human down in which groups of three are common and groups of five occasional. In these clusters, one hair is almost invariably larger than the others. In view of its central position as well as its size, it is probable that the largest hair is produced by the oldest follicle in the group. The significance of these hair groups and their physiologic and probable morphologic relation to sweat glands is a subject that requires much further study.

There is a peculiar tendency for the skin around a hair group, or more often around only two of the hairs, to become invaginated, forming a little pit from which the hairs project, like the fur hairs of *Ornithorhynchus*. This grouping of hairs in pits is most noticeable among the coarser, more easily visible hairs of the arms and legs, from which one might easily get the impression that two hairs frequently arise from the same follicle. Grouping of hairs whose follicles open into a common pit is not to be confused with the appearance produced during replacement when both the old and the new hair may often be seen emerging from the same follicle. Figure 39 shows these two arrangements as seen in a section of the skin of the forearm. It is possible that "conglomerate hairs" and the pathologic condition known as thyrsanothrix may have some relation to this tendency.

THE DOWN (VELLUS)

Owing to its delicacy and the consequent difficulty in studying it, information on human down hair is rather meager. So far as known, it is the same in all races, but the employment of an adequate method of examination might reveal unsuspected differences in its amount or arrangement. Each down hair is said to last about four and one-half months. Later in life, it is more or less reduced through atrophy of follicles, especially in some persons. Whether the loss of down differs with sex or race is uncertain. A study of this form of hair with ref-

erence to the amount of subcutaneous fascia would be of interest, since it has been claimed that in mammals generally phylogenetic increase of subcutaneous fat is accompanied by loss of the small hairs.

In many regions of the body, a considerable amount of down is replaced by the larger terminal hairs and by intermediate forms (Fig. 38). The transition from down to terminal hair is gradual, involving several generations of progressively larger hairs produced by the same

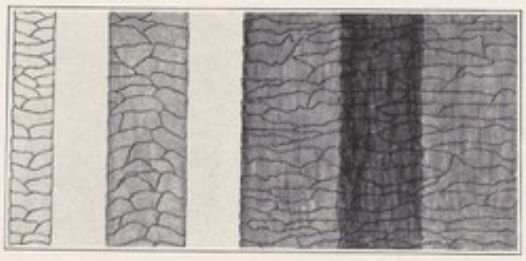

Fig. 38.—Three hairs from the midline of the chest at the level of the fifth rib from a man 38 years old (about ×280). These specimens show the characteristics of vellus, transitional and terminal hair. The total lengths were 1.6 mm., 15 mm. and 57 mm., respectively.

Fig. 39.—Sketch of a section of the forearm of an adult man. On the right is a typical group of three hairs, two of which are from follicles which open into a common pit, *P*. The third hair, *S*, comes from a follicle which reaches the surface. On the left is a similar group but cut at a deeper level. In one follicle, *A*, there are two hairs, one, *X*, is about to fall out, and another which is replacing it. Adjacent sections show that follicles *A* and *B* open into a common pit, while *C* reaches the surface.

follicle, which itself becomes proportionately hypertrophied. Here and there, particularly in borderline zones, an intermediate type of hair may persist for long periods. In a few places, all the down is either lost or replaced by terminal hair, but for the most part only certain follicles change their output, while other follicles all about them continue to produce nothing but down. Why, in the same region, with apparently

identical blood and nerve supply, one follicle should produce a terminal hair and another a down hair is an attractive problem, which may possibly be correlated in some way with the question of the "hair districts" that Toldt believes he can distinguish in the furry mammals, where there is one bristle to several awns, and to each of the latter a number of fur hairs. Closely related to this problem is the question of why some terminal hairs appear early in life and others near by not until many years later. It is also uncertain (in that there seems to be no really conclusive evidence on the point) whether or not the destruction of a terminal hair follicle may cause a neighboring down follicle to hypertrophy and produce a terminal hair to take the place of the one that was lost.

Change from the downy to the terminal form takes place to a greater or less extent throughout life but is most rapid at about the time of puberty. There are marked sexual and indivdual differences in the tendency to produce terminal hair and also well-known racial differences in this respect. In tracing the development of terminal hair, it will be most convenient to consider different parts of the body separately.

HAIR OF THE HEAD (CAPILLUS)

The scalp, as already stated, is one of the first regions to become covered with primary hair. By the time of birth the hairs, which now represent at least the second or third generation, have reached a length of several centimeters. They are still very fine and silky and covered with cuticular scales that suggest those of down, except that they are rather more irregular and less rounded. There is usually considerable pigment, but no medulla. During the first few years of childhood, the hair becomes much coarser, the average diameter often approaching that of the adult. Most of these coarse hairs of young children are without medullas, although an occasional hair with an interrupted or even continuous medulla may be found from an early age. After puberty, the number of hairs with medullas increases, but as a general thing there are many hairs, even in old age, which still lack a medulla. Consequently, if one were to stick closely to the definition of a terminal hair as one containing a medulla, it would be necessary to regard a considerable part of the hair of the head as transitional. Practically, however, there seems to be no essential difference betwen hairs with and hairs without medullas. Morphologically, they all seem to be modified bristles comparable to the mane hairs of some animals. Between them and the vellus which persists and forms from 6 to 25 per cent. of all the hairs of the scalp, there are all intergradations. The average diameter of the larger hairs has been said to be slightly greater in women than in men.

In middle life, or much earlier in certain persons, some of the follicles cease to produce pigment. The white hairs growing from these follicles are commonly coarser and rarely lack well developed medullas. The frequent coarseness of white hair as compared with pigmented hair of the same person may be noticed in elderly people, in young people with an hereditary tendency to early grayness, and even in pathologic grayness of children. The cause of this relation between the diameter of a hair and its predisposition to loss of pigment is obscure. Apparently, the change in the physiology of the hair follicle takes place at the time a new hair is being formed, since usually, if not always, a hair is entirely pigmented or entirely gray. Among different races and even among different family lines in the same race, there are wide variations in the frequency and extent of grayness.

Finally, at a more advanced age the hair, even though it remains white, again tends to become fine, sometimes assuming a silky character like that of an infant. A similar change is occasionally noticed in younger persons who are becoming bald. In these cases, the delicate fuzz which is last to disappear is probably, although not certainly, largely a growth from follicles which had earlier produced coarser hair, rather than exclusively a persistence of the fine hair which is generally overlooked when the scalp is more luxuriantly covered. The various indications that the same follicle may during a lifetime produce hairs of rather different character, and that its functional activity may vary considerably, do not favor the idea of strictly delimited subtypes of hair on the head. However, there is a universal tendency for group formations of two, three, or even more hairs and considerable normal range in the diameter of the hairs within a small region. It remains to be determined whether follicular atrophy or graying follow a regular sequence in reference to the hairs of a group. Whether or not the return to a more infantile type of hair is accompanied by a change in arrangement from that of the anthropoids to that of the American monkeys, reversing the process which Friedenthal says takes place between childhood and maturity, is unknown. If determined, this might settle the question of whether this late fine hair is simply the persistence of hair that was originally present or the partial replacement of coarse hair that has been lost.

The boundaries of the area which produces the capillus or typical hair of the head are subject to well-known variations. Early in life there is a rather broad transitional zone in which all the hairs are intermediate between capillus and vellus, but later, particularly on the forehead, this zone becomes progressively narrower and the transition proportionately more abrupt. In the back of the neck and in front of the ear, no sharp line of division is established.

The number of hairs in the scalp area varies considerably, and is said to be correlated with the size of the individual hairs and the amount of their pigmentation, finer and less pigmented hairs being more abundant than coarse and darker ones. Friedenthal gives the following estimates for Europeans: light, 140,000; dark, 102,000; red, 88,000. The average length varies greatly with the race but is probably potentially about the same in both sexes of any given race. In white women, it seems to be not far from 60 to 70 cm. The rate of growth averages around 0.4 mm. a day, so it presumably takes from four to five years for one of these hairs to reach its full length. If its entire life span is about four years, as stated by Friedenthal, or according to Stöhr, 1,600 days, it must remain in a resting condition for a very short period. If their estimates are correct, growth of hair is practically continuous in women and also in men.

From an anthropologic point of view, the form and color of the hair of the head have attracted a great deal of attention,[1] but despite an extensive literature, knowledge on these points is still in an unsatisfactory state. The type of hair, whether straight, curly or kinky, was early recognized by anthropologists in England, France and Germany as an important racial characteristic. Later the form of the hair as seen in cross section was emphasized as of great anthropologic significance. The credit of calling attention to this supposed criterion of race is almost invariably given to Pruner-Bey, whose publication in the memoirs of the Anthropological Society of Paris for 1865 is widely quoted. Pruner-Bey emphasized three types of cross-section forms, the elliptical, the oval and the circular, which he regarded as characteristic respectively of the black, the white and the yellow races. In his classification of mankind, groups of the first order are based on the form of the hair as seen in cross section, groups of the second order on the shape of the head, and those of the third order on the color of the hair.

It is interesting in view of the universality with which the first emphasis on the racial significance of cross-section form of the hair is attributed to Pruner-Bey, to find that the same idea, based on an extensive study of the hair of many people, was clearly stated twelve years earlier by Peter Browne of Philadelphia. In his book, entitled "Trichologia Mammalium or a Treatise on Pile," published in 1853, Browne divided mankind into three "species": "the cylindrical piled," represented in his Plate A by an Indian; "the oval piled," represented by a white man, and "the excentrically-elliptical piled," represented by a

1. For the proposed classifications of the human race on the basis of hair form and color suggested by Huxley, Haeckel and others the reader is referred to treatises on anthropology.

negro. In addition to these three main types of hair, which he described and figured in section, Browne recognized several minor subdivisions and variations. It is remarkable that this work which contains a large amount of valuable information on the physical properties and racial characteristics of hair should have been almost universally ignored.

The claims of Browne and Pruner-Bey, however, have not remained unshaken, since it turns out that the cross-section form varies greatly within the same race and even to some extent in the same person. The hair of the Chinese, for example, is often, if not prevailingly, ellipitical, and may be as flat as that of many white people. The cause of the shape of the hair has been the subject of much discussion. According to Fritsch, it is determined by the shape and inclination of the papilla, and

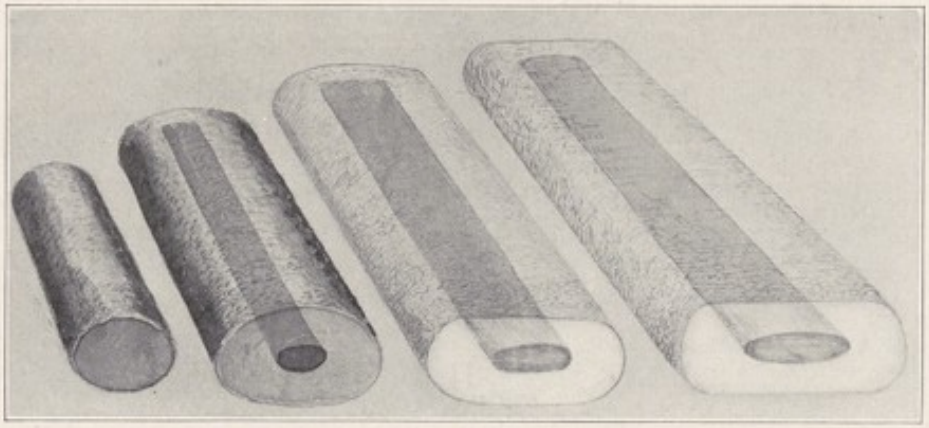

Fig. 40.—Four hairs from the temple of a man 38 years old (about ×200). These hairs grew near together. The two on the left were pigmented, the other two gray. The indexes from left to right were 88, 67, 53 and 42.

this on the whole seems to be the most plausible suggestion, but it cannot be accepted without reservations.

The relative degree of flattening of a hair may be expressed in the form of a hair index, obtained by dividing the least diameter of the hair by the greatest diameter and multiplying the result by 100. The measurements should be taken just far enough from the scalp to ensure maximum values. It will be apparent that the more compressed the hair the lower will be the index. In white Americans, the index generally has a value somewhere between 60 and 90. In twenty-five persons, from the vertex of each of whose heads five hairs were measured, the average index was found to be 73, with a range of from 50 to 89. The actual diameters generally fall between 0.05 mm. and 0.1 mm. Hairs that grow side by side on the same head may vary in their index by 30 points or more (Fig. 40). In the series just mentioned, the average

variation in index for hairs from each of these twenty-five persons was nineteen. It would be premature to make any statement on the heredity of hair form as determined by careful microscopic measurements, but it appears from such data as are at hand that both in index and in actual diameters the hair of the child may occasionally either exceed or fall below that of either parent. In studies along this line, care should be taken to get all specimens from the same part of the scalp, since there are appreciable regional variations.

It will be apparent from the foregoing discussion that the hair shaft is generally a more or less ribbon-shaped structure, much more flattened than is usually imagined even by those who are accustomed to see hairs under a lens, for it requires a specially devised hair rotator of some sort to reveal the true form of the shaft. The shape of the cross section varies widely, approaching a rectangular form on the one hand and a smooth ellipse on the other. This tendency to flattening is remotely suggestive of scales and feathers, but the similarity is probably only a coincidence. A relation between the flattening of the hair and its tendency to curl has often been suggested. Browne, in his discussion of hair types attempts to prove by physical analogy that:

1. Hair that is cylindrical must necessarily hang straightly and lankly from the head.
2. Hair that is oval must inevitably flow or curl.
3. Wool that is eccentrically elliptical must always be crisped or frizzled and sometimes spirally curled.

The first two types of hair, he maintained, leave the skin at an acute angle, the last at a right angle. The latter part of this contention has not been sustained.

Another much discussed explanation for curling is that suggested independently by Gotte in 1867 and Stewart in 1873, who discovered that the follicle of the negro hair is strongly curved or saber-shaped whereas that of peoples with other types of hair is straight. It has been amply shown by subsequent workers that the curly hair of the negro arises from falciform follicles, but opinion has been divided as to whether or not the shape of the follicle could account for the form of the hair. The association of the two conditions seems suggestive; in spite of the fact that the hair is fairly well cornified down nearly to the bulb and the ability of the curved follicle to leave its impress on the shape of the free part of the hair is somewhat doubtful. Perhaps the characteristic bend of the follicle immediately above the papilla is the point where the tendency to curl is really imparted.

Coupled with the long spiral curl of the individual hair is the tendency of groups of such hairs to unite in the formation of ringlets or more tightly wound masses. In the "peppercorn" formation, there are

bare areas of skin showing between each tangle of hair, and much work has been done in attempting to determine whether each tuft of curled hair represents a natural or a chance grouping. Topinard is among those who have expressed the opinion that when the hair is combed out new groups form without reference to the previous arrangements, while Krause and many others have maintained that each group of hairs which naturally curl together do so for some special reason. Frédéric attempts to reconcile the two views on the basis of his finding that while the hairs are uniformly distributed over the head in all races, the direction of follicles is more or less parallel in straight or wavy haired races, but irregular and convergent toward many little centers in the curly haired.

From the point of view of heredity, Davenport regards the type of hair form with reference to the curl as due chiefly to the interaction of a pair of allelomorphic genes in various combinations. Curly hair represents the dominant form, straight the recessive. The dominance, however, is not complete, so that heterozygous persons have wavy hair. According to this hypothesis, straight haired parents should have only straight haired children, curly haired parents predominantly curly haired children. Two wavy haired parents might have curly, wavy or straight haired offspring. On the basis of a histologic study of the scalps of several persons of mixed parentage, Fritsch concludes that while the curly form of hair behaves in general as a dominant trait, there is no clear-cut manifestation of mendelian segregation in later generations.

The character of the hair and follicles has been used as a criterion for determining racial purity. In all study of race and heredity, it is necessary to bear in mind the fact that at least in the white race the hair becomes less curly as the person passes from childhood to maturity. The hair has considerable elasticity and some hygroscopic powers which cause it to respond temporarily to differences in moisture. Advantage is sometimes taken of its physical properties to effect more or less lasting changes in its superficial appearance.

Another factor affecting the appearance of the capillus is the twisting of the individual hairs on their own axis. The flattened shaft tends to twist in such a manner that when the hair is drawn slowly through the field of a lens now one side and now the other appears uppermost. This twisting varies greatly in different hairs, being almost absent in some cases and pronounced in others. It may occur in hairs that have the superficial appearance of being lank and straight. It is possibly an exaggeration of this condition that Pinkus refers to as "bayonet hair." Generally the twisting consists of a series of half turns so that one side of the hair is alternately toward the observer and away from him. The length of hair that is involved in the twist ranges from less than a millimeter to several millimeters, or so great a distance that it is difficult

to detect any twist at all. In general, the twisting is not continuous but interrupted. When the twists or half turns involve only a short distance on the hair shaft, and especially when two or more twists occur close together, the hair tends to change its direction in a way that gives it a peculiar frizzly character. Since this apparently irreversible twisting of the hair on its own axis may be seen even within the follicle, there is some probability that it is determined there, perhaps by irregular or periodic changes in the function of the papilla, or by irregular compression of the sheath immediately above. Strangely, this characteristic has been as much neglected in hair work as some of the other traits have been emphasized. It deserves more careful study and may be found to have a greater anthropologic significance than the cross-sectional form.

Finally, the color of the hair is an obvious and much studied trait. In the white race, the range is great. Except in some black haired strains, children are prevailingly lighter than adults. Thoroughly dependable studies on color should be controlled by the use of standard samples for comparison, and wherever possible should include microscopic study of form and grouping of pigment granules. The color is due to the amount and combination of granular melanins and soluble red pigment. In most cases the former is superimposed on the latter, which behaves in heredity as a hypostatic. There are various grades of intensity in the soluble as well as in the insoluble pigments, and the two seem to be controlled by the same factors, since the intensity of the red hair is correlated with the amount of melanin pigment in the parents. Persons with glossy hair are usually heterozygous for the brown pigments, and consequently when two such marry they are likely to have some red haired children. In some cases the dark pigment is acquired, unusually late, so that a red haired child may have more or less black hair at maturity. Leaving red out of consideration, and making due allowance for age changes, darker hair is generally found to be dominant to lighter, so that the child is rarely if ever darker than his darkest parent. Whether or not there may be more than one form of light hair, from the genetic point of view, has not been determined, but if so, there should be rare cases in which light parents produce dark children. Albinism, as is well known, affects the hair, which in some cases is quite white. There is a form of dominant spotting which produces most commonly a white forelock. Sometimes red spots appear on a black field. There are also not infrequent variations of several shades between hairs from different parts of the same scalp. According to a report on army anthropology from the Surgeon-General's office, 100,000 soldiers demobilized in 1919 showed the following proportions of the different hair colors for every 1,000 men: flaxen, 46.67; light brown, 222.77; medium brown, 212.57; dark brown, 460.69; clear red, 12.66;

red and black (i. e., glossy black), 44.64. Total, 1000.00. The incidence of the various colors differs considerably in different states and sections of the country, depending on the racial stocks which prevail there.

As is well known, hair has some capacity to take up stains artificially, as is exemplified by the green hair of copper workers. Friedenthal describes a family characterized by hereditary chrysochloris or "rainbow colored" hair due to some physical property resulting in iridescence.

The various characteristics of hair are undoubtedly determined in large measure by its chemical composition. Rutherford and Hawk conclude, on the basis of what in some respects is inadequate material, that the chemical composition of the hair of the head is influenced by six factors: the race, sex, and age of the person, the color of the hair, the purity of breed, and whether the sample is from a living or a dead subject. Their figures for the percentage distribution of chemical elements in the hair of several groups are given in Table 2.

TABLE 2.—*Percentage Distribution of Chemical Elements in the Hair*

Subjects	Sulphur	Nitrogen	Carbon	Hydrogen	Oxygen
Indians	4.82	15.40	44.06	6.53	29.19
Japanese	4.96	14.64	42.99	5.91	31.50
Negros	4.84	14.90	43.85	6.37	30.04
White adults	5.22	15.79	44.49	6.44	28.66
White children	4.93	14.58	43.23	6.46	30.80

EYEBROWS (SUPERCILIA)

The development of the eyebrows has already been described. At the time of birth, they consist largely of down or hairs only slightly coarser than down. Little by little the down is replaced by terminal hairs of a special type. These hairs have a well-known crescent shape with attenuate or acuminate ends. Many of them are wide in proportion to their length. They are not arranged in group form. The scales are relatively large and moderately flattened except toward the ends. The medulla is conspicuous through the middle part of the hair. The shaft is flattened with a cross section that is more or less angular. According to Friendenthal, the total number of hairs in each eyebrow ranges around 600, and the life span of an individual hair averages about 112 days.

A curious metamorphosis takes place in many of these hairs in the majority of men and in a few women. This change is unusual before the thirtieth year, but may occur in children. It consists in the replacement of some of the typical eyebrow hairs by long irregularly curved or twisted forms with the general characteristics of beard hair. They may reach a length of 6 or 8 cm., and generally have to be kept trimmed. When single or few, they are commonly called "wild hairs"; when more numerous, they produce the effect characterized as "bushy eyebrows."

There is no reason to think that they are a partial reversion to a sinus hair form. Instead they may be regarded as a characteristic manifestation of the general tendency for coarser hairs to appear in various places at and after middle age.

There is considerable variation in the length, width and configuration of the eyebrows. They are sometimes continuous across the middle line. This condition, frequently regarded as hypertrichosis, is possibly due to an embryologically more anterior origin of the eyes or to some other factor causing a lesser interpupillary distance and concomitant slight expansion of tissues near the midline. The direction of hairs in the eyebrows is interesting. According to Frédéric, the prevailing primary arrangement in the fetus shows a division into a short medial and a long lateral portion. This division in the fetus undoubtedly represents the natural part in the eyebrow that is frequently to be seen in adults. Medial to the parting the direction in both fetus and adult is upward and outward. Laterally, there is a narrow zone above in which the hairs point downward and inward and a wider zone below in which they point upward and outward. Since these relations are established in the early fetus, they cannot be attributed to the direct effect of repeated muscular pull.

EYELASHES (CILIA)

In general structure and appearance, the eyelashes are practically identical with hairs of the eyebrows, except that they are typically longer and slightly more curved. They are exclusively of the terminal hair form, all down having disappeared from among them before birth. They do not undergo the later hypertrophy common in hairs of the eyebrows. It is claimed that they are slightly longer in women than in men. LeDouble and Houssay describe an hereditary variation in which the lashes of the upper lid are arranged in three equal rows. Friedenthal says their duration of life is 112 days, with a possible variation of 30 per cent.

THE BEARD (BARBA)

Because of such of its peculiarities as are associated with race and sex, the beard is of particular interest to students of hair. It varies greatly in extent and thickness. In some races, it is virtually lacking. The vellus of the chin, cheeks, upper lip and fore part of the neck corresponds to that on other parts of the body and shows no sexual or, so far as known, racial, differences during the first few years of childhood. In boys of heavily bearded strains, some of the down at the lateral corners of the upper lip begins to be replaced by terminal hair at about the time of puberty. These restricted areas of terminal or transitional hairs spread gradually toward the middle line till a soft downy

mustache has formed. This requires a considerable period, during which time growth of the hair is relatively slow. By the time the mustache has become apparent, scattered, short, and often curly terminal hairs have developed on the fleshy part of the chin. It is at about this stage that the boy usually begins to shave. Further development of the beard consists in the enlargement of terminal hairs already present and in the appearance of new ones. The latter process results in an increased thickening of the beard on the chin and an extension of the beard covered area. This extension proceeds from centers on the chin and in front of the ears. The downgrowth of hair in the latter area produces the effect of a gradual invasion of the parotid region by the capillus. Careful examination, however, shows that, at least later in life, a transition in characters between the hair of the scalp and that of the face takes place at about the junction of the temporal and parotid regions. The parotid and mental hair areas ultimately become confluent, covering the cheek and extending downward through practically the whole anterior triangle of the neck, and to some extent over the skin above the sternocleidomastoid muscle. The upper boundary of the beard area in its full development is represented roughly by a line drawn from the corner of the nostril across the zygoma to the highest point of attachment of the ear. In front of the ear, there is a zone about 1 cm. wide in which terminal hair is lacking.

The development of the beard is slow and does not reach its ultimate extent till many years after puberty. In fact, it has been shown (Trotter) that the average diameter of beard hair increases throughout life. Another point of considerable interest is that only a part of the down hairs are ever replaced by terminal hairs, so that in the beards of men at all ages fine down like that on women's faces is always present. Further, it is only in relatively exceptional cases that the beard reaches the full development just described. A "bald spot," or an area lacking terminal hairs, is common on the lower lip to either side of the midline. The middle region of the cheek also frequently has relatively little or even no terminal hairs. In most negroes, in Indians, in Chinese, and with few exceptions in the darker races generally, the beard is scanty or even lacking in some. It is in the white race that the heavy beard characteristically appears, but even among white men there is wide variation, and frequently it is deficient. In general, the more completely the face is covered, the more numerous are the terminal hairs in the areas where they first appear.

It is interesting to observe that the distribution of the beard in races in which it is little developed corresponds to stages in the development of the beard in young persons of more hairy races. Thus the mustache is the part that is most universally present. Very few men and no

race except, according to Branca, some Australians, who have much other facial hair, lack a good mustache. Some Indians have a few hairs on the upper lip and practically no other indication of beard. Others have a better mustache and a slight beard on the chin with the rest of the face smooth, and so on. Thus, two closely parallel series could be arranged by taking, on the one hand, progressively older boys and young men of a hairy race, and on the other, a series of progressively more heavily bearded old men of less hairy races. This regularity, developmentally and comparatively, in the sequence of appearance of terminal hair on the face is undoubtedly significant, and probably means that the different regions have a certain degree of autonomy and a characteristic reaction to whatever it is that causes hair to grow. It likewise suggests that different follicles of the same region have different

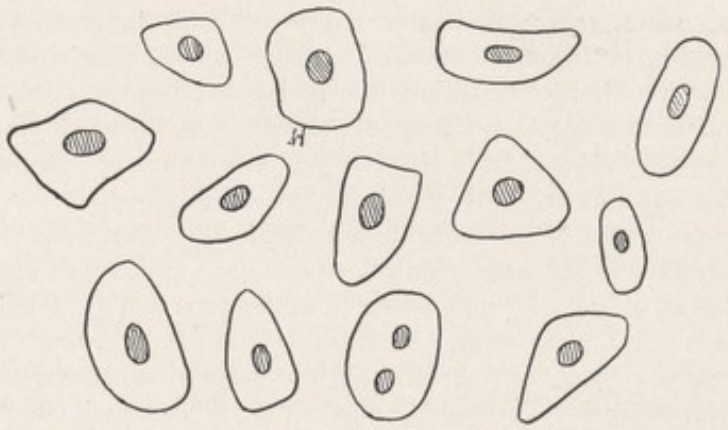

Fig. 41.—Cross sections of beard hairs from an adult man (×82). The four in the upper right part of the group are from the cheek, the five to their left from the upper lip, and the four at the bottom from the chin. One of those shown in the bottom row had two distinct medullas.

susceptibilities, since in general the more restricted the region in which terminal hairs appear the fewer are the terminal hairs to the unit areas.

Phylogenetically, the beard is probably related to that of some of the apes in which its appearance, especially in the orang-utan, is more or less suggestive of the beard in man. In the orang-utan too the mustache when present is more definitely developed toward the corners of the mouth. The question of homology, however, is complicated by the large proportion of sinus hairs in ape beards and their complete absence in human beards.

The individual hairs form a complete series from down to long coarse bristles. Typical beard hairs are variable in shape, with large medullas and flattened, somewhat irregular, scales. The form in some cases closely simulates that of hair from the scalp. Others, especially

the larger ones, are more or less prismatic with triangular or polyhedral cross sections (Fig. 41). The angles are generally rounded; the sides may be either convex, nearly plane, or concave. A common form has three rounded angles with one short convex side and two longer nearly straight sides. This is the effect that would be produced by thickening one side of any ellipse. The normal length up to middle life is probably about from 20 to 30 cm. in the average white man, with a tendency to become decidedly longer in Semitic races. In colored races, it is generally shorter. Like the hair of the head, it may be straight, wavy or curly, and the characteristics of the follicles for these several types should be more thoroughly investigated. The life of a beard hair has been estimated by Friedenthal as from ten to twenty years, which is probably much too long.

The color of the beard is probably never darker than that of the capillus, except where the latter has preceded it in turning white. Darwin called attention to this fact long ago, and emphasized the frequency with which the beard is red in both men and apes. The combination of black hair and red beard is common. On the whole, the hairs of the beard are much less uniformly pigmented than are those of the head, black and blond hairs often being intermingled.

In women, the beard generally remains in the down form. About 30 per cent., however, have a mustache nearly or quite as well developed as that of the average boy at the time he begins to shave, and the number of women who shave or use other means of depilation is much greater than is popularly supposed. It is often stated that the mustache is better developed in dark haired women than in those with light hair, but the critical measurements made by Trotter have failed to substantiate this claim. It may be that there are racial differences, and it has recently been possible to demonstrate a strong tendency to familial idiosyncrasies in this respect. Women with beards on other parts of the face are much less common, and those with a full beard are unusual. This matter will be discussed in the section on hypertrichosis.

In both sexes, Trotter found the number of facial hairs visible with a hand lens to be essentially the same. She likewise found no constant differences between white and negro subjects. But there are characteristic differences for different regions of the face and rather wide individual fluctuations. Disregarding the minute vellus, and counting only such hairs as are revealed by a low magnification, the most frequent numbers to the square centimeter according to Trotter's figures are as follows: cheek, 74; lower lip, 99; side of chin, 86; center of chin, 91; upper lip, 107. It seems probable that if the down hairs could all be counted, the number for each area would still be found relatively constant; in other words, that individual and racial differences in the

beard are due not to the actual number of hairs to the unit area but to the number of those hairs that show a greater or less degree of hypertrophy. The duration of an individual down or transitional hair on a woman's face is unknown.

HAIR OF THE EAR (TRAGUS)

At birth the ear is often covered with conspicuous lanugo-like hairs. On the pinna, they converge toward a point at about the site of Darwin's tubercle, giving the infant when viewed from the side a particularly fawnlike appearance. These hairs are soon replaced by secondary hairs, which in most women and many men retain their typical down character throughout life. With some men, during the third and more especially subsequent decades, coarse terminal hairs appear on the tragus and to some extent on the margin of the pinna. The terminal hairs on the tragus, which may vary in number from one to a large tuft, partake of the general character of wild eyebrows which usually appear at about the same time. On the pinna itself, they not infrequently take the form of elongated down when hairs of great delicacy may be as much as 2 cm. in length. Ultimately, these also become typical terminal hairs. Both on the tragus and on the pinna the amount of terminal hair, if present at all, seems to increase steadily with advancing years. Whether or not its production is an hereditary trait, does not seem to have been determined.

HAIR OF THE NOSE (VIBRISSAE)

The hairs that grow in the nostrils have a prior claim to the designation vibrissae, but the term is also commonly applied to the wholly dissimilar and unrelated tactile hairs of lower mammals. The vibrissae of man bear a strong resemblance to eyelashes in general proportion, curvature, scales and medulla. Like them, they are decidedly flattened in one plane and as a rule show little tendency to rotate on their axis. They differ from eyelashes in the possibly somewhat less regular medulla, the frequently greater size, and particularly and characteristically in their much blunter ends. Where the former terminates in a decidedly acuminate tip, the latter narrows abruptly (for a hair) to an acute point. Vibrissae occur, but, as well developed hairs, are relatively much less common in women.

As an occasional family trait, the down near the tip of the nose becomes more or less enlarged and may form conspicuous terminal hairs.

AXILLARY HAIR (HIRCUS)

The axillary hair first becomes apparent at about the time of puberty, but the follicles from which it will grow can be recognized macroscopically long before that time. In the adult, the individual hairs are

flattened, often having an index of fifty or less. The cuticular scales are rather irregular and perhaps more divergent than in most other terminal forms, since they offer considerable resistance when a hair is drawn through the fingers from tip to bulb. They are of about the same absolute size as those of the hairs of the head, but relatively they are considerably smaller. There is a well developed continuous medulla. The hair shaft, which is generally from 4 to 8 cm. long and very tapering, is twisted irregularly on its own axis. As in the hair of the head, the turns may be through any number of degrees, from a slight deflection to a complete revolution, and they may be short or long drawn out. Each turn, or partial turn, is usually accompanied by a deviation in the direction of the hair, those which are completed within 2 or 3 mm. producing angular bends in the shaft, while the more gradual turns result in wider curves. The rather large diameter of the shaft and the irregular combination of short and long turns with the resultant angular and curved deflections give the hair its characteristic kinky appearance. A regenerating axillary hair attains its full length in about three and a half months, but how long it persists in a resting stage is not known.

There is little or no sexual difference in the axillary hair. It has been reported by some authors to be more abundant in men, by others as better developed in women. Like the beard, it is not often darker than the hair of the head. Frequently it is dull red. No satisfactory suggestion as to its function has been advanced.

PUBIC HAIR (PUBES)

Pubic hair differs little from that of the axilla. It is slightly larger in all dimensions and perhaps relatively more flattened, since the index not infrequently falls below 50. In other respects, the two are alike. As transitional forms they may be recognized long before puberty. Sexual differences in the individual hairs are slight. They are probably rather longer in men and relatively coarser in women. The color corresponds to that of axillary hair. Of 1,000 women and girls examined in Berlin, Bartels reports that 333 had dark head hair and 667 light, and that of this same thousand, 329 had dark and 671 light pubic hair, indicating a rather close general correlation between the color of head and pubic hair.

The area covered by pubic hair is not quite the same in the two sexes, since in the female the labia minora and medial side of the labia majora are without hair, while the homologous regions in the male are in part covered by hair. Otherwise constant differences are slight. In the majority of women and many men, the upper border of the pubic hair forms a nearly horizontal line at about the boundary between

the pubic and hypogastric regions. In a few women and most men, terminal hair is also present in the hypogastric region, rising in a triangular formation to or toward the umbilicus. This hair, however, is not typical pubic hair, being softer and sometimes of a different color. This suggests that the hypogastric hair belongs with the terminal hair of the trunk and does not in the true sense represent an upward extension of pubic hair, the upper limit of which may consequently be regarded as the same in both sexes.

The function of the pubic hair is not very evident. Many hypothesis have been put forward to account for its presence, not the least bizzare of which is the serious suggestion that in the prehuman era when the species was becoming hairless but when the mother could ill afford to spare an arm for holding her young, natural selection resulted in the retention of tufts of hair in the axillae and on the pubis to which the nursing apelike infant could cling with outstretched arms and inturned feet. On this hypothesis the appearance of hair in these regions in men might indicate an early participation of the male in care of the young, or it might represent a transfer of a trait to the opposite sex. The one suggestion that has not been urged is that the axillary and pubic hair has no important function.

HAIR OF THE TRUNK

In addition to pubic and axillary hair, over 90 per cent. of white men and about 35 per cent. of women have more or less terminal hair on their bodies. Terminal hair of the trunk is intermediate in character between that of the axilla and of the head, finer than the former, stiffer and more flattened than the latter. There is considerable variation in length, but body hair is usually shorter than the axillary hair of the same person, all gradations between down and well developed terminal body hairs occurring (Fig. 38). Pigmentation is generally similar to, or lighter than that of the hair on the head, but is occasionally darker. The rate of growth on the chest is about the same as on the head.

The regions in which terminal hair most frequently appears on the body are the hypogastric, the region of the nipples, center of the chest, and lumbar region. A band of terminal hair on either side of the umbilicus over the rectus muscle, epaulets in the deltoid region and infrascapular patches are common. Observation of many thousand soldiers gave the impression that the different regions mentioned have a certain degree of autonomy in respect to their hair growth, but that there is in general a more or less regular sequence in the regions that are covered. Thus, if there is only a little terminal hair on a man's body, it is almost invariably found in the hypogastric region, giving the appearance of an angular rather than a straight superior border to the

pubic hair. In most men, this about reaches the umbilicus. When there is more terminal hair, it is found in the hypogastric region and also around the nipples and in the center of the chest. Next, the hairy covering of the latter regions becomes confluent, and another patch occurs above the umbilicus or on the shoulders. By further extension and confluence of these hair patches, the whole anterior surface and often the posterior surface of the trunk becomes covered with a thick growth of terminal hair. The latter condition was met in about 0.4 per cent. in a series of some 10,000 soldiers. An independent growth of hair in the lumbar region is in general quite normal but may at times have a pathologic significance. It will be discussed in the chapter on hypertrichosis.

With women, the amount of terminal hair is generally slight, often consisting of only a few scattered hairs, which, however, are of the same character as those in men. They are most frequently found around the nipples and next in the center of the chest. There is some evidence that they are slightly more abundant in dark than in light subjects of both sexes. They are uncommon in the negro but when present conform to the same general pattern. The marked sexual dimorphism in this respect raises the question as to what are comparable conditions in the two sexes. In a recent discussion of the subject, Danforth and Trotter conclude that over half of the white subjects are included in a group in which the women have no terminal hair in the regions under consideration, and the men have as a maximum well developed hypogastric hair and a moderate amount on the chest and about the nipples. If subjects are classified simply according to the presence or absence of terminal hair, the corresponding group for men and women are of different size.

HAIR ON THE EXTREMITIES

It is unusual to find a person who does not have some terminal hair on the legs. In childhood transitional hairs are conspicuous. These are later replaced in part by terminal hairs, which resemble those on the body but are generally shorter. In some women, they are limited to a few on the inner side of the leg, but frequently their number is considerably increased. In many men, the entire leg is covered with possibly fifteen or twenty to the square centimeter. In some instances they are noticeable only near the ankles, at other times they are abundant above and terminate abruptly along a transverse line just below the calf and an oblique line from without inward across the front of the leg. Kidd noticed the latter arrangement and attributed it to "use inheritance" due to the tight fitting shoes of ancestral generations. There is much variation in the pattern of the areas of terminal hair

on both the leg and the thigh. In the latter region, it is characteristically present in men, prevailingly absent in women.

On the forearm, terminal hair first appears just above the wrist and extends downward over the hand and upward to the elbow. From the latter, it continues on the exterior side of the upper arm nearly to the shoulder. The front of the upper arm, the hollow of the elbow and an ill-defined area on the upper half of the flexor surface of the forearm are practically free. The bare area on the front of the wrist and the common absence of hair from the middle segments of the digits have already been mentioned.

SUMMARY

The study of human hair reveals a wide range of forms appearing not only in different racial stocks but even in the same person at different times and in different parts of the body. One of the outstanding peculiarities of the pilary system is the ability of certain hair follicles to produce a series of similar down hairs during a period of years, and then, with a few transitional forms, to convert its subsequent production into the very different type of terminal hair. The capacity, and not infrequently the tendency, to form terminal hair seems to inhere in many and perhaps all down hair follicles. The question of what influences may awaken this tendency is one of the fundamental problems in the study of hypertrichosis.

In the white race, at least, there are few if any sexual differences of importance in the hair before the middle or latter part of the second decade of life. Up to this time, the hair of the head, eyebrows, eyelids, axillae and pubes is essentially the same. From this time on men acquire a greater abundance and wider distribution of terminal hair, while many women, as Friedenthal has remarked, retain almost unchanged throughout life the amount, character and distribution of hair that is typical of the boy of 15 or 16. But while the factors that make for increased production of terminal hair are more effective in men, they are not altogether lacking in women. In both sexes, they seem to increase with age.

CHAPTER V

FACTORS AFFECTING THE GROWTH OF HAIR

Although complete agreement as to the exact nature of the histologic changes that take place in the follicle during growth and replacement of hair is still lacking, the general character of these processes is more or less evident. But when it comes to the factors that control, or even influence, production of hair, the available information is far less satisfactory. Even in the apparently simpler phases of the problem, those relating to the normal duration of life for individual hairs and periods of activity and quiescence in the follicle, there is a deficiency of convincing data. This is not because of lack of work in these lines, but is due rather to certain inherent difficulties in the problem and occasionally, perhaps, to faulty premises as to the character of hair growth in general. The evidences of endocrine and other indirect influences are abundant, but they are exceedingly difficult of interpretation.

One of the first points that it would seem necessary to settle in any attempt to determine and evaluate the factors regulating hair growth, is the normal cycle of hair production. This has been studied in several ways. Estimates of the duration of the cycle have been based on the rate of growth of hairs, the frequency with which the hairs fall out and on indirect evidence of the cyclic activity of individual follicles. The growth of a hair after shaving or cutting can be easily measured and the rate of further growth determined. While this rate fluctuates to some extent, it is fairly constant for a given region and size of hair. The individual differences for healthy persons of the same age and sex are usually not great. In a series of eight young women, Trotter found that the average rate of increase in length for a unit of time was roughly proportional to the diameter of the hair. The range of variations (including any possible observational errors in selection of hairs) and the average rates of growth are indicated in the accompanying extract from one of her tables (Table 3). If the hairs from each region had always been of exactly the same diameter, the fluctuation in recorded length increase would no doubt have been less. Knowing the rate of growth for a hair, it is easy to determine the time necessary for it to reach its maximum length. If there were no resting period, this would amount practically to the life span of the hair, as some authors have assumed. Friedenthal's determinations seem to have been made by dividing the total length by the rate of growth, without allowing for periods of quiescence.

CYCLIC ACTIVITY OF THE FOLLICLE

Nevertheless, a resting period undoubtedly does occur, as histologic appearances clearly show. But unfortunately, not much good evidence is found as to how long a time elapses between the cessation of growth and the cornification of the bulb with atrophy of the papilla or between these processes and the resumption of hair production. In animals that molt at definite seasons, the hair generally reaches its full length in a relatively short time and then remains stationary for several months, so that active functioning of the follicle occurs only at infrequent intervals and lasts for comparatively short periods. The histology of the cycle in animals has been studied in great detail by Schwalbe and others, but adequate study of bodily changes which condition molting and replacement should throw much additional light on hair regulation in man.

TABLE 3.—*Range of Variations and Average Rate of Growth of Hair*

Region of Body	Average Increase (8 Subjects) for Each of Six Weeks						Weekly Average for from Six to Eleven Weeks
	First	Second	Third	Fourth	Fifth	Sixth	
Axilla	3.0	2.4	3.6	2.6	2.8	2.6	2.92
Vertex	3.0	2.8	2.6	2.5	3.5	2.9	2.73
Leg	2.2	1.8	2.4	1.4	0.7	1.3	1.62
Arm	1.5	2.5	2.0	1.2	1.2	0.8	1.52

The careful studies of Giovannini, who pulled out hairs from the scalp and then after varying periods excised the skin and sectioned it, indicate that regeneration of the capillus begins at from forty-one to seventy-two days after epilation. It is not safe, however, to assume that this is the normal resting period of the follicle, for the forcible removal of a hair may involve a certain amount of traumatism that might tend to delay the resumption of normal function. On the other hand, it is quite possible that pulling a hair out might be a stimulus to follicular activity, just as a new crop of feathers may develop when a bird is plucked at a time other than the molting season.

The most reliable way to determine the resting period is probably to watch individual hairs and their successions through a period of several years. Terminal hairs on the ears and in the eyebrows watched in this way showed an occasional quiescent period lasting for as long as three months. Since it took these particular hairs about eight weeks to grow to their full length, the resting period of the follicle would seem in these cases to be rather longer than the period of activity. Likewise Trotter, in the above mentioned study, found that hairs on the leg and arm may persist without being renewed for at least eleven weeks after their full length has been attained. This is as long as or longer than it takes these hairs to grow.

While this evidence indicates that in some follicles the resting period may be fully as long as the period of active hair production, it does not follow that this is universally the case. It is possible that in the hair of the head, for example, there is an almost incessant follicular activity, each hair being replaced nearly as soon as it reaches its full length. This question could no doubt be answered with certainty by watching the hair production of a number of definitely identified follicles during a period of four or five years.

RESPONSE OF THE FOLLICLE TO INJURY OF THE HAIR

Without knowing exactly what a hair follicle might be expected to do under normal conditions, more or less uncertainty necessarily attaches to conclusions drawn from its behavior when the conditions are modified. Nevertheless, there are many unfounded or ill supported beliefs which have become widespread and generally accepted. One of the most prevalent of these views is that cutting, and especially shaving, the hair not only accelerates the growth of the hairs that are cut but also stimulates the neighboring hairs to increased growth. It is possible that this is true, but it is probably safe to state that no unquestionable scientific evidence for such a view has been presented. On the other hand, there is considerable evidence to the contrary, and in view of the practical importance of these questions, it seems worth while to present some of the considerations that bear on this point.

In the first place, it is easy to draw, subconsciously, an analogy between the growth of hair and the growth of grass or twigs. Clipping off a twig from the hedge removes a growing point and results in the deflection of the growth material to buds which might otherwise have remained latent, with the result that often two or more twigs grow where only one was before. In the case of hair that is cut, the growing point remains undisturbed and continues to utilize the nutriment brought to it as before. It is frequently stated that a more or less extensive growth of terminal hair, particularly on the face in women, has followed the shaving of only a few hairs that appeared originally, and shaving is usually assumed to have been the causative factor for the increase. But when it is recalled that the appearance of terminal hair is in general a gradual process and the presence of a few hairs frequently presages the subsequent appearance of more, even in the absence of all treatment, the value of the evidence on this score is greatly impaired. In case a hair is killed, by electrolysis or otherwise, it might seem probable that its absence would favor the growth of hairs nearby. Bodin (Pratique dermatologique) states that such is the case at least in women under 30, but he does not present conclusive evidence for this statement, which

must consequently be accepted with reservations. In order to prove that killing or even cutting one hair favors the growth of other hairs it is necessary to show, under carefully controlled conditions, an actual increase in the neighboring hairs or to explain how such an effect could be brought about.

Even though there might be serious doubt as to the possibility that injuring one hair is beneficial to others, one would naturally have much less hesitancy in accepting the dictum that cutting or shaving profoundly alters the growth processes in the hairs that are affected. But here again the most critical evidence points in the other direction. As in the first case, there are several reasons for popular misconceptions. For example, a young man's beard is soft and fine when he begins to shave, but after a few years it is observed to be relatively stiff and coarse. The fact remains, however, that in subjects who never shave the beard may become quite as coarse as in those who have shaved for a number of years before allowing their beard to grow. Thus two men of about the same age, one of whom had shaved regularly for twenty years, the other never at all, had facial hairs that were, so far as could be determined, of the same diameter. Superficially, closely clipped or recently shaved hair appears stiffer and coarser than ordinary hair, but this is only a simple physical effect due to the ratio between diameter and length of the projecting shaft. This explains why after three or four days without shaving the beard begins to seem softer. The illusion is heightened by the fact that in cutting or shaving, the attenuated tips of the hair are cut off leaving the ends blunt. All such sources of error must be eliminated in attempts to determine whether or not shaving or cutting of hair results in any change in the character of the hair growth.

NEGATIVE RESULTS FROM SHAVING

The effect of shaving has been tested on the hairs of various parts of the body in both sexes, and some of the results have been reported in papers mentioned above. The procedure has been either to make careful measurements of the hair at the beginning and at the completion of the experiment, or to compare accurately symmetrical areas on the body, shaving one and using the other as a control. The results have been uniformly similar. For example, a man with a moderate amount of hair on the chest shaved the whole anterior part of the body twice a week for eight months and then allowed the hair to grow undisturbed. At the end of five months more, the new growth of hair was carefully compared with the original, which had been retained. No differences could be detected in amount, length, diameter or pigmentation. The down hair likewise remained unchanged.

Even hairs in which there are sexual differences, and which consequently might be expected to be in a more unstable state and likely to respond readily to unusual conditions, apparently show no changes as a result of shaving. Three women subjects shaved one leg from the knee to the ankle twice a week for eight months without being able to produce any change in the hair growth. Three likewise shaved the hypogastric region for an equal length of time without changing in the slightest the character of the vellus, despite the fact that in most men and many women some of this vellus spontaneously changes to terminal hair. These results from shaving various parts of the body make it seem probable that regular shaving for a long period would not cause an increase of facial hair in women or improve the beard in men, but in view of the demonstrated differences in the hair of different regions, such a statement cannot be made with absolute assurance until exact experiments have been carried out. Nearly every man performs one such experiment with the down on his cheeks and chin. It is amply demonstrated that this down may be shaved (along with neighboring terminal hairs) almost daily for long periods of years without causing it to deviate from down that is never shaved.

Views quite different from these are often expressed and generally accepted, but, as previously stated, there is some question as to their validity. In this connection, studies of the hair bulb, while carried out on lower animals, are illuminating. Perhaps the most generally cited of these are the investigations of Remesow, who published a treatise on hair growth at St. Petersburg in 1898. According to Remesow, the growth of hair in dogs and rabbits is promoted by cutting; and especially is this the case if the hair is subjected to three successive clippings, removing about a third of the original amount on three successive days. If the final cutting is made close to the skin, with a razor, it is said to be especially efficacious. The statements are based on a series of experiments in which, after cutting the hair in this manner, and allowing another five or six days for the effects to become apparent, the skin was removed and sectioned microscopically. At the same time, a control piece of skin, symmetrical with the one removed, but undisturbed by shaving or other unusual treatment, was also preserved. The two pieces were then studied and the follicles compared as to absolute size and number of mitotic figures. This has the appearance of a critical procedure, and it is not surprising that the conclusions drawn from the work have been generally accepted. According to Remesow the follicles in the skin where the hair had been cut or shaved showed a greater size and succulence of the hair bulb and an increased number of mitotic figures, both of which phenomena are indicative of increased growth.

The number of mitotic figures, however, was always small, and normal variation in the size of follicles makes it difficult to determine their relative size.

Schifferdecker and Bischoff, accepting these results as established, attempted to determine whether or not the impulse resulting from cutting the hair was conveyed to the bulb through the marrow. After a series of negative results, they were led to repeat Remesow's experiments. Their work, as carried out and reported chiefly by Bischoff, shows a complete failure to substantiate any of the original claims, even though Remesow's procedure was followed throughout, except for occasional unessential deviations or refinements. Bischoff states that he was unable to detect any differences in the size or character of the bulbs or in the frequency of mitotic figures between the side on which the hair was cut and the side on which it was left undisturbed. The number of mitoses was determined by counting those visible in longi-

TABLE 4.—*Mitoses in Follicles of Cut and Uncut Hair*

Animal and Age	Treatment of Hair	Number of Follicles Examined	Total Number of Mitoses	Average in Round Numbers	Maximum Number in a Single Follicle	Minimum Number in a Single Follicle
Dog, 3 years	Cut	30	142	5	12	1
	None	30	135	5	11	0
Dog, 2 years	Cut	30	169	6	11	0
	None	30	249	8	18	3
Dog, 1 year	Cut	30	119	4	9	1
	None	30	114	4	9	1
Cat, 3 months	Cut	30	113	4	8	0
	None	30	112	4	7	1
Pig, 2½ months	Cut	18	175	10	17	3
	None	18	221	12	22	6

tudinal sections of follicles whose papillae were in view. Table 4, which is taken from Bischoff, with some abridgement, shows in the upper line after each animal the number of mitoses in follicles of hair which had been cut on three successive days and then allowed a few days to regenerate; in the lower line are corresponding figures for follicles of uncut hairs from a symmetrical position on the other side of the body. A striking similarity between the two sides is shown, and the only data reported for cases in which the hair was shaved show an even closer agreement between the treated and untreated sides. One might wish that Bischoff had supplied more complete data as to the general condition of the pelt in his animals; but as it stands, this affords very good evidence against the assumption that cutting or shaving the hair increases the number of mitoses in the bulb. The lack of agreement between Bischoff and Remesow seems to be due to the latter having failed to make sufficiently careful counts and measurements. In spite of this evidence, it seems that hair grows out on the shaved skin of an animal sooner than

it is normally replaced in the absence of shaving. It is clear that all of this work should be repeated under fully controlled conditions.

Bischoff makes the interesting suggestion that disturbance of the hair, instead of increasing the number of mitoses in the bulb at any one time, may perhaps increase the rate at which mitoses are completed, so that the total number of cells dividing in a day is greatly augmented. This would be difficult to prove, and there is no need for such an hypothesis until it is shown that the growth of hair is augmented by cutting or shaving. That such is the case, has not been clearly established. Indeed, there is some evidence that the hair follicle passes through its periods of activity and quiescence irrespective of whether the part of the hair beyond the skin remains intact or not. Easily identified hairs of the eyebrow and tragus cut down to 5 or 10 mm. in length may remain unchanged for several weeks or months, at the end of which time they fall out and are replaced by new hairs; they do not themselves regenerate. Trotter also reports similar results for hairs on the leg, where she found that those which were growing at the time they were shaved continued to grow at the same rate, while those that had stopped growing were uninfluenced by shaving. In another subject, thirty hairs on the basal segment of an index finger were cut and then shaved close to the skin. At the end of three weeks, several of these hairs had fallen out, fifteen others showed no indication of growth. There were three that had grown to about 2 mm. in length and five that had reached from 4.5 mm. to 5.5 mm. The rest, which tapered more or less to their cut ends, were about 7 mm. long. There were several new hairs replacing the old ones which had fallen out and others growing beside still persistent blunt stubs. Of the original thirty follicles, twelve showed no indication of activity during a period of more than three weeks.

There still remains the possibility that a hair which has begun to grow can be kept growing longer than would be normal by frequently cutting off the tip, but there is perhaps no real evidence for this. On the other hand, some indications are against such an idea. Thus in the experiment in which the chest was shaved regularly for eight months and then left unshaved, it was found after several weeks that many of the hairs had cornified roots and came out with a minimum of tension, i. e., were undoubtedly falling out spontaneously. These mature hairs, which continued to be shed, were at first short with bluntly cut ends; later, those with pointed ends became more abundant, and the ones with cut ends, fewer and generally longer. These phenomena are completely explained on the assumption that the shaving had no effect on the follicles, which at the time the experiment stopped were in various phases, some just starting a new cycle of hair production, others nearing

the end of a cycle. Those in the latter phase round out their period by producing the proximal end of a hair and then going into a resting phase. The amount thus produced would depend on the phase in which the follicle happened to be. That the short blunt hairs which were falling out did represent the basal part of a hair was indicated by the fact that they were indistinguishable from long hairs when enough of the distal ends of the latter were cut off to equalize the lengths.

If it is true that the activity of the follicle is in no way affected by shaving, the average life of the hairs in any region might be estimated by counting all those in a given area and then shaving or cutting them close to the skin, when the number which failed to show immediate growth would indicate how many follicles were in the resting condition. The proportion of resting follicles, the rate of increase in the growing hairs and the normal length give the necessary data for determining the average life span of a hair. If the periods of follicular activity and quiescence are equal, about 50 per cent. of the follicles will be in a resting stage at any given moment, and the percentage will rise or fall as the ratio between the lengths of these two periods varies. Apparently, when the head or face is shaved, most of the cut hairs grow out at once, and if this is really the case, it might indicate that the hairs in these regions come from follicles which not only have greatly lengthened growth periods, but also much shortened resting periods.

Ways in which a cut hair might react on its papillae could easily be postulated. The cells of the medulla might be functionally active protoplasm and conduct an impulse to the papilla (Bischoff's original hypothesis); the space among the medullary cells might conduct oxygen or other gas to the papilla; or conversely, they might draw off something from the papilla; or the injured hair might begin a slow disintegration, the by-products of which are stimulating to the papilla; or again, the short hair stub might produce a different mechanical effect on the whole follicle, directly or indirectly through the arrector pili muscle. Any differential reaction which a cut hair, in contrast to a normal one, could produce on its follicle, or its papilla, might serve to explain the supposed regeneration as a result of cutting, but up to the present time attempts to discover such a reaction have met with little success. It may consequently be stated that the best available published evidence indicates that cutting or shaving the hair has no effect whatever on its growth.[1] Attempts to supply scientific evidence that will controvert this statement are very much to be desired, since any careful study of the subject will help to clear up a problem that is far from being solved.

1. The results of W. Schultz with mice probably do not constitute an exception. (See p. 87.)

EFFECTS OF VARIOUS EXTERNAL APPLICATIONS

Much the same kind of problem is presented by the question of whether or not external applications can influence hair growth through their effect on the hair itself. Here it is necessary to differentiate between direct action through the hair shaft and indirect action through the skin. That the former occurs is generally believed, as shown by popular opinion and frequent answers in medical query columns; but conclusive evidence bearing on the question is not easily to be found, and possibly does not exist. Only one experimental test need be cited. Four subjects in Dr. Trotter's group were requested to use liquid petrolatum on the skin regularly for several months, since this substance enjoys the reputation of being especially efficacious in promoting the growth of hair. The application of liquid petrolatum on the leg twice a week for eight months, during which period it is to be presumed that all the hairs of the region had been renewed, failed to produce any effect that could be detected on comparing the treated and untreated sides. Likewise, the frequent application of liquid petrolatum to one eyebrow for four months gave a wholly negative result. It is quite probable, therefore, that the supposed hair promoting qualities of liquid petrolatum and cold cream are mythical.

It would be interesting to see similar experiments tried, using substances with more nearly the properties of the secretions of sweat and sebaceous glands. That the character of the latter has a real and direct effect on the quality and appearance of the hair probably cannot be denied. But whatever its cosmetic value, its action on hair growth is another matter. The anatomic association between the hair and its sebaceous gland is so intimate that whatever affects the one might be expected to affect the other, and so when changes in both structures occur together, it may often be difficult to establish any causal relation between them. Consequently, cases in which hair growth seems to be affected by the function of the sebaceous glands call for critical examination. In a recent study, devoted mostly to alopecia, Jerina has brought out some interesting points in connection with the interrelation of sweat glands, sebaceous glands and hair. He states that in general there is an inverse connection between the size of a sebaceous gland and the follicle with which it is associated, large glands occurring in relation to small hairs, and vice versa. But between hairs and sweat glands there is a direct physiologic relation. This is brought out especially in his studies of thallium poisoning; in this condition, the sweat glands and hair always are injured in the same way. In fact, Jerina goes so far as to postulate a physiologic antagonism between sweat and sebaceous glands. The former are under nervous control, the latter possibly not.

In view of the morphologic relation of sweat glands and hair that has been claimed by Römer and others, it is not surprising to find also a physiologic relation. The latter probably depends on a certain community of attributes between the hair follicle and sweat tubule rather than on any mutual interaction. The studies of Diem and others, ignored in many textbooks of histology and of embryology, indicate that developmentally also there is a fundamental connection between hair and sweat glands in those parts of the skin where both occur together. The sweat gland arises directly from the hair follicle, and only secondarily comes to have an independent opening on the surface of the skin (Figs. 42 and 43). This relation may be assumed to be the primary one, even though sweat glands like sebaceous glands occur in some places where hairs do not develop. It is these intimate ontogenetic and functional interrelations between hair and the cutaneous gland that often make it difficult to be sure that an agency acting on one of the glands is not also acting directly on the hair and not indirectly through the affected gland.

There are several other external agencies which have been supposed to influence hair growth, among them temperature. This has been referred to previously and need not be discussed in detail here. Opinions on the subject are diverse. On the one hand, it is claimed that cold favors the production of hair, and on the other hand, heat is said to stimulate hair growth to such an extent that the daily production of the beard is appreciably greater in summer than in winter. The negro is frequently cited as an example of loss of body hair in the tropics, but the Eskimos have failed to develop a protective covering, perhaps because they get it in other ways. Any effect of either heat or cold is probably slight and brought about indirectly through nervous or other mechanisms.

REACTION OF THE FOLLICLE TO ACTINIC RAYS

It has also been suggested that while the temperature itself may be immaterial, the actinic rays do have a direct stimulating effect on hair growth. Parts of the body exposed during the summer and tanned are commonly believed to show an increased growth of hair. Several preliminary attempts to measure this growth gave negative results, and the question is further complicated by the fact that the places most exposed —legs, arms and shoulders—are the ones which normally have a tendency to produce more or less terminal or transitional hair. Trotter has tested this on twelve college women by selecting and comparing symmetrical regions on the most exposed part of the forearm and then taking samples from one side, at the beginning of the summer season, and from the other side, at the end of the season. During the period intervening between the collection of the first and the second samples all of the subjects spent much time outdoors with their arms bare, and some of them

became deeply tanned, yet microscopic examination of the two sets of hairs from each subject failed to show any increase during the summer months. In another instance, however, a man shaved both forearms in midsummer, after which one was kept protected by a sleeve, the other

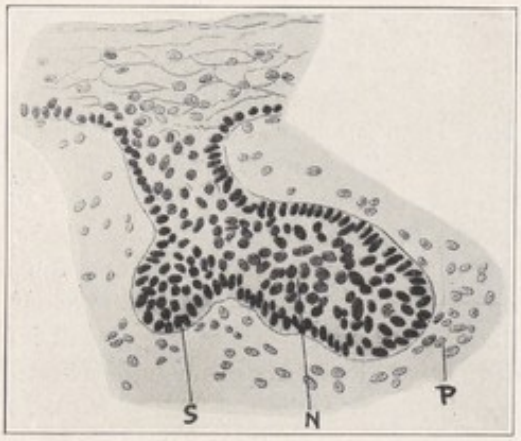

Fig. 42.—Early stage in the development of a sweat gland in the pig (after Diem). *N*, hair peg; *P*, beginning of papilla formation; *S*, sweat gland rudiment.

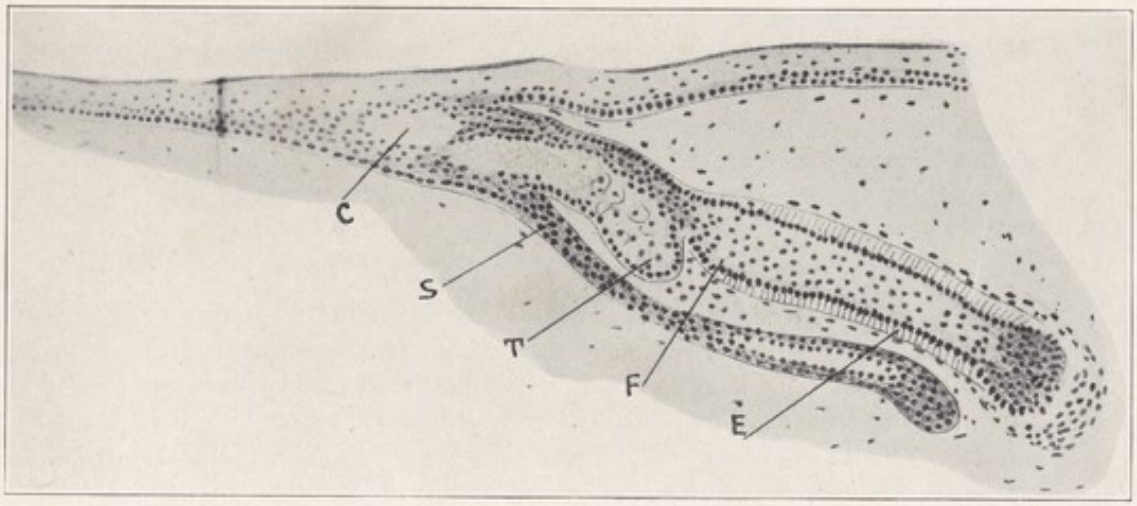

Fig. 43.—Later stage in the development of a sweat gland in the pig (after Diem). *C*, hair canal; *S*, duct of sweat gland; *T*, sebaceous gland; *F*, follicle; *E*, follicular sheath.

exposed as much as possible to the sun. After about twelve weeks, the hair on the exposed arm seemed to be slightly but definitely longer. This difference disappeared in the course of another few weeks. Here the growth of hair seems to have been somewhat accelerated as a result of

exposure to sunlight. Since the arm burned and then tanned, hyperemia may have been a factor in this slight and transient manifestation.

The artificial application of actinic rays is credited with producing definite effects on hair growth. Temporary suppression of follicular activity by roentgen rays is of common occurrence, and occasionally the follicle is permanently destroyed, at least from a functional point of view. Practically, roentgen-ray depilation has not in general proved feasible, owing to the difficulty of properly regulating the dosage. As is common with agents which generally have a deleterious action, roentgen rays in the proper intensity may stimulate hair growth, according to a rather large number of reports in the literature. While it probably could not be claimed that the refinements of technic have been carried far enough to be of any great practical use, it does seem clear that roentgen rays may influence the follicle, and this directly rather than through any secondary reactions. But with violet rays there is more room for doubt, since there is some question as to whether they can penetrate deeply enough to be effective in the growing part of the follicle, especially when the subcutaneous tissue contains any appreciable amount of hemoglobin.

A few experiments with ultraviolet irradiations were tried on mice at the time they were getting their first hair and later after depilation by means of sodium sulphid. With few exceptions, all the results were negative. Figure 44 shows three adult specimens that had been treated by Dr. Cady. The one on the left had the hair removed from its back and was then treated rather intensively until the growth indicated had been reached. The other two had the hair removed at the same time, but were not treated. This looks like a favorable effect from the violet rays; but in view of the generally negative character of most of the experiments, conclusions must be drawn with caution. Schultz obtained more constantly positive results by the same treatment. If care is not exercised in treatment, hyperemia occurs, and it is possibly to this that any results obtained from ultraviolet irradiation may be attributed. That hyperemia is really capable of stimulating the growth of hair, as Schöne maintains, is not so firmly established as might be desired, but under some circumstances it may be a factor.

There are races of rabbits which tend to produce dark or light hair, depending on the temperature in which they are kept. This phenomenon was discovered by Schultz, who erroneously supposed that the change of color was due to the direct effect of shaving rather than to the resulting change in cutaneous temperature. The latter is almost certainly the real cause—a discovery of great interest, even though it may hold for only a few small mammals.

VASCULAR AND NERVOUS FACTORS

The relation of blood supply to hair growth might reveal some significant facts if adequately worked out. In general, the vessels to the papilla are branches from the same stem as those to the follicle, but whether or not the greatest vascularity of the latter is at the zone of growth or beyond it, and whether or not there are any variations in this respect correlated with the rate and amount of hair production, has not been determined. These are important points, as Burrows' study of the nail has emphasized.

The regulation of blood supply to the follicle is no doubt under control of the sympathetic system and this in turn intimately related with the central nervous system. That cutaneous structures respond

Fig. 44.—Three mice after removal of hair from a spot on the back and the subsequent treatment of one with ultraviolet rays. (From a photograph by Dr. Cady, the background retouched.) The mouse on the left which shows a good new growth of hair had been treated regularly under an Alpine lamp, the other had not. Such results were not obtained in all cases.

readily to emotional crises is illustrated by such phenomena as blushing, nervous perspiration and erection of hair, or the physiologic equivalents —gooseflesh and the "creepy sensations" that result from contraction waves of the arrector muscles. Whether the latter manifestations are brought about wholly through changes in the circulation, may well be doubted. Structures ordinarily entirely in the field of sympathetic control may in exceptional cases be brought under volition, and Maxwell has reported one case in which the subject could contract his arrector pili muscles, producing cutis anserina at will. The muscles were of the ordinary type without striation. Since many of these more pronounced indications of nervous control are revealed under special conditions, it is a natural inference that the nervous factor is an important one, and one that is continually operative.

The close relation of hair follicles to other cutaneous structures has afforded a basis for assuming that hair growth is dependent to a high degree on the nervous system. Figure 45 represents a section from the mouse, and probably does not exaggerate the wealth of nerve terminations in and about many hair follicles in lower mammals. In man, where there are no tactile hairs, the nerve supply is perhaps less rich, but nevertheless abundant in all the larger follicles. This furnishes an anatomic support for the view that hair is intimately and directly under the influence of the nervous system. Friedenthal, who is perhaps the most energetic supporter of this idea, has marshaled some of the evidence

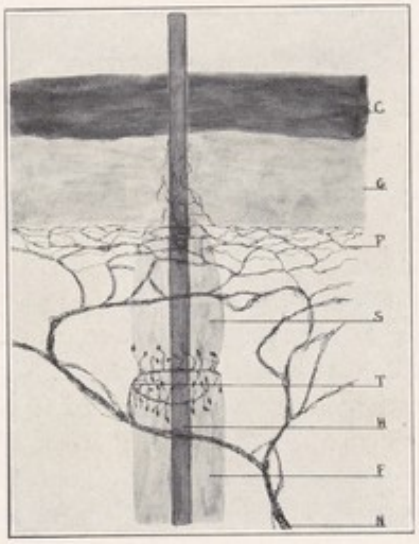

Fig. 45.—Nerve terminations around a hair (presumably tactile) of a young mouse, as shown by the rapid Golgi method (from Branca, after Retzius). *C*, stratum corneum of the skin; *G*, stratum germinatinum; *P*, superficial nerve plexus; *S*, region of sebaceous gland; *T*, nerve terminations in follicle; *H*, hair shaft; *F*, hair sheath; *N*, sensory nerve.

from the abundant clinical and popular literature. But however plausible his thesis, he is carried to extremes that it is difficult to follow in the absence of more conclusive evidence than he has been able to supply. He did the service of vividly directing attention to the problem and putting forward a number of hypotheses which an energetic student could no doubt disprove.

A consideration of such data as have been available leads to the general conclusion that, on the whole, external stimuli, excepting roentgen rays, whether applied to the hair itself or to the skin, have little or no direct effect on hair growth, but that when there is a resultant reaction which tends to alter the cutaneous circulation or more especially

to cause a sympathetic nervous response, an indirect effect may be brought about. Convincing evidence on all of these points is meager, and more critical data are greatly to be desired. There is also a lack of much real information on the relation of psychic states to hair growth. The general conditions of nutrition and the endocrine complex are other factors that must be considered. The former is keenly appreciated by animal exhibitors, and is often emphasized in connection with treatment of human hair, but here the situation is usually complicated by factors of disease or endocrine disturbance. In most cases, the effects, unless the condition is chronic, seem generally to be confined to at most the life span of a few successive hairs, after which normal growth may be resumed. Apparently there is no evidence that nutritional deficiency affects the hair differentially to any appreciable degree.

ENDOCRINE FACTORS

With regard to the hormonal factors that may influence hair growth, the difficulties in the way of arriving at a clear conception are especially numerous. Any knowledge along this line must generally be derived from the doubtful evidence that comes from a study of pathologic states. On *a priori* grounds it seems probable that all of the "incretions" which are poured into the blood are brought to the hair follicles, and that they may stimulate or inhibit cell division and growth of the hair-producing cells. It is also conceivable that while some of them may act directly on the follicle cells, others affect them only indirectly by modifying their nutrition. But in the present state of knowledge it does not seem profitable to speculate on the possible nature of reactions the presence of which is open to doubt. Much of the uncertainty with regard to the relation of endocrine disturbances and hair growth is due to failure to recognize the normal range of variation in the hair of healthy persons. The mere presentation of photographs showing, for example, acromegalic subjects with well developed terminal hair on the chest and shoulders has little weight until it is shown that at least the relative frequency of such hair growth is higher in subjects with hypophysial disturbance than in those without. Nevertheless, despite the unsatisfactory character of much of the evidence, there is little doubt that the endocrine secretions exert an important influence on the development of the hair.

The glands which at present seem most important in this connection are the suprarenals, the gonads, the thyroid and the pituitary. It is possible that the two last have no real direct effect, but that disturbances in them react on the suprarenal, which in turn influences hair. However, the roughness and often scantiness of hair in cretinoid conditions, as well as the reported falling of hair after thyroidectomy, suggest a possible

direct relation in this case. The supposed increase of hair in acromegaly and the precocious appearance of pubic and other terminal body hair in the occasional cases ascribed to pineal disorder suggest, one can hardly say more, that perhaps normal secretions from both the pineal body and the hypophysis are essential to typical hair growth.

In view of the sexual dimorphism in the pilary system, it is natural that attention should have been focused on the gonads and the interstitial glands which they are generally assumed to contain as causative factors in producing the observed differences. The appearance of increased amounts of terminal hair at about the time of puberty further tends to direct the attention to the sex glands, which are developing functional capacity at that time. But the relation is by no means a simple one. Two diametrically opposite suggestions have been offered to explain these sexual differences: (1) The male type of hairiness is latent in all persons, but the ovary suppresses its development over the greater part of the body. (2) The hairiness of the male is really due to stimulation of the testicular secretion, in the absence of which the body hair remains undeveloped except within narrow limits. The evidence bearing on these possibilities is for the most part of a rather circumstantial nature. The hair of the head develops equally (?) in both sexes, so that the stimulating or inhibiting factors must be more or less circumscribed in their sphere of action. Considering only normal persons it would appear, too, that, at least during early years of sexual maturity, axillary and pubic hair is unaffected. But the situation is complicated by the well established fact that in persons actually or physiologically castrated before puberty, axillary and pubic hair either fails completely or develops but little. The production of this hair consequently seems to depend on the presence of a gonad, which may be either testis or ovary. Beyond this, evidence that the ovary has any positive effect on hair development is slight. Indication that the ovary inhibits hair growth is also meager. It has been claimed that ovariotomy and the menopause result in the appearance of beard hairs, but thirty-two women in St. Louis who had both ovaries removed showed after several months or years no greater frequency of terminal hair than normal persons, and Falta states that terminal hairs grow on the faces of eunuchs, who never had any ovaries, at the same age as that at which women enter the menopause.

The popular belief in an association between baldness and heightened sexuality, especially as manifested by a vigorous growth of beard and body hair, has often been ridiculed by scientific writers and probably is without real foundation. On the other hand, one may easily be impressed, on reading a series of case histories, by the frequency with which the hair of the head and that of other parts of the body show more or less opposite tendencies in patients with endocrine disturbances. Such

a possible differential response by the hair of different parts of the body very likely may exist, with the result that a testicular or other hormone may be favorable to hair growth in one place and not in another. Eunuchs apparently do not often become bald.

In view of the definite and clear-cut results of Goodale, Morgan, Duerden, and others who have studied castration in birds with reference to sexual differences in plumage, it may be worth while to review their finding briefly. In the birds thus far studied (duck, fowl, ostrich), it happens that surgical removal of all ovarian tissue, and the occasional pathologic destruction of this tissue, results in the assumption of the male type of plumage; whereas removal of the testis has no marked effect in this respect and in any event does not produce the female type. But most interesting is the discovery that the "henny" males of the Seabrights and Campine, which have plumage like the female, on complete castration immediately develop a male plumage. Finally, microscopic study of the gonads of these birds has revealed the presence of special cells which occur in the ovaries of hens and the testes of hen-feathered cocks but not in normally feathered males. Since there is no difference in the comb or sexual potency of the males, it has been thought that the special cells produce an "incretion" which acts solely, or chiefly, to inhibit the development of the male type of plumage. There is no evidence that these cells are the cause and not the effect of a general physiologic tendency. Their presence or absence in the male follows the simple laws of heredity.

While it is certain that a similar relation between the gonads and the male and female hair distribution in man does not exist, there is still a possibility that something more or less analogous might occur in connection with some gland other than the gonad. But the supposition that such is the case is a purely hypothetical one at the present time.

The remaining gland the secretion of which seems likely to be important in the regulation of hair growth is the suprarenal. There is great abundance of clinical data that points more or less clearly to an association between hyperfunction of the cortex and excessive growth of hair, so much so in fact that one might suspect this to be the most important gland of all so far as its influence on hair growth is concerned. The slight excess of hair growth which is said to take place during pregnancy, according to Falta, may as well be explained by an increase in the activity of the suprarenal cortex, which occurs at that time, as by any supposed change in ovarian function. It is often maintained on grounds of phylogeny and embryology that there is an intimate morphologic relation between the gonads and the suprarenal cortex. The supposed relation of cells in the former to control of feather growth and the possible relation of the latter to hair growth, is of interest,

although no close parallel could be expected in view of the widely divergent conditions reached by both sets of structures.

The summary of the situation by Leopold Levi is suggestive, but cannot be accepted without reservation. According to him, secretion of the thyroid affects the hair of the scalp, the eyebrows and eyelashes; that of the ovaries and testes, the pubic and axillary hair. The testes also affect the body hair and beard. The hypophysis and suprarenal through their influence on the testes indirectly influence the hair generally, except the capillus, eyebrows and eyelashes.

One problem of great importance in this connection is to learn which, if any, of the endocrine glands increase their activity with advancing age, or how the "endocrine balance" changes. For one of the outstanding characteristics of the pilary system, barring certain alopecias, is the continuous and progressive increase of terminal hair until late in life. How much of this is due to intrinsic peculiarities of the follicles themselves is open to question; but there can be little doubt that they constitute an important factor.

Considering the whole problem of hair growth, it becomes apparent that the phenomenon is primarily determined by the inherent character of the hair follicles, which are potentially different in different races, in different persons and in different parts of the same body. These fundamental variations result in differential growths of hair in response to both normal and abnormal influences. There is considerable evidence suggestive of what some of these conditioning factors for hair growth are, but anything like a useful knowledge of their mode of action is lacking.

CHAPTER VI

ABERRANT FORMS OF HAIR GROWTH

It is now coming to be generally recognized that there is no sharp line of demarcation between what is normal and what is abnormal. The same physical trait may have very different meanings in two persons. In the one subject it may be entirely normal, in the other quite aberrant. A full beard, for example, would have a different significance in a man and a woman, or in a white man and an Indian. Likewise, fine curly hair might in one case be indicative of profound physical disturbance but in another case simply the manifestation of a natural inherent tendency. Such phenomena have led Keith and others to make the plausible suggestion that racial differences such as stature, pigmentation, and character of the hair are due to differences in the endocrine output of the various races, and that early modification of the endocrine balance may produce a person approaching in some respect the characteristics of a race other than his own. But it is important to keep in mind the fact that even such a relatively simple structure as hair is the product of a number of interacting factors, of which certain incretions may count as one, and that the *a priori* probability is that in racial differentiation not one but several of these have become modified. The hair follicle of the negro may be physiologically, as it seems to be anatomically, somewhat different from that of the white man and consequently incapable of responding in exactly the same manner to identical stimuli. Study of aberrant forms of growth might be expected to throw new light on the factors regulating hair, but the available knowledge is too meager to be of much value as yet.

There is another consideration which suggests caution in the interpretation of aberrant conditions, and that is the probability that many structures, including hair, have reached a stage in their evolution in which the possible types of variation are rather definitely limited. There is a great deal of evidence from various sources that mutations are prone to take place in certain directions and not in others, that as a probable result of some unknown quality of the germ plasm some modifications are far more easily effected than others. While nothing like definite proof of this assumption exists, much evidence in support of it has accumulated from experimental breeding of both plants and animals. Finally, there is a likelihood that given an unmodified germ plasm there may be only a limited number of reactions which changes in the environment can produce. The growth of a hair and its follicle is limited, as

are other materials, by the physical structure, and even more so by the physiologic constitution. By way of analogy the relation of nerve and muscle furnishes a good illustration of limited reactions to varied stimuli. If, for example, the sciatic nerve in the thigh of a freshly killed frog is stimulated by heat, electricity, pressure, acid, or by any other means, the end-result is the same, a contraction of the muscles of the leg. Somewhere in this nerve-muscle mechanism is something which apparently can respond in only one way. This is probably almost equally true in respect to some developmental processes, which makes it entirely conceivable that similar physical manifestations may be induced by dissimilar agencies. Indeed, the same condition may conceivably be of germinal origin in one case and of environmental origin in another. This may be illustrated by presenile cataract, in which it has been shown that in some families the germinal constitution is such that the persons develop cataract even in a favorable environment, while in other families cataracts form late in life or under adverse conditions; and yet so far as seems to be known at present, the cataracts formed by persons of these two types of families may be identical. The possibility of the same condition being sometimes hereditary and sometimes not has often been overlooked in attempts to catalogue definitely particular clinical or physical entities. That this possibility is a real one seems in the highest degree probable, but wholly adequate support of it is still lacking.

RELATION BETWEEN HEREDITARY AND NON-HEREDITARY MANIFESTATIONS

Several of the aberrant manifestations of hair have been recorded as showing definite hereditary tendencies in some instances while of apparently sporadic occurrence at other times. This has caused some confusion in attempts at classification and may mean that while the end-result, as expressed in the observed condition, is the same, the etiology is sometimes varied. It is commonly assumed that variations which are of an hereditary nature are not due to the action of pathogenic organisms, while other forms often are. However, the presence of heredity does not necessarily preclude a factor of infection, since it may in some instances be a special increased susceptibility or conformation of tissues that is inherited. In sporadic cases which show no hereditary tendency, the causal factor should undoubtedly often be sought in a disturbance of nutrition or the conditions of growth.

MISCELLANEOUS ABNORMAL AND PATHOLOGIC CONDITIONS

The variations which have been observed fall into several categories, including excess growth or hypertrichosis, which will be discussed in the next chapter, deficient development, and various forms of abnormal

growth. Such of the latter as are of known pathogenic origin may be dismissed briefly, since the irregular and variable nature of the infections is such that the responses of the hair do not seem to throw much light on the nature of the vital processes concerned. The treatment of nearly all of these conditions that is generally recommended is, if feasible, complete removal of the hair by clipping or shaving, followed by germicidal applications. Since a number of organisms invade the follicle, this treatment is often reported to be only moderately successful. The characteristics of the common plant parasites—*Achorion, Microsporon, Trichophyton*—and their behavior in infected hairs and in cultures are exhaustively treated by Sabouraud in his "Maladies du cuir chevelu." There is also a considerable literature on animal parasites, which are described in most of the textbooks covering this phase of medicine and in a recent semipopular treatise by Lloyd entitled: "Lice and Their Menace to Man."

There are several conditions, relatively rare in this country and often uncertain of etiology, concerning which little can be said beyond what is found in standard textbooks. These may be passed over with only brief mention. From an historical point of view, probably the most interesting of all the diseases affecting the hair is the "Polish plait" (plica polonica). It seems to be due to lack of care resulting in the capillus becoming infected with lice and nits, followed by falling and agglutination with the invasion of fungus and bacterial parasites. The scalp becomes tender, and frequent bleeding easily gave rise to the belief that in this condition hairs become hollow and allow the humors to escape. In the early days, if it did not occur following spontaneous injuries to the head, it was frequently induced as a therapeutic measure. Although now regarded as simply the result of filth, it took a strong hold on the imagination of physicians of the seventeenth and eighteenth centuries. Dissertations on plica polonica began to appear about the year 1600, and for the next two centuries or more were published at the average rate of at least one every four years. As late as 1853, Browne, who examined a patient in Philadelphia, states that despite the fact that a "monstrous deal has been written on this disease, nevertheless there are some authors who doubt its existence." It is mentioned here purely for its casual interest.

Among the rare conditions that have been noticed more recently is one designated as trichotillomania. This is characterized by persistent itching in the follicles, leading to a desire to pull out the hair. It is a question whether this is the result of an actual infection or functional disturbance in the follicle or is due wholly to a neurotic factor. It is probably distinct from the more common habit of pulling at the mustache or vibrissae, which is sometimes designated by the same term.

Trichonodosis, as described by Galewski, is an actual or apparent knotting of the hair. Kren has pointed out that the hair is seldom actually tied in a true knot but may be so twisted as to give such an appearance. It seems to result from an inability of new hairs to grow freely from their follicles, due probably to an increased toughness of the surrounding tissues rather than to a softening of the hair shaft. There may perhaps be a justifiable doubt as to the wisdom of considering trichonodosis as a distinct pathologic entity.

A condition of definitely known parasitic origin is lepothrix, in which scattered masses of agglutinated organisms of the genus *Trichosporon* occur in the hair shafts. This is said to occur most often in axillary and pubic hair. Of the ringworm fungi in the genus *Trichophyton* there are several species which attack the hair both within the follicle and in the free part of the shaft where the spores may be formed, according to the species, either outside the cuticle or in the cortex and medulla.

A curious modification of the hair shaft, which seems to occur in several forms, began to be recognized about 1880 or a little earlier and was described under the name of piedra. It was for some time believed to occur only in the state of Cauca in Colombia, and is said to have received its name from the Spanish word for stone, since the hair, when it is being combed, rattles like pebbles. The hard masses which occur at irregular intervals along the hair shaft are believed to be due to accumulations of *Trichosporon giganteum*. It affects the hair of the head, and the same, or a closely related form, attacks the beard. There is voluminous literature on this disease, which is complicated by the fact that the condtion is frequently confused with other diseases, especially trichorrhexis.

TRICHORRHEXIS NODOSA

The term "fragilitas crinium," introduced long ago by Erasmus Wilson, has been applied to almost any condition in which the hair shows a tendency to break or split. It is sometimes employed to denote a condition caused by a parasitic form such as *Microsporon*, and at other times, even by the same author, applied to nonparasitic manifestations. It seems clear that Wilson himself, at least on one occasion, meant it to apply to what is now generally called trichorrhexis nodosa. Since the latter designation has come into general use, fragilitas crinium is left without scientific standing. Synonymous, or at least frequently synonymous, with trichorrhexis nodosa are trichoclasia, clastothrix, nodositas crinium and even trichoptilosis and scissura pilorum. It is usually the case that before knowledge of a subject becomes systematized, the number of terms is greatly in excess of the number of conditions which they are meant to designate. This is undoubtedly true of diseases of the

hair. Trichorrhexis nodosa, however, is a well established designation for what seems to be a rather definite entity. The hairs show, at more or less regular intervals, what appear, on superficial examination, to be white spots. Under the microscope, these spots are revealed as places where the hair cortex has fractured and split into many short strands (Fig. 46), giving the appearance of pairs of brooms stuck together end to end by their bristles. Breaking of the hair occurs at these nodes. The beard hairs are most frequently affected. Occasionally the pubic hairs are involved and rarely those of the head. A bacterial etiology has been claimed but not substantiated. There is no good evidence of heredity.

Fig. 46.—Trichorrhexis (after McCall Anderson).

MONILETHRIX

Another interesting condition, probably not of parasitic origin, is monilethrix, in which likewise there are changes in the character of the hair shaft occurring at more or less regular intervals (Fig. 47). The condition was described by Smith in 1879 and, according to Bodin, simultaneously by Luce in a thesis in French. This is perhaps the most striking of the hair anomalies, and one which is not extremely uncommon. With few exceptions, it is congenital and hereditary, although there seem to have been a few cases observed which appeared in late childhood and which were not hereditary. Typical monilethrix hairs show alternate elliptical nodes and slender internodes. There is considerable variation in the relative length of nodes and internodes, but the former are generally about twice as long as the latter, although occasionally they are shorter. The combined length of a node and internode is frequently from 0.6 mm. to 0.8 mm. The nodal parts consist of cuticle, cortex and occasionally medula in about the usual arrangements, and the greatly attenuated internodal regions consist of a thick-

ened cuticle and a slender cortical core. All gradations may be found between hair that is essentially normal and that which is typically moniliform (Fig. 47). Owing to the great delicacy of the internodes, the hair tends to break just beyond the follicle, causing at times a virtual alopecia.

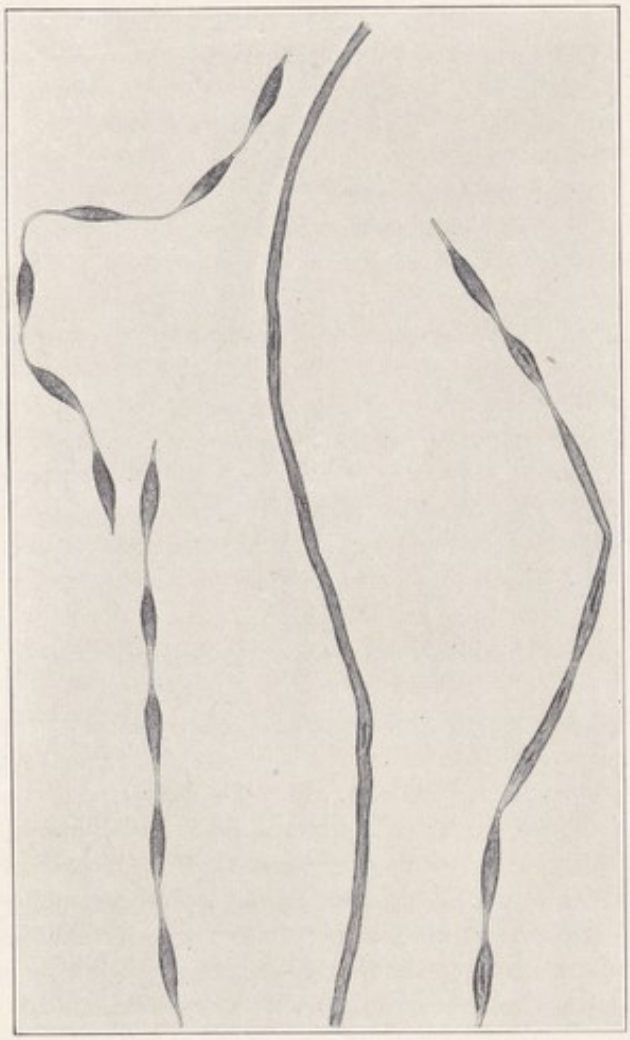

Fig. 47.—Monilethrix. Hairs from the head of a girl aged 18. (About ×20.) The subject was virtually bald as a result of the breaking of the hairs most of which were of the characteristic monilethrix type, as illustrated by the two specimens to the left. The hair on the right shows an irregular manifestation of the condition; the one in the middle is nearly normal.

The condition affects the capillus and occasionally the hair of the arms and legs but usually not other hair.

The etiology of monilethrix has excited a great deal of interest, but no adequate explanation of the condition has been suggested. That the

ultimate factor in practically all cases is an hereditary one, is evident. The problem that remains to be solved is how this factor becomes effective in producing the anomaly. Archambault found moniliform hairs coiled in little elevations of the scalp. In other cases, generally the affected regions show some kind of dermatosis and often degeneracy of sebaceous glands, which has suggested that the immediate cause of the condition lies in structural or functional characteristics of the skin which are supposed to inhibit the continuous normal function of the follicle and hair bulb. The regularity of the nodes makes it difficult to accept this view, unless it be assumed that the supposed obstacle to growth results in something in the nature of periods of activity and fatigue in the production of hair. An alternative view advocated by Bodin holds that the causal factor is an hereditary lesion of the nervous system, and this might help in an understanding of the associated cutaneous lesions. It has been claimed that at any particular moment all the hair follicles are in the same phase, every hair at one time showing a node at the surface of the skin while at another time they all show internodes. If this were established as generally true, it would be evidence in favor of nervous or nutritional control. No success has been obtained in attempts to link up the periodicity of node formation with any other periodic function. The length of a complete unit of hair shaft in monilethrix is about equivalent to the length of normal hair that is produced in a little less than two days. The fact that the length of the cycle in trichorrhexis and ringed hair seems to be about the same is interesting but of unknown significance.

It is frequently stated in the literature that the nodal parts are in every way normal, while the internodes represent regions of periodic incomplete suppression of growth. It is doubtful, however, that the condition is as simple as this. The nodes, instead of being, as is stated, of the same thickness as the ordinary hair shaft are frequently thicker. This might be explained on the assumption that the condition is more common in coarse hair were it not that a considerable number of measurements on hairs that are in some places moniliform and in other places of constant diameter showed a slightly greater average thickness at the nodes. While the nodes are sometimes moderately flattened, they are often evenly fusiform with a nearly circular cross section. Occasionally, there are twists in the shaft, but these occur at the internodes. In many if not all nodes there are small spaces in the cortex filled with a substance with a different refractive index from the rest of the medulla. This substance, which may possibly be a gas, makes the nodes appear darker in transmitted light and often mottled in reflected light. It is especially noticeable in the middle and toward the distal ends of the nodes but disappears promptly on treatment with sodium sulphid. This is

another particular in which monilethrix has a slight resemblance to ringed hair. When treated with sodium sulphid for a few minutes and then placed in water, the nodes swell and ultimately burst, but this reac-

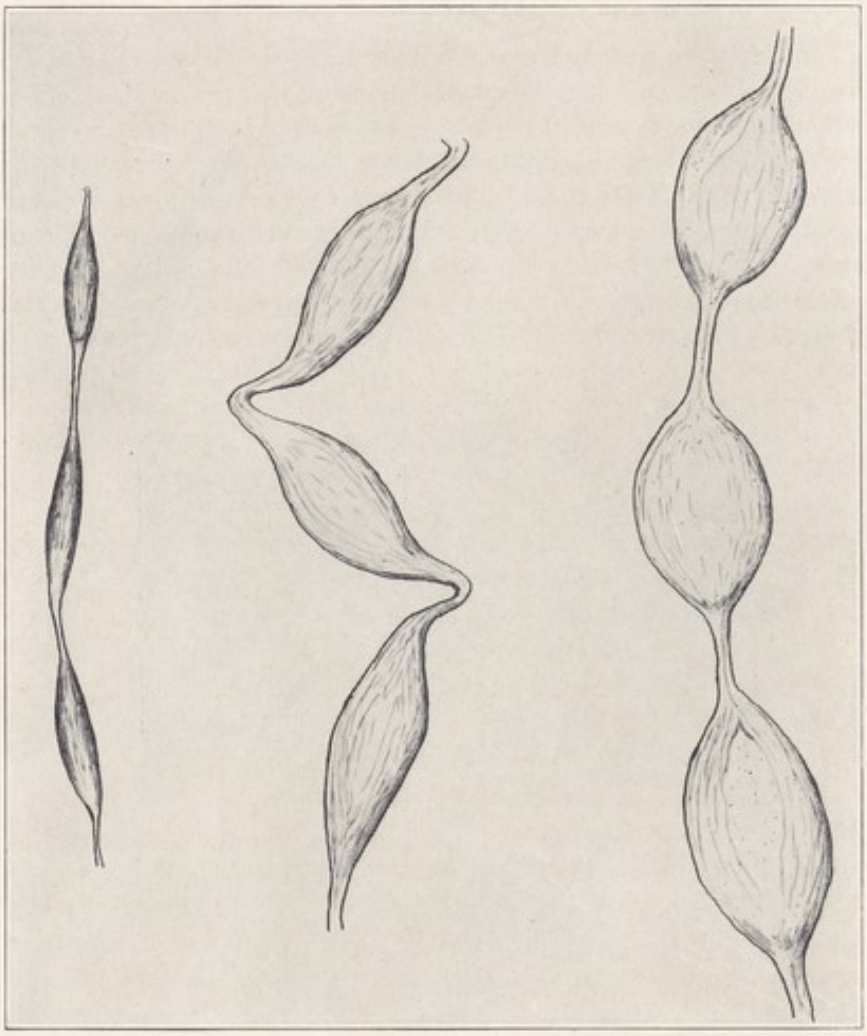

Fig. 48.—Three views of a piece of moniliform hair treated with sodium sulphid. (About × 40.) On the left, untreated hair; in the middle, the same hair after eight minutes in a 10 per cent. solution of sodium sulphid; on the right, the same hair immediately after being put in water. The internodes are affected by the sodium sulphid, but only little, if at all, by the water. The sodium sulphid renders the nodal parts hydroscopic. The difference is probably due to the relative amounts of cortex and cuticle.

tion is no more marked than in normal hair, which indicates that the cortex is not greatly altered. The internodes do not swell proportionately (Fig. 48) and remain much tougher than the nodes. The cuticle

of the internodes shows a remarkable alteration (Fig. 49), which may possibly be the critical feature in monilethrix. Here the scales, which in ordinary hair are short and only moderately imbricated, are elongated and greatly imbricated, so that the cuticle may comprise more than two-thirds the diameter of the shaft. This seems to localize the site at which the condition is established well down in the follicle not far above the bulb. It may be that the tremendous hypertrophy of the cuticular scales is stimulated by the relative absence of cortex, in which case it would have only an incidental significance, but it is also possible, and this is suggested by the frequency of cuticular flaking on the surface between the follicles of the same subject, that the primary condition is in the cuticle. On the latter assumption, it might be imagined that a primary disturbance of the cuticle reacts to produce an hypertrophy of the scales and an almost complete suppression of corticular development, perhaps

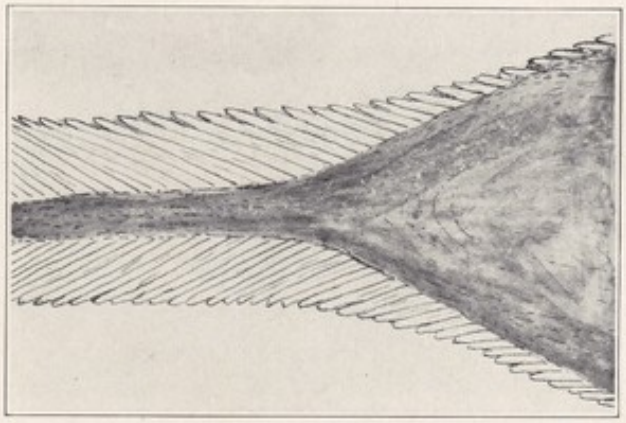

Fig. 49.—Cuticular scales at the region of transition from a nodal to an internodal part of a moniliform hair. (About × 500.) This section of hair had been in sodium sulphid for a few seconds to differentiate the scales which are consequently slightly distorted, but left in such form as to show accurately their relative size and arrangement.

pushing back the still plastic matrix to form the enlarged nodes. This hypothesis fails to account for the regularity and extent of the constrictions. It will be apparent that nothing definite is known concerning the exact manner in which monilethrix is brought about, but there is a chance that more intensive study of the condition will yield illuminating results.

The data on heredity of monilethrix indicate that it is separated from the normal condition by a single factor difference, since it behaves in heredity as a simply dominant trait without sex linkage. The accompanying chart (Fig. 50) represents a family in which monilethrix was reported by Sabouraud. McCall Anderson's report of the condition in

an English family was almost identical with this. In three different families, in which during several generations a number of persons with monilethrix each married a normal person, there were fifty-five children who had one affected parent. Of these children, twenty-five were characterized by monilethrix. This is as near a 1:1 ratio as could be expected from a simple dominant trait.

RINGED HAIR

A third condition involving more or less regular alteration in the appearance of the hair shaft is known as ringed hair (pili annulati). It has also been designated by several other names, including trichonosus versicolor and leucotrichia annularis. It has been known since 1846, but is of rather rare occurrence. Cady and Trotter, who have recently made a careful study of this condition and reviewed the literature on the subject, state that eighteen cases had been reported up to 1921. They

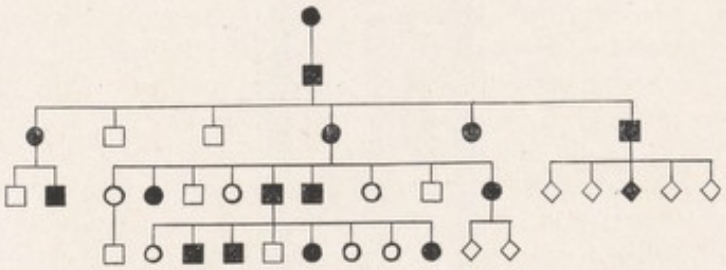

Fig. 50.—Pedigree chart of a family reported by Sabouraud. Squares represent males; circles, females; diamond, individuals whose sex is not stated. The black symbols stand for individuals with monilethrix.

call attention to about twenty new cases, so the total number now on record is not far from forty. To these should probably be added a not inconsiderable number that may have been noticed from time to time but which have not been recorded in the literature.

The outstanding peculiarity of ringed hair is that when seen in reflected light it has the appearance of being banded by alternate zones of light and dark. These apparent bands vary considerably in different persons, but are commonly from 0.2 mm. to 0.6 mm. long, the dark ones being longer than the light ones. In a brunette subject, the length of the light and dark parts, coupled with the contrast in color, is enough to make the banding macroscopically apparent, but unless the hair is observed closely, it gives the effect of a diffuse slate or maltese color rather than a ringed appearance. Karsch, who described the first case on record, believed the white areas to be due to a white pigment, perhaps the "white melanin" of later authors, but it was early shown that no really white substance is present and that by transmitted light the

white areas appear dark, indicating the presence of some substance of different refractive index from the rest of the cortex. Cady and Trotter have shown this to be gas, possibly air, as has long been suspected. All the hairs of the scalp may be affected, or only a small percentage of them. The same hair is often affected through part of its length and normal elsewhere. It may be banded at either end. The idea that the banding is comparable to the ticked hair of many mammals is expressed by Friedenthal and others, but there is clearly no relation between the two phenomena. Even more prevalent is the idea that the white areas

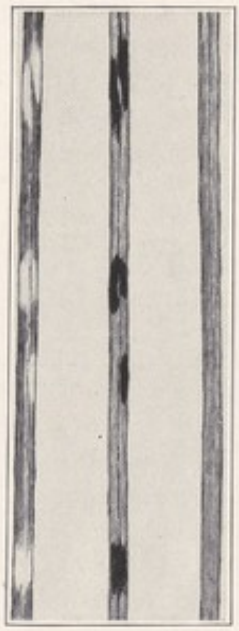

Fig. 51.—Ringed hair. (About × 20.) The three figures are all from the same hair. The one on the left shows it by reflected light, and the one in the middle by transmitted light. The one on the right is the same hair after being dipped in sodium hydroxid for a moment and then dried.

represent regions of pigment deficiency or atrophy. This is disproved in the paper just mentioned, in which it is shown by a variety of tests that as soon as the contained gas is removed no difference in color can be detected in the regions which had appeared light and those which had appeared dark. Ringed hair is consequently normally pigmented hair in which there are more or less regular accumulations of gas. Viewed in reflected light, these regions appear white; viewed in transmitted light, they appear dark (Fig. 51). This is due in both cases to the diffractive properties of the gas. The same phenomenon is duplicated in all terminal hair to the extent that when a dry hair is held against a black

background the medulla appears white, but when held toward the light it is black. Cady and Trotter were able to demonstrate exactly the same banding in hairs wholly devoid of pigment, which is only supplementary evidence that pigmentation is in no way involved. Treatment with nascent chlorin removed the pigment but not the banding.

The banded appearance is not produced to any great extent by periodic enlargements of the medulla but is primarily due to modifications of the cortex, as is revealed on microscopic examination. These modified areas, which occur with equal frequency in hairs that have no medulla, are seen on careful examination to be irregular spots extending for variable distances in the longitudinal direction and often nearly across the hair transversely. Many of them are confined to one side of the hair. When there is a medulla, they may appear to be confluent with the opacity which it causes, or entirely distinct from it. Hairs showing this condition may be much flattened or nearly cylindrical, the index apparently being unaffected. The manifestation, like monilethrix, is confined almost exclusively to the capillus. Two cases are recorded in which other hair was affected. Crocker reported its presence in the mustache of a man with trichorrhexis nodosa, and Cady and Trotter mention its presence in the eyebrows of a subject in whom the hair of the head was also affected. The association with trichorrhexis raises the question as to whether Crocker's case might not have been a modification of that disease rather than true ringed hair. In another case reported by Crocker, the shaft is said to have had a greater diameter opposite the white spots, but other observers mention nothing of the sort, and careful measurement on a considerable series of such hairs failed to reveal any difference between the diameters of the light and dark segments. Crocker's two cases suggest a possible association with trichorrhexis on the one hand and monilethrix on the other.

How the gas gets into the hair remains unexplained. Unna suggests that the condition is due to the alternate production of harder and softer hair substance. When the softer parts dry, spaces are formed among the cells, and these spaces become filled with air. Since the banding has been observed in the root of a hair a few minutes after it was pulled out, there may be some question as to its being due to drying. Cady and Trotter make the tentative suggestion that the gas may be carbon dioxid, since when a hair is immersed in a 5 per cent. solution of sodium hydroxid which has been completely saturated with air, the light spots disappear, as they would be expected to do if composed exclusively of carbon dioxid rather than of the various components of atmospheric air.

There is nothing definitely known as to the etiology. All attempts to establish a bacterial or fungal origin have failed. In the three families

described by Cady and Trotter, an hereditary factor is evident (Fig. 52). Two other families whose cases were reported in the literature showed evidence of heredity. Owing to the degree to which the condition may fluctuate, it is possible that some cases occur which are not recognized, and that some of the subjects whose cases were not recorded as showing direct heredity may have done so in reality. While there is definite evidence of heredity in over half of all the cases, there seems to be enough irregularity in the transmission of the trait to make further critical data desirable. In the great majority of cases, the condition seems to have been present from birth, but in a few instances it was acquired later, and in some of these it subsequently disappeared. Twice it was associated with alopecia. Ringed hair is apparently one of the conditions which may be caused either by hereditary factors or by factors which are not hereditary. Since the latter are presumably more variable and often less persistent, they may be expected frequently to produce transient manifestations which are likely to disappear spontaneously.

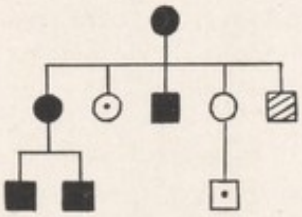

Fig. 52.—Chart of a family with ringed hair described by Cady and Trotter. Black symbols represent individuals with ringed hair; those with a dot in the center are probably normal but may have irregularity in the medulla; the one that is cross-hatched could not be examined.

The three conditions—trichorrhexis, monilethrix and ringed hair—form an interesting group probably not due to parasitic involvement but very likely directly or indirectly influenced by the vegetative nervous system. The outstanding feature which challenges investigation is the indication of periodicity of function in connection with the hair follicle or bulb. All three forms, despite wide fluctuations, give evidence of varied activity occurring in cycles of about the same length. It would be strange if three conditions so different as these should by mere chance show the same time relations in their production. In a number of specimens of monilethrix, the average length of a cycle, as indicated by the distance from the center of one node to the center of the next one, appeared to be about forty-two hours. Wilson estimated the cycle for ringed hair at thirty-seven hours. It seems clear that the average cycle requires for its completion considerably more than one day but less than two days. That normal hair growth also occurs in cycles of the same length is suggested, and also the possibility of cyclic

function of the sympathetic nervous system. In attempting any investigation of this question, first the reality and then the length of the growth cycles should be established.

A tendency for several hairs to "grow from the same follicle," known as thysanothrix, is described in the literature. The "conglomerate hairs," covered at first by a tough scale, perhaps represent an exaggeration of the tendency for several follicles to open into a common pit. Like the three preceding conditions, this is probably not due primarily to infection but to a fundamental morphologic alteration.

CANITIES

Graying of the hair, canities, is a nearly universal phenomenon in the white race, and one which has excited an immense amount of almost fruitless investigation. The white hair of albinos and the hereditary

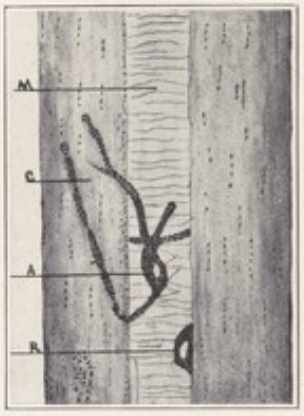

Fig. 53.—"Pigmentophages" in a hair which is becoming gray. (From Branca, after Metchnikoff). *M*, medulla; *C*, cortex; *A*, active "pigmentophage" ingesting pigment in the cortex; *R*, resting "pigmentophage."

white spots on otherwise dark haired persons apparently correspond respectively to the recessive and dominant whiteness of lower animals. At times whiteness may be a concomitant of leukoderma or other pathologic processes involving pigmentary disturbance in the skin. It also apparently sometimes follows severe constitutional disturbance, after which it seems that recovery may possibly occur. The sudden graying of hair has been claimed but not proved. It probably does not occur, although it is conceivable that hair might in some purely physical manner be made to increase its gas content and seem to become gray, a possibility seriously doubted by Strong. There is little evidence for such a mode of change, but Hoepke has recently described a most remarkable case of a subject with ringed hair, in which not only the

pigment but the gas content changed with the seasons. Metchnikoff suggested another means by which hairs might become white in a relatively short time. He put forth the hypothesis that all senile graying and possibly graying at earlier ages is due to the removal of pigment granules by phagocytes which, apparently arising in the medulla and wandering into the cortex, ingest the pigment granules (Fig. 53). Having become loaded with pigment, these "pigmentophages" make their way through the bulb into the connective tissue. This idea has received little or no support and has been pronounced untenable by a number of students. Whether the phenomenon that Metchnikoff described has nothing to do with whitening of the hair or is a factor of occasional limited importance, remains an open question. What actually happens in the follicle before a hair turns white, is still unknown.

Aside from abnormal types of hair growth, various deficiencies often occur. The frequency with which aberrant hairs are covered with a horny scale which holds them beneath the surface suggests a possible relation of some forms of abnormal hair growth to alopecia. Until there is evidence that the conditions that have been mentioned are dependent on inherent peculiarities of the hair follicle itself, it will be justifiable to seek their cause in modifications of the surrounding connective tissue, as so many investigators have done. This point of view seems to simplify the question by reducing it more nearly to a single problem, but it perhaps assumes more than the present state of knowledge justifies.

ALOPECIA

In the discussion of the complicated problem of hair deficiency, attempted refinements of terminology are rather ahead of actual knowledge of conditions. The terms atrichia, oligotrichia, hypotrichosis, calvities and acomia might all be replaced by the word alopecia, coupled with properly qualifying adjectives. To be sure, alopecia from its derivation may carry to the classical student the idea of pathologic involvement, but equally weighty objection could be raised against any of the other terms; for example, actual "atrichia" does not seem to have been observed. It consequently seems best to follow what is already the prevalent custom of designating the relative absence of hair on all or part of the body as alopecia, whether or not the etiology of the condition is known.

Alopecia in its various forms may be congenital or it may be acquired at any time subsequent to birth. Depending on the circumstances, it may be either transient or permanent. Any thing which destroys the follicles or inhibits their function becomes an etiologic factor. There are many claims, not wholly convincing, that areas of alopecia tend to coincide with distribution of nerves. The parasites

in ringworm and favus are among the agents commonly credited with a rôle in the production of alopecia areata. Seborrhea, possibly due to bacterial stimulation, is frequently regarded as a predisposing condition. Severe constitutional diseases also are sometimes accompanied or followed by alopecia, which in these patients is likely to be transient. The forms of alopecia due to traumatism or pathogenic organisms are of less interest from the present point of view than are those produced by less direct agencies.

Among the latter, the baldness of the head so common in men is of particular interest. Various causes for this baldness have been suggested, and it is not improbable that some of them are effective in occasional instances. The fact that baldness is generally confined to certain areas and may be associated with luxurious growth of hair on other parts of the scalp does not support the popular notion that cutting the hair, wearing of headgear, or even dandruff are significant factors in its production. On the other hand, whatever the ultimate cause, it is difficult to regard the loss of hair from the scalp, or a part of it, as other than the result of an alteration of function which may induce a set of mild manifestations that are the product and not the cause of the approaching alopecia. The typical areas of baldness seem to have no relation to the distribution of the subcutaneous nerves, but in the more pronounced form ("Hippocratean baldness") toward which most types seem to tend, it is noticeable that the loss of hair is practically coëxtensive with the epicranial aponeurosis. This may be only a coincidence, but it is mentioned since it suggests the possibility of a modification in that part of the subcutaneous tissue which does not cover a muscle layer. Whether there is any differences in the male and female scalp in this respect or any constant variations in subcutaneous tissues of men who are bald and those who are not, would have to be determined before any such suggestion could be regarded seriously.

Few of the theories that have been advanced offer any adequate explanation of the differential sex incidence of baldness. Perhaps the only one that comes near doing so is that put forth by Dorothy Osborn, who regards baldness as a definitely hereditary sex limited trait. She presents five family charts in support of this claim. Four generations of one family are shown to have had no members who were bald, while in other families baldness is indicated as prevalent, being transmitted directly from father to son and through both sons and daughters to the grandsons. Osborn regards the trait as dominant in the male, recessive in the female. The data from the twenty-two families which she studied agree very well with expectations on such an assumption, but they are not sufficient to give one absolute confidence in her conclusion. Two modes of checking these results are available. One is to determine

statistically the relative frequency of baldness in men and women. If Osborn's hypothesis is correct, a definite relation should exist between the two, when, if it should be found, for example, that 20 per cent. of men have hereditary baldness it would be expected that about 1 per cent. of the women in the same population would also be bald, if 10 per cent. of men, then only 0.25 per cent. of the women, and so on. The other method is the obvious one of adding to the number of records of family histories involving critical matings. Why this particular trait should act as a dominant in men and as a recessive in women presents a particularly interesting problem, the solution of which would probably throw much light on the regulation of hair growth. It is interesting in this connection to note that eunuchs do not become bald, according to Sabouraud, who quoted Aristotle to this effect and also gathered (second hand) data on about 400 recent cases.

Baldness, like many other conditions, is probably hereditary in some and not so in others. It seems probable, however, that it is most often hereditary, particularly when without obvious pathologic involvements it appears before the thirtieth year. The observation on eunuchs, if correct, suggests that the factor for baldness may ordinarily be effective only in the presence of the testis. One of the main problems is to determine how the hereditary factor, or factors, operate to produce their result.

The remaining alopecias not due to pathogenic organisms or specific trophic disturbances may probably all be placed in a single category, for although they show rather wide fluctuations they have many points in common. They are for the most part hereditary and frequently congenital. The degree of alopecia in these cases varies widely. In some instances only the scalp, or perhaps even part of it, is affected, axillary and pubic hair, and in the case of men the beard, being well developed. In other cases, the pubic hair is also deficient. In still others, only the eyebrows or eyelashes are present, and even these may nearly all disappear. Such extreme hair deficiency is illustrated by the two Australian aborigines, frequently cited in French, English and German literature. These two subjects were a brother and sister, each aged about 40. The man had several eyelashes and four vibrissae, the woman had only eyelashes. It is reported that neither of them had any other hair. Nothing is known of their parents, but an older sister, also "hairless," is reported to have had normal children. Cases nearly or quite as pronounced as these are not so infrequent as might be supposed. They probably occur in all races, since hereditary alopecia seems to belong to that little understood group of traits which, like polydactylism, appear again and again in widely separated groups of animals.

What seems to be essentially identical with the human condition has been observed in the horse, goat, rat, mouse, guinea-pig and dog, and no doubt in other forms.

In many cases of hereditary alopecia, the subject is born with as much hair as he has later in life, but occasionally there is only a moderate amount at birth which is lost in the course of a few weeks. The teeth are also frequently reported as carious and deficient in number, a characterization which must always be noted with caution. Owing to the relative ease with which a small piece of scalp may be excised, it has been possible for several investigators to make histologic examination of the skin. This has been done by Waelsch and Schede and others. The skin of lower mammals with alopecia has been studied by Jerina, Bonnet, de Meijere and Kohn. The histologic picture is not always the

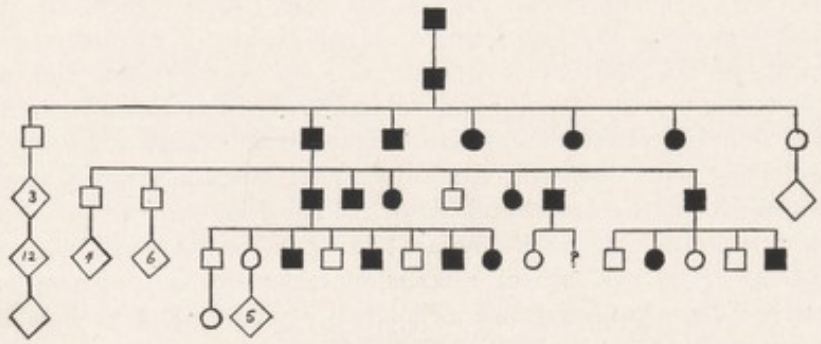

Fig. 54.—Chart of a family showing hereditary congenital alopecia. (Condensed from chart of the Franz family reported by Linzenmeier.) Black symbols represent hairless persons. Normal consorts who have married into the family are not shown in this chart. The normal children of normal parents are represented in groups by diamond-shaped symbols. In the original, their sex and relationships are shown in full.

same, but there is on the whole a general agreement between the different cases. It is one of the outstanding features that abortive hair devolpment is always found beneath the surface, although there is considerable evidence that the actual number of these defective hairs is less than the number ordinarily present in normal persons. Whether or not this numerical reduction is due to earlier regression and partial absorption of suppressed hair rudiments is uncertain, but that hair follicles in a special region may sometimes show a complete failure to develop is indicated by study of digital pilosity referred to earlier. The abortive hair follicles are sometimes solid, sometimes cystic, but without open communication with the exterior. Often they are normal down to the mouth of the sebaceous gland. They sometimes contain elements of

hair, and may show a well developed papilla. In others, no papilla can be found, and only the outer epithelial sheath seems to be present. Masses of epithelial cells, apparently representing suppressed hair follicles, have been reported to tend to proliferate in the connective tissue.

The other cutaneous appendages are variously affected. The nails are often thickened or otherwise aberrant. Teeth are undoubtedly sometimes deficient, although in other cases they are not so. Jerina says that all hairless dogs have few or defective teeth. The sebaceous glands are variable but often well developed and functional, or some functional and others cystic. Sweat glands are quite variable. Sometimes hypertrophied, according to Waelsch, they may in other cases be largely absent. It is reported that one hairless man had to spend hot days in the cellar because of his inability to sweat. Arrector pili muscles are not only usually present but often hypertrophied. In two patients (sisters), Waelsch found a decided deficiency in elastic tissue elements of the skin. This he interprets by assuming that the hair germs trying to grow cause a continual irritation of the connective tissue, which first hypertrophies and then degenerates. There is room for considerably more work on the histology of congenital alopecia, but in a general way the broad outlines of the condition seem to have been determined, although the factors that bring it about are still obscure. There is strong evidence of arrested development as the immediate cause, and there has been some inclination to attribute this to the effect of the connective tissue. It may be noted in passing that other structures seem to be affected to about the degree to which they may be presumed to be homologous with hair; which, taken in conjunction with the evidence of heredity, suggests a mutation of a specific germinal factor. It is quite possible that the mutation of any one of a number of different genes would produce essentially the same result.

The exact mode of heredity of the condition is not definitely settled. The frequent failure on the part of clinicians to appreciate what data are needed for a study of heredity makes many of the reported cases unsatisfactory from this point of view, but the frequency with which two or more children are reported to have alopecia with no reference to the parents suggests that the latter are commonly normal and the trait a recessive one. Such cases as these may be mentioned: a subject with normal parents and normal children; two patients, a boy and a girl, with two normal brothers; a man and two sisters; four brothers and sisters; a man and his brother. An interesting family history showing seven or eight cases in three generations has been worked out by E. Fischer, who is inclined to regard the trait as dominant despite the presence of exceptional cases and the occurrence of intermarriages.

Linzenmeier has also presented histories of two families in which dominance of the trait is definitely indicated. He refers to evidence that in some families the trait may be recessive, in others possibly sex linked.

Probably there are many congenital cases which are not hereditary but in which, nevertheless, the same syndrome is manifested. Jerina states that alopecia artificially produced in young rats by feeding thallium acetate to the pregnant and nursing mothers is characterized by typical abortive and cystic hair follicles.

Several attempts have been made to classify these alopecias on the basis of their presumed etiology, but the results on the whole are not altogether satisfactory. Bonnet suggests three classes as follows:

1. Congenital lack of hair associated with deficiencies or anomalies of teeth and nails, indicating that the disturbing factor became effective early.

2. Congenital lack of hair associated with normal teeth and nails, indicating a later disturbance.

3. Delayed development in which the pilary system ultimately comes into its own.

Bettmann presents a considerably more elaborate classification, but one which is perhaps no more satisfactory.

It will be apparent that in alopecia no less than in the other disturbances of hair growth one of the most important problems is to distinguish between intrinsic, mostly genetic, factors which act directly through the follicle itself, and extrinsic factors, which inhere in the character of the connective tissue or become effective through the intermediation of the nervous system.

CHAPTER VII

HYPERTRICHOSIS

Hypertrichosis, in common with some other forms of aberrant hair growth, is undoubtedly due to a variety of different causes. Like alopecia, it may be present at birth, or may appear at any subsequent period of life. But unlike alopecia, it is probably never directly induced by any pathogenic organisms, and it is probably correct to state that there is as yet no satisfactory evidence that it can be induced by external factors. That there may be predisposing external causes cannot be denied, and every effort should be made to establish the fact of their existence, but in the light of our present knowledge hypertrichosis seems to be preeminently a matter of constitution. And so it becomes a question of interpreting hypertrichosis in terms of variation in the complex of factors which usually result in ordinary hair growth. To this end, studies directed at an understanding of the conditions of normal growth in some respects promise quite as much toward the solution of the problem of hypertrichosis as investigations confined to cases which actually show an excess growth of hair.

The proper definition for hypertrichosis and the characterization of different types of the condition have given no little concern to many of the numerous writers on the subject. There are several rather distinct manifestations, including general and localized excesses of hair development and those which do and which do not seem to be associated with pathologic disturbances. But in general the term is applied to all cases in which the growth of hair on any part of the body is in excess of the amount usually present in persons of the same age, race and sex as the subject. Attempts at greater refinement than this, in the absence of an understanding of the etiology, are likely to be more misleading than otherwise.

CLASSIFICATION OF FORMS OF HYPERTRICHOSIS

For purposes of description, however, and for study, it is convenient to classify the cases in groups based on similarity of appearance or on the presumed etiology. Several attempts in this direction have been made, but all with indifferent success, as numerous critics have pointed out. Virchow recognized three classes of hypertrichosis: (1) excess hair of the masculine type in woman, (2) excess hair complicated by the presence of nevi, (3) "edentate" forms of hypertrichosis.

Bartels proposed a classification which has often been followed, at least in part. His grouping of manifestations of excess hair is as follows:

1. With evidence of irritation as a causative factor:
   - (*a*) On nevi
   - (*b*) Hypertrichosis irritiva
2. Without evidence of irritation:
   - (*a*) Heterogeny (growth of hair normal for the opposite sex)
   - (*b*) Heterochrony (normal for the sex but not for the age of the person)
   - (*c*) Heterotopy (not normal for either age or sex):
     - A. Hypertrichosis partialis
     - B. Hypertrichosis universalis.

More detailed, and in some ways less open to criticism, is Chairi's classification of all forms of abnormal hairiness in the following eleven categories: (1) abnormally developed lanugo, (2) excess development of the hair of puberty, (3) early development of the hair of puberty, (4) hair of puberty abnormal for the sex of the individual, (5) senile hypertrichosis, (6) hypertrichosis of the "dog men," (7) hypertrichosis on unaltered skin, (8) hypertrichosis due to action of nerves, (9) irritative hypertrichosis, (10) hypertrichosis from trophic disturbances and (11) the hair of nevi pilosi. More precise knowledge is likely to reduce the number of forms to less than these eleven, which Chiari considered distinct from each other. In the following discussion hypertrichosis present at birth will be considered first, followed by a review of forms that appear later in life.

HYPERTRICHOSIS UNIVERSALIS

Congenital hypertrichosis sometimes involves practically the whole hair-bearing surface of the body, but at other times is restricted to localized manifestations. The two types usually have little in common, and both are probably essentially identical with similar hair growths which do not actually appear until later. An extensive hypertrichosis present at birth or appearing within the first few months or years, and persisting thereafter, is generally regarded as a rather distinct type. In the classifications just presented, it appears as number 3 in Virchow's grouping, as 2 *c B* in Bartels' and is 6 in Chairi's. It is generally designated in the literature as hypertrichosis universalis congenita, hypertrichosis lanuginosa or pseudohypertrichosis lanuginosa. The term pseudohypertrichosis has been employed with reference to the most hairy of all people on the assumption that the covering is lanugo and not "hair." Subjects showing the anomaly are often referred to as

"dog men," "ape men" or "Haarmenschen" and several of them have been exhibited as representing tribes of wild men or the "missing link." Typical cases are few, perhaps not more than thirty unrelated families being known. According to von Luschan, one new case occurs in about every one thousand million. When the trait once appears, it is transmitted in heredity as a simple mendelian dominant.

The condition is a most interesting one, and has inspired a mass of literature out of all proportion to the number of cases that have been reported. In its typical expression, judging from the most careful descriptions, the scalp is covered by hair that tends to be rather softer than normal, at least until relatively late, and is not differentiated by any line of demarcation from a thick growth of lanugo-like (transi-

Fig. 55.—Hypertrichosis Lanuginosa in a family from Upper Burma (Le-Double and Houssay). *A*, Shwé-Maong; *B*, his daughter Maphoon; *C*, one of her sons, probably Moung Phoset.

tional?) hair on the forehead, face and neck. The whole face, including the upper eyelids and nose, is covered with a thick coat of long soft hair, light in Russian representatives, dark in those from India. The ears are very hairy and characterized, in several unrelated cases, by long drooping tufts projecting from the external meatus. Eyelashes, typical eyebrows and beard hairs are said by some authors to be wholly lacking and replaced by soft hairs like those of the forehead. Likewise pubic and axillary hairs are not present in the normal form but replaced by the same "exaggerated lanugo" that covers the rest of the body and limbs. It is on the head, however, that the aberrant growth is most excessive. On other parts of the body, the hair is often relatively shorter and may even be normal over small areas.

Typical examples of this "universal hypertrichosis" are represented in the accompanying illustrations, which may be presumed to be of a fair degree of accuracy. Some others, such as the famous pictures from Ambras Castle in Tyrol and sketches of Barbara Urslerin are perhaps of doubtful authenticity, although they are vouched for by Bartels. It is probably significant that the condition is often essentially the same even though it appears in unrelated persons from widely different places. The family of Shwé-Maong from the town of Ava in upper Burma and that of Adrian Jefticheff from Russia may be cited as examples of this rare condition. These people were examined by numerous competent students. Shwé-Maong (Fig. 55 *A*) is said to have been born of normal parents and to have been normal himself at birth except for excess hair on his ears. Shortly after birth, he developed the characteristic growth

Fig. 56.—Three Russian "dog men." (Regrouped from LeDouble and Houssay). *A*, Adrian Jefticheff; *B*, his son Fedor; *C*, Stephan Bibroski.

of hair over the body that typifies the dog man. He is reported to have been of rather superior intelligence. Of his four children, two, and possibly three, were normal, but at least one daughter, Maphoon (Fig. 55 *B*) was of the same type as her father. In her case also, the condition was less pronounced at birth than a little later. Maphoon in turn had at least three children, one of whom was normal and, another, called Moung Phoset, had a more pronounced case than either his mother or grandfather. Adrian Jefticheff (Fig. 56 *A*) was born in Russia about 1820. Nothing reliable is known of his antecedents, but there is no evidence that he was related to the Warsaw family which produced the similar Stephan Bibrosky (Fig. 56 *C*). Jefticheff is said to have had two children, a hairy daughter who died in infancy, and a son Fedor (Fig. 56 *B*) who closely resembled his father. The Jefticheffs were extensively exhibited in Europe.

An understanding of the true nature of this form of hypertrichosis is complicated by a number of uncertainties. It has been suggested by Unna and others that it is the result of an arrest of development, the hair of these dog men being in reality an extensive growth of lanugo. Under the stimulus of this idea, several attempts were made to find out whether the arrangement of hair on the adult dog man corresponds to the arrangement on the normal fetus, but there are so few differences known to exist between the usual arrangements in fetus and adult that the comparisons have yielded unsatisfactory results, although the grouping in this hypertrichosis is said to be that of true lanugo.

Virchow pointed out that in many of these cases the teeth were mostly lacking, and he tried to find some atavistic tendency in the combination of abundant hair and deficient teeth. His quest led him to the unpromising group of edentates as representing approximately the condition to which these hairy men are reversions! This idea of atavism has been favorably received by some and severely criticized by others. In any event, a deficiency of the dentary system seems to be fairly well established as one of the characteristics of the typical dog man. The dental formulas for several of the subjects may be indicated after the manner of Bartels as follows:

Shwé-Maong	$\frac{00400}{01400}$	Adrian Jeftischeff	$\frac{01000}{51415}$
Maphoon	$\frac{00400}{00400}$	Fedor Jeftischeff	$\frac{00000}{00400}$
Moung Phoset	$\frac{01210}{01410}$	Stephan Bibrosky	$\frac{00000}{00200}$?

In this scheme, the figures above the line are for the upper jaw, those below for the lower jaw. The middle figure indicates the number of incisors (normally four), the next figure on either side represents the number of canines (normally one) and the other figure the total number of premolars and molars (normally five on each side). It is not certain that any of these people have permanent teeth. Shwé-Maong shed his milk teeth at the age of 20.

Despite what might seem to be a pertinent objection, namely, that an extensive growth of hair, sometimes making its first appearance as late as the sixth year, does not look like an arrest of development, Unna pressed his claim that it is such, and he has been followed by a number of prominent investigators, among them Sarasin and von Luschan. It is interesting to find Virchow maintaining that the condition represents a "normal" atavistic reversion, and von Luschan insisting that it must be considered as a pathologic manifestation. Sarasin goes to considerable pains to link up this condition with neoteny, considering it as a partial persistence of embryonic or fetal conditions in one system, associated with normal development in other systems. In the hair men

it is the teeth and hair of ectodermal origin that remain behind in their development. The time at which the inhibition takes place is wholly unknown. Von Luschan set it at an early period of fetal life, Sarasin at a late period.

No one seems to have taken into account fully the time relations in the development of teeth and hair germs. It is noticeable in the cases of universal hypertrichosis which have furnished accurate data, that the incisors are most often present, particularly on the lower jaw. These teeth are normally ready for eruption during the first year, and germs of the permanent incisors are laid down before this time. In normal persons, the germs of all the permanent teeth except the third molars are present by the end of the second month after birth, and yet the onset of marked hypertrichosis associated with deficient teeth is often later than this. In other words, at a time corresponding to the appearance of hypertrichosis in these subjects, not only the milk teeth but the permanent teeth of a normal infant have made a good start toward development. This suggests either that what causes the hypertrichosis definitely tends to inhibit further tooth growth, or that the actual cause of both tooth and hair variation is effective much earlier than the time of birth. The development of hair and teeth has not been studied in the same series of embryos, but there is little doubt that the teeth germs on the whole rather precede the hair germs in their earliest formation. All of the germs for the twenty milk teeth are reported to be present by the middle of the third month of intra-uterine life, which is earlier than the period at which hair germs are found over the greater part of the body. It consequently seems out of the question to assume that the inhibition is one which occurs during a very early period. Since it apparently does not become effective until after the teeth have started to develop, it must act as an inhibitor of their growth rather than preventing their first formation.

In his extensive study of the production of abnormalities of development, Stockard has been led to postulate a critical period for each organ, a time when it begins to differentiate vigorously and when its future character is largely determined. Adverse conditions of moderate degree acting on the embryo either before or after this period do not affect the organ in question, but acting at the critical period they may produce permanent modification of its structure. Such modification is brought about, according to Stockard, through the slowing down of growth at the very moment when it should normally be most active. A consequent dispersion of energy and lack of unified and harmonious coordination in the growth processes of all the cells involved in the production of the particular organ result in an aberrant form which, in general, cannot return to normal, however favorable conditions may subsequently

become. From this point of view, it might easily be imagined that at perhaps the sixth or seventh month of intra-uterine life some inhibiting factor becomes effective on both hair follicles and enamel organs. The former at this time are in an active phase of development, already producing lanugo, which in consequence of the temporary inhibition, they continue to do throughout life, never subsequently acquiring the capacity for production of normal down or terminal hair. The tooth germs must be at a stage where only the most advanced ones, particularly the lower incisors, are able to survive.

This, in somewhat modified terms, is essentially the position of those who see in hypertrichosis lanuginosa and the associated tooth defects an expression of a temporary embryonic arrest of development. It has some weak points. Particularly difficult is it to harmonize the late appearance (at 3 or 4 years) of the excess hair with tooth deficiency which has appeared before this time. The possibility of inaccuracies in the observations and the occasional hereditary retention of embryonic conditions, seemingly due to arrest, such as harelip and coloboma, help indirectly to support the view, but it remains unexplained why the "persistent embryonic lanugo" should become so greatly hypertrophied over the whole body. Waldeyer's statements, if they should be substantiated, would add another difficulty, since he claimed that the number of hairs in a group is actually increased in these cases, and this is not easily consistent with an arrest of development.

In the absence of additional material or first-hand information, it would be out of place to develop a new hypothesis. It may be mentioned, however, in passing that all the conditions might be explained on the assumption that an occasional mutation occurs in the human germ plasm, resulting in a modifying gene which greatly influences the development of the hair, giving the whole "pelage" a character intermediate between lanugo and terminal hair, and at the same time exerts a disturbing influence on the development of teeth, which are somewhat homologous to hair. A slightly different mutation which also influences the production of teeth may be assumed to be the cause of congenital alopecia. Such an interpretation would at least be consistent with current ideas in the field of animal genetics.

If new cases of hypertrichosis universalis should appear, it would be of the greatest importance to determine the character of the hair, the number of hairs in a group, and especially the history and condition of the teeth. It would be highly desirable if by roentgen ray or otherwise a search for unerupted teeth were made. The nails should also be examined. Further, the presence or absence of hair on the last two phalanges of the fingers and toes might throw some light on the mode of action of the causal factor.

CASES OF DOUBTFUL RELATIONSHIP

Besides the cases which it is universally agreed belong to the group showing hypertrichosis lanuginosa, there are several concerning which opinion is not unanimous. The most famous is that of Julia Pastrana (Fig. 57). She was a Mexican, who is said to have married an American named Lent, and was in no way related to "Zénora Pastrana" a European subject with marked hypertrichosis of a different kind. The uncertainty about Julia Pastrana's status is due to the fact that her hair was rather coarse and that she had all of her teeth except the four upper incisors and two canines. The statement that she had a double set of teeth which accounted for her marked prognathism does not seem to have been correct. She died at the age of 26, at the birth of her only child, who was very hairy like his mother.

Fig. 57.—Julia Pastrana (LeDouble and Houssay).

A full face view of a Siamese woman (Fig. 58) is presented by both Friedenthal and Le Double. It is presumably an authentic case, possibly copied from Hutchinson, and seems to represent an intermediate stage between a generalized covering of soft lanugo-like or transitional hair and localized hypertrichosis of the terminal hair. Between this condition and the almost complete absence of hair a series of finely graded cases could easily be arranged. Despite the numerous objectors, Waldeyer was probably correct in saying that a complete scale exists between dog-men and people with little hair. This need not mean, however, that there is an equally graded series of direct etiologic causes. It is well known, as Johannsen's work has emphasized, that individuals of identical germinal constitution fluctuate considerably, so that two different manifestations may seem to overlap. In other words, it is probable

that there are a number of distinct mutations or other etiologic factors which, operating in conjunction with other constitutional and environmental factors, produce results which are sufficiently variable to permit of such an artificial grading as Waldeyer suggested.

LOCALIZED HYPERTRICHOSIS

Hypertrichosis that is strictly localized is also frequently congenital. Besides the reported cases of infants born with full beards, there are

Fig. 58.—A Siamese woman with hypertrichosis (Friedenthal).

well authenticated instances of tufts of long hair, especially in the cervical and lumbar regions, being present at birth and persisting throughout life. These hairs are sometimes slightly pigmented, but often nearly as dark as the capillus. Rarely have they been adequately described, but in a few cases it is reported that although of considerable length they are entirely without a medulla. In most cases, their direction is that of normal hair in the same region. These localized patches occur either on skin that shows no obvious change or on skin that is variously

modified, as in pigmented nevi. In some instances, while the nevi were noticed at the time of birth, no excess hair was observed till considerably later. This indicates that in circumscribed as well as in general hypertrichosis the excess growth of hair may make its first appearance at any time during a period beginning in late fetal life and extending through the first few years of childhood. If the hairy nevi are due to an hereditary factor, as they may often be, there is little evidence that the expression of the tendency is specifically localized. It would seem probable that the skin of different persons varies in its capacity to develop nevi without having any inherent tendency to develop them in specific locations. Large pigmented nevi extending over nearly the whole thigh and covered with a rather abundant growth of dark hair have been observed in unreported cases and are also recorded and figured in the literature. Somewhat similar hair growth is reported to occur sometimes as a temporary manifestation associated with minor lesions and hyperemia.

The tufts of hair that occur along the spine are of especial interest. It was first pointed out by Virchow that the American woman, Miss Belle Carter, who was exhibited about Europe as the "lady with a horse's mane" presented definite indications of spina bifida in the vertebrae beneath the "mane." Since this observation it has been noticed that an association between spina bifida and a tuft of hair is a common one, and some have even gone so far as to regard the latter as a sure indication of the former, even when a roentgen-ray examination failed to confirm the diagnosis. Three cases in which spina bifida was recognized are illustrated in Figure 59. Cases are described in which the hair from the sacral region formed a definite tuft eight or ten inches long, suggesting the tail of a faun. Indeed Féré believes that such cases gave the Greeks their idea of the faun's tail which, it may be noted, is portrayed as arising from the sacral region, and not from the coccyx, as a morphologist might have expected.

That a moderate growth of terminal hair in the lumbosacral region is common must be obvious to every one who has occasion to see any considerable number of naked subjects. It was observed relatively frequently in examination of demobilized soldiers and may often be seen in gymnasiums. It is not likely that many of these subjects suffer from spina bifida, and one needs to be especially cautious in assuming that abundant hair in the lumbar region is indicative of this condition. But in the cervical or upper thoracic region the association is so frequent that there can be little doubt that the two conditions are intimately related. What the common cause may be is still unknown. Local inflammations, temporary hypoplasias and trophic disturbances have each been suggested, the latter two being perhaps thought of as associ-

ated with rachitis. Wanjura considers spina bifida as due to a circumscribed arrest in development, and points out that the condition most frequently occurs at the two places where the neural canal is last closed over. This theory explains hypertrichosis associated with spina bifida as being due to a temporary localized arrest of the cutaneous as well as the skeletal elements, and is in line with the view which would explain universal hypertrichosis as being due to a temporary arrest involving the whole hair-bearing area.

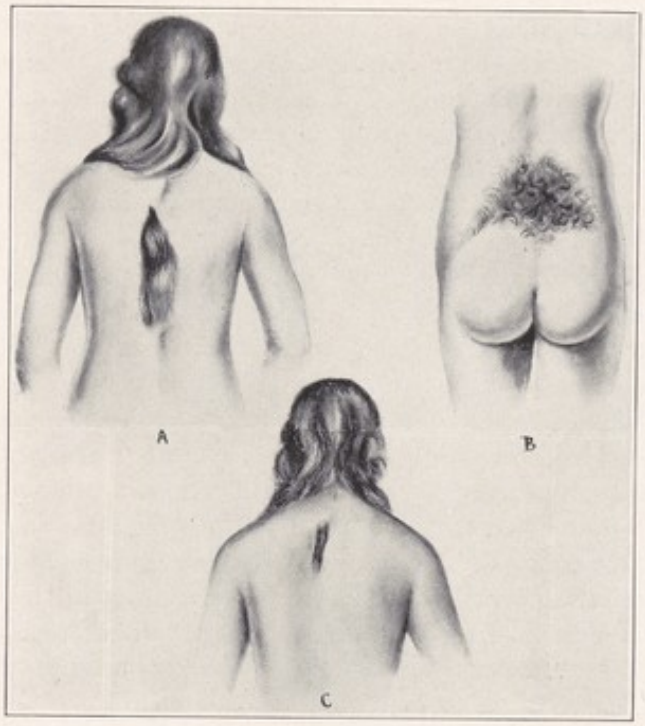

Fig. 59.—Three cases of hypertrichosis associated with spina bifida occulta. (*A* and *B* from Friedenthal, *C* from Neugebauer.)

Schein, however, regards the matter from a diametrically opposite point of view. He believes that growth energy results, so far as the cutaneous system is concerned, in the production of a greater expanse of skin or in more hair. The little triangle of cutaneous tissue which is closely bound over the sacrum cannot expand in proportion to the rest of the body surface during growth and consequently it produces hair. This accounts for sacral hypertrichosis without spina bifida. In the presence of spina bifida in other regions, Schein seems to think there is a less active growth of skin than normal. The scalp grows slowly, hence hair on the head. Like many other rather dubious explanations, this fails to account for the continued growth of hair throughout life.

Whatever may be the true cause of these forms of general and localized hypertrichosis which are either present at birth or show indications of having been potentially so, there is at least no evidence that they should be ascribed to endocrine disharmony. Especially in the case of nevi and the tufts of hair associated with spina bifida does it seem evident that the immediate cause of the excess growth is some factor whose effect is very much localized. These manifestations indicate that changes in the germ plasm and possibly other influences may effect an early but permanent modification of the potentialities of the hair follicle, which henceforth behaves differently from unmodified follicles. There are few statements as to the presence or absence of down among the larger hairs. It is of course conceivable that the nevus or the condition of spina bifida may continue to produce some stimulating effect even in adult life, but it is more probable that when the alteration in the capacities of the follicle is once established it persists. It would seem that this is, as it were, a constitutional alteration rather than simply a functional response to some ever present stimulus.

HYPERTRICHOSIS OF PRESUMED ENDOCRINE CAUSATION

Early hypertrichosis, which seems to be of an entirely different sort, is relatively not infrequent. This involves the premature appearance of the adult distribution of terminal hair, the heterochrony of Bartels' classification. It occurs in both sexes but in the female is generally complicated by an increase in the amount of hair in excess of that normal to the adult. This is generally indicative of endocrine disturbance of one sort or another and the genitalia, even in young children, are frequently developed nearly or quite to the adult stage. A case described by Lesser may be reviewed briefly as an illustration of this remarkable condition. The subject (Fig. 60), aged 6 years at the time of the examination, came from a family in which no other case of abnormal hairiness was known. The child was said to have been normal in every way at birth, but during the second year a gradual enlargement of the breasts was noticed. In the third year, menstruation began and occurred eight or nine times during the next year and a half. The menstrual periods seem to have been of the same character as those of an adult but none had occurred during the preceding eighteen months. At about the time that menstruation ceased, a diffuse growth of hair appeared on all parts of the body. A depilatory paste was then used on the face, after which it is reported that the hairs became coarser. At the time of examination, the child was said to have had the appearance indicated in the figure, with a potential heavy black beard and a short but definite mustache. The eyebrows were bushy, the axillary and pubic hair especially long and abundant. The breasts and external

genitalia were like those of a young adult. The vagina and uterus were enlarged, as was apparently at least one of the ovaries. Subcutaneous fat was developed, and the child was unusually plump and well filled out. There is definite evidence here of precocious maturity involving other systems as well as the hair, and it seems most plausible to attribute the whole syndrome to endocrine disturbance. Since what seems to be

Fig. 60.—A girl, aged 6 years, showing hypertrichosis and general physical precocity (Lesser).

the same condition occurs in boys, it is not certain that the gonads are the primary cause. Nevertheless, in one case, a boy aged 6, with an extensive growth of pubic and facial hair and enlarged sex organs is reported to have returned to a nearly normal state after the removal of an abnormal testis. At other times, there is more or less definite evidence of suprarenal abnormality, as was the case in a young male

patient with these peculiarities, who was recently exhibited at the Washington University Medical Society.

This form of excess hair has sometimes been linked with congenital hypertrichosis of the type characteristic of dog men, but it is reasonably clear that the two conditions have little in common. In the one type, the condition is hereditary and characterized by a diffuse growth of soft lanugo-like or, at most, transitional hair, deficient teeth, and no sexual precocity. In the other type, the heredity is doubtful, the hair is of the terminal sort, the teeth are normal, and there is marked sexual precocity. It is to be assumed that if an adequate "endocrine therapy" were developed, the latter condition could be made to disappear, or at least could be immediately checked as soon as noticed, where it is improbable that anything of the sort would be effective in a case of hypertrichosis lanuginosa.

WOMEN WITH WELL DEVELOPED BEARDS

A form of hypertrichosis which may be related to that accompanying premature sexual development is found in women with extensive full beards. Such women, who are often exhibited as "bearded ladies," sometimes show no other anomaly. But frequently there is reported to be considerable excess hair on other parts of the body. In many of them, the hypertrichosis appears at a very early age, for example, 6, 7 or 8 years. In other instances, probably the most numerous, it becomes apparent in the teens. More rarely, it makes its first appearance after the twentieth year. In a number of instances in which the hypertrichosis developed early, its appearance was accompanied or followed shortly by the onset of menstruation, which seems to link up this whole series of cases with those in which there is a still earlier hypertrichosis and a more pronounced early sexual development. In other words, a review of the literature fails to reveal any sharp line of differentiation between Bartels' two categories, heterochrony and heterogeny. There is little doubt that a similar condition occurs in boys and young men, but in them it is likely to pass unnoticed after the twelfth or fourteenth year.

The relation of this condition to hermaphroditism is an interesting one. Neugebauer has collected in his book descriptions of a large number of cases many of which are genuine "intersexes." Not infrequently, supposed hermaphrodites prove to be in reality male subjects with hypospadias and undescended testes. Among the latter, a typically feminine distribution of body hair is often encountered and, moreover, the breasts may appear to be as well developed as in women. As far as the urogenital system and general habitus are concerned, there are all grades between males that approach the female type, females that approach the male type, and true hermaphrodites. There are a number

of records in medical literature of adults whose sex could not be agreed on by competent clinicians. One such appeared in St. Louis a few years ago. There is consequently little doubt that many so-called bearded women were men, or at least hermaphrodites, and the genuineness of reputed cases should be regarded with skepticism in the absence of definite data as to the true sex of the person. On the other hand, careful physical measurements and thoroughly performed necropsies

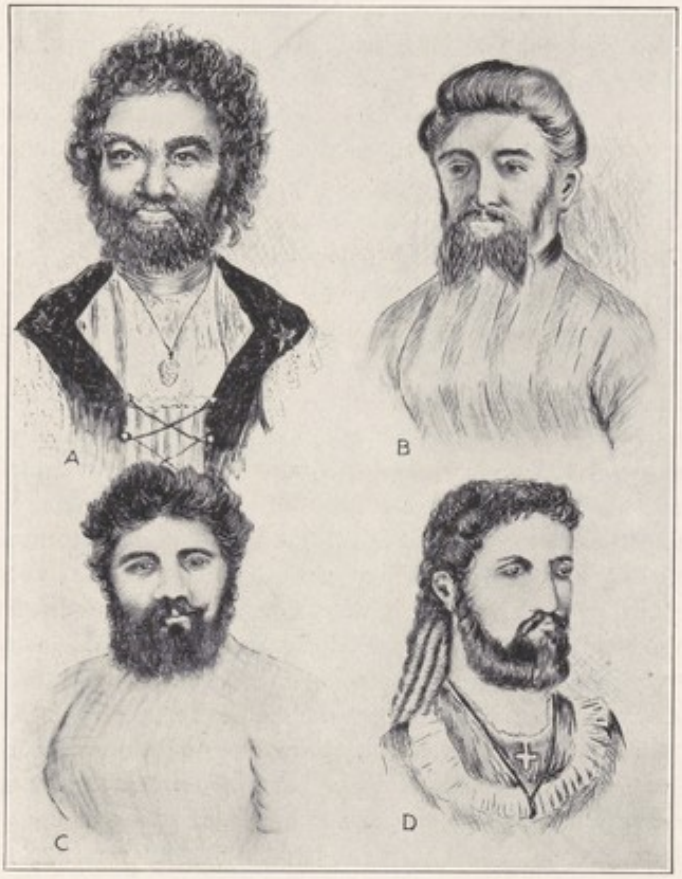

Fig. 61.—Four women with beards. (Neugebauer and LeDouble and Houssay). *A*, Zénora Pastrana; *B*, Mme. Augeard; *C*, Frau Anna Hudjon; *D*, Viola M.

have clearly established the general physical normality of many women who have had beards that were even better developed than those of average men.

Four examples of women with full beards are illustrated in Figure 61. These were selected from the numerous similar cases in the literature because they had been observed by reliable authorities

and because, unlike an equally striking case examined by the writer, they had each borne one or more children, thus supplying supplementary evidence that they were essentially normal females. Zénora Pastrana (*A*), as she was known to the public, has sometimes been confused with the earlier Julia Pastrana, owing no doubt to the assumed name, but Gassner dispelled all uncertainty on this score by exhibiting at one time before the anthropologists of Munich the living Zénora and embalmed Julia. Zénora Pastrana was married and had one normal son who died at the age of 7. Mme. Augeard (*B*) is reported to have had indications of a beard at an early age and a full beard at 20. There was no excess hair on her arms, neck or shoulders, but some in the center of the chest. An older sister presented a similar appearance. The former had a son who developed only a slight mustache on reaching manhood, the latter a normal son and daughter. A photograph of Mme. Augeard, taken when she was 47, shows little change in the hair. Frau Anna Hudjon (*C*), a native of Posen, is said to have had in addition to a full beard and a luxuriant capillus, heavy eyebrows and a generally well developed pilary system. She had at least one child. As with Zénora Pastrana, there is some uncertainty as to the amount of body hair. Finally, Viola M. (*D*), a native of Pennsylvania, was first described by Duhring and later by several German authors. At birth, she is reported to have had a rather noticeable covering of lanugo on the face and elsewhere. This fell out in the course of a few weeks. At the age of 3, there was a flaxen "lanugo" on the cheeks. By the time she was 6, a stronger growth had developed and a mustache appeared. Menstruation began at 14, and two years later the hair became considerably heavier, reaching its maximum development at 18. Axillary and pubic hair developed normally. Hair was well developed on the arms and legs. Between the shoulders at about the level of the first thoracic vertebra, there was an area about 4 inches wide covered with dark hairs. All her relatives are said to have been normal. She had two, or according to Geyl, four, normal children.

These cases are typical of a considerable number that have been reported. Evidence of heredity is generally either lacking or uncertain. In about sixty records, many of which are defective, the father is reported to have had excess hair in one case, the mother in two cases and a sister in another case. It is frequently stated that the parents, brothers and sisters are all normal. Among twenty-four children of these bearded women, twenty-one are recorded as normal and three as showing hypertrichosis. More carefully recorded data might show a greater incidence of hereditary cases. If inherited at all, the etiologic factor may be recessive. In the present state of knowledge, it seems useless to speculate on the real cause of the condition. From some

points of view, the most satisfactory tentative hypothesis assumes that it is due to an early functional anomaly of the genitocortical system or of the suprarenal cortex alone, the direct effect of which may be confined to the intra-uterine period of life. Such an hypothesis tends to link up indirectly these extreme cases of hypertrichosis with hermaphrodites; but to refer to the beard in women as an expression of local hermaphroditism, as does Friedenthal, seems wholly unjustified, unless the expression is used in a very special sense, which should then be fully explained.

GRADATIONS IN THE AMOUNT OF FACIAL HYPERTRICHOSIS

An unbroken series, starting with a type such as is represented by Viola M., and ending with a subject wholly "normal" as to hair could

Fig. 62.—Sketch of "negroid type" of hypertrichosis rather common in white women.

easily be arranged. It is one of the problems of the hypertrichosis question to determine whether the arrangement of such a series is possible through the overlapping of the manifestations of two or more essentially distinct etiologic entities or whether it is in fact a natural grouping. It is interesting to note that among women with hypertrichosis, the same sequence of extension is noticeable as in men with varying amounts of beard the mustache being most common. It has been convenient to refer to one rather frequent arrangement of facial hair as the negroid type, since a similar arrangement is often seen in negro men. This negroid type, characterized by a more or less developed mustache and a growth of hair on either side of the chin (Fig. 62) is found in women of all ages but is seemingly more common in those past middle life. This type of hypertrichosis is supposed popularly to develop at the menopause,

but Trotter was entirely unable to substantiate this view. Instead she found evidence that the average length and the average diameter of facial hairs in women increases steadily from youth to old age with no conspicuous change at any particular period. The fact that the condition is noticed in many young women while many old women do not have this hypertrichosis, as well as the fact that it cannot be produced by removal of the ovaries, counts against the idea that hypertrichosis in elderly women is due to the cessation of ovarian function. It seems far more probable that the excess hair that may appear on the faces of older women is comparable to that which appears on the ears, in the eyebrows and in other regions of men as they grow older.

SUPPOSED CAUSES OF HYPERTRICHOSIS

Various external factors have been thought to favor the development of hypertrichosis. Those that involve superficial stimulation have been discussed previously, and need not be considered in this connection, beyond calling attention to one or two possible sources of error in determining the real causal factor. It should be borne in mind that when hypertrichosis is developing gradually, any treatment which does not actually check it will seem to favor its increase, since the hair will continue to become more abundant. In a recent article by a well-known dermatologist, it is stated that hypertrichosis is so common following acne that it has become axiomatic that nothing should be done in the treatment of acne that will affect hair growth. This probably represents the prevailing opinion of dermatologists, and it is quite possible that the acne bacillus of Engman and others actually gets into the hair follicle and sets up changes which permanently alter its function; or, as seems to be implied in the article just mentioned, the applications employed in the treatment of acne may accomplish this end. Still, it seems to be true that hypertrichosis follows acne only in those places where it occurs in the absence of acne, and the possibility suggests itself that it is the larger sebaceous glands and follicles, the probable forerunners of hypertrichosis, which predispose to acne rather than the reverse.

Numerous other external stimuli, such as bruises, application of plasters, and especially wounds of various sorts, have been reported to produce hypertrichosis. It has been claimed that hypertrichoses following wounds occur whenever the nerve in a region is injured, but in the last few years a considerable number of contributors, especially to the French journals, have denied that this is the case. No such hypertrichoses as have been said to follow paralysis are usually found, and when they do occur they are now believed by many to be due to a disturbance of the sympathetic system rather than the cerebrospinal nerves.

Several diseases have been credited with leaving hypertrichosis as one of their sequelae, but the evidence of this is generally vague and unconvincing.

In regard to other supposed causes of hypertrichosis, while much has been written, there is little to be said. Hair on the forehead, espe-

Fig. 63.—Prehistoric carving on a fragment of bone, found in a rock shelter at Laugerie Basse in France (LeDouble and Houssay).

cially laterally between the eyebrows and capillus, has been claimed to be a stigma of degeneration. Hrdlicka, quoted by Le Double, found this condition in a number of cases in the New York Juvenile Asylum, but it is not stated that the subjects showed mental aberrations. It has been urged by several writers during the last ten years that hypertrichosis is

associated with insanity. Hegar, Ewarts, Dupré and Duclos, and O'Malley may be mentioned as maintaining the existence of a correlation between mental disorders and facial hypertrichosis in women, the association being due, it is assumed, to a common cause in endocrine disharmony. Dupré and Duclos present statistics to show the association between the type of neurosis and the frequency of beards. Their sequence runs in descending order of frequency from patients with senile dementia of whom 64 per cent. showed hypertrichosis, through paretic patients, other insanities, dementia praecox, idiots and imbeciles,, to epileptic patients, of whom 37 per cent. had hypertrichosis. Of 363 insane women over the age of 50, 48.8 per cent. had hair on the face, while of 637 insane women under 50, 38.7 per cent. showed hypertrichosis. The normal women examined included 188 over 50 and 820 less than 50. Thirty-eight per cent. of each of these groups had hypertrichosis. Since women under 50, whether sane or insane, show the same frequency of hypertrichosis, it is not clear from these data that there is any association between hypertrichosis and insanity, although the higher percentage of insane women over 50 with excess hair is suggestive. In over 1,600 subjects, Trotter and Danforth found the incidence of facial hypertrichosis to be essentially the same (about 27 per cent.) in college girls, clinic patients and insane women. The difference between 38 per cent. and 27 per cent. in the two studies may be due to a difference in the racial stocks examined.

Finally, there is considerable literature to show that pregnancy is a cause of increased hair growth on the face and other parts of the body. This has been attributed to the influence of the suprarenal cortex which hypertrophies in pregnancy; to some obscure effect of the ovaries, linking it with "hypertrichosis of the menopause"; and to an incretion produced by the placenta. In many cases, the hypertrichosis of pregnancy cannot be demonstrated.

SUGGESTIONS AS TO PHYLOGENETIC SIGNIFICANCE OF HYPERTRICHOSIS

In contrast to the interpretations of hypertrichosis that have just been cited, is the view that it is simply the manifestation of the normal primitive hairiness of the race. This notion takes two forms: (*a*) all kinds of hypertrichosis are atavistic, that is, either partial or complete returns to a type of hair that was once common to all; or (*b*) hypertrichosis is a persistence of a form of hair distribution that has never been lost in the lines where it now occurs. Adrian Jefticheff, Julia Pastrana, Viola M. and Belle Carter, not to mention less conspicuous subjects, have all been cited as illustrations of "reversion." Imagination pictures the ancestral germ plasm as having run a strange gantlet. A

number of carvings left in the caves of France by the ancient Cro-Magnon race have lines on them which are thought by some to represent hair, and these illustrations of people contemporary with the woolly rhinoceros are used as an argument in favor of the idea that prehistoric man was well covered with hair. Figure 63 is from the picture which probably best represents this supposed hairy covering. The proponents of the idea that pregnancy predisposes to hypertrichosis seem to have overlooked this bit of evidence.

Since reversion as generally conceived is a little understood, if not a nonexistent, phenomenon, and since there is considerable uncertainty as to what the ancestors of the species were like, it seems futile to evade the issue by calling these unusual conditions atavistic. That the milder forms of hypertrichosis may involve a persistence of the condition from

Fig. 64.—Sketch of the most common type of facial hypertrichosis in women.

an earlier time, is an idea that is less improbable. The amount of hair in certain white races is very different from that in negroes and Indians, and there is good evidence of definite differences in the subdivisions of the white race itself. The most common form of hypertrichosis in women (Fig. 64), in contrast to some extreme forms, is, according to Trotter and Danforth, a definite hereditary dominant trait which shows a correlation of 0.8 between mothers and daughters. Other writers have expressed the same opinion, but usually without a definite statistical foundation. It is often thought to be more common in dark subjects. McEwen states that the condition is hereditary and more frequent in persons of Jewish or Celtic extraction. The frequency of hypertrichosis in Jewish women has often been noted. But Trotter was unable to find any difference between dark and light subjects when actual measurements of the hair were made. Likewise Eggels, cited by Bartels, found

an excess of pubic hair as often in light-haired women as in dark-haired ones. It may be that pigment per se has nothing to do with hair growth, but that the amount of hair is largely a matter of races, and that it happens that several lines which are prevailingly well pigmented are also rich in terminal hair. As indicated in the foregoing, this may account for the difference between the reported 27 per cent. of normal American women who have hypertrichosis and the 38 per cent. of normal French women who show the same trait.

It has been suggested, on the other hand, that the beard, instead of being in process of disappearing, is a recent acquisition of the male which is now being attained by the female. As an argument in favor of this view, Brandt, who has been a thoroughgoing exponent of the recapitulation theory of morphology, stated that had Pithecanthropus had a beard, then beards would have had to appear at the present day in late fetal life! It is still a question whether the negro has been losing terminal hair or the white man acquiring it since the time when these racial stocks became separated.

In any event, subjects with the mild type of hypertrichosis and many of those with a more pronounced form cannot properly be considered as abnormal. It has never been shown that they have any other constant physical or psychic peculiarity which differentiates them from women with less hair. In this one respect, they show a secondary sexual characteristic in less marked form than do those women who belong to other lines of descent. Whether it turns out that the amount of facial and body hair of women is increasing from an evolutionary point of view, is decreasing, or remaining stationary in each strain, the observed differences are undoubtedly to be explained on the same anthropologic grounds as are other inherited physical differences.

In short, hypertrichosis manifests itself in a number of forms which have somewhat different etiologies. Germinal modifications and endocrine "disharmonies" are among the causal factors in the more pronounced cases. Nervous origin is a possibility. Hypertrichosis due to mechanical or other irritations may exist but, if so, is little understood. The cases due to all extraneous causes combined probably represent only a small fraction of those which come to the attention of the clinician or disturb the equanimity of the subject. The great majority of these instances, whatever may be their actual cause, represents a moderate "excess" growth of hair which is probably as normal to the person who has it as are eyebrows or axillary hair. This does not mean that normal hypertrichosis may not be controlled in one way or another, but it does indicate that the problem of doing it is essentially the problem of controlling normal hair growth on any other part of the body.

CHAPTER VIII

GENERAL ASPECTS OF THE HAIR PROBLEM

A cursory survey of available information on the pilary system suffices to show that our knowledge of hair is deficient in many respects. Even in its anatomy and embryology there are a number of points that have not been cleared up. There is nothing but speculation concerning the phylogeny of hair. Its comparative anatomy in the mammals is better understood, although even here there are important problems that remain to be solved. Racial differences in hair have been much studied, and there is a considerable volume of literature relating to this phase of the subject, but much of it is of a superficial character with little real value. The weakest place in the whole field, with the possible exception of questions of phylogeny, is in the understanding of the factors regulating growth, either normal or abnormal. It is scarcely an exaggeration to say that next to nothing is known on this phase of the subject.

A summary of the present status of knowledge relating to any other important system or organ of the body might be stated in much the same terms. Certain types of vital processes are easily demonstrable while others are especially baffling. Peculiarly difficult to understand is the phenomenon of growth and differentiation, no matter in what structure it is observed. At present nearly all questions in the field of biologic studies lead ultimately to the same fundamental problem as to the meaning and regulation of the changes involved in growth processes. Probably no system is better suited to the study of these processes than the pilary system, in which the individual hairs each represent easily accessible structural and functional units which may be observed and subjected to experimental treatment, or even excised, without serious inconvenience to the subject.

An attempt has been made in the foregoing discussion to indicate what seem to be some of the outstanding problems relating to hair. In the field of morphology and phylogeny, new light on the relation of hair to other dermal appendages would be most welcome. The idea of partial homologies, which it was ventured to suggest in the first chapter, may help in formulating new hypotheses and in planning new modes of attack. In all of these various aspects, the questions relating to hair are fundamentally the same as those relating to the skeleton, or to any other system. In the relation of different types of hairs to each other, the problem is presented of determining whether controlling factors that

regulate the differences are inherent in the follicles themselves or are of a circumstantial character. This problem takes a practical form, for example, when the question arises as to the advisability of early removal of superfluous hair. Particularly important would seem to be an understanding of hair groups. If these groups should be shown to have a morphologic unity and the hairs composing them to be related among themselves in a definite way, considerable advance toward an understanding of what are now some of the most puzzling problems would have been made.

The more accurate determination of normal sexual and racial differences in hair, not only of the head but of other parts of the body, will no doubt aid materially in an understanding of the variations encountered in any restricted group of subjects. Such aphorisms as "the negro is only a pathologic white man, and vice versa" are not wholly without grains of truth. For the anthropologist no less than for the student concerned only with the problem of growth, it is important that wherever possible pieces of skin be obtained with the hair on it so that the relations of the follicles and hair shafts can be checked against each other. One technic for handling hair-bearing skin is described by Bischoff. For examining individual hairs, some kind of a hair rotator or device for turning the hair under a lens is almost indispensable, since an erroneous idea of hair form might easily be obtained from hairs mounted in the usual manner. A Zeiss "Kapillarrotator" is described as a small glass tube into which the hair is drawn before being dipped in xylol and mounted. The tube with the contained hair can then be turned as desired. Hausman's hair rotator consists of two fine wires with loops at either end for holding the hair. These wires are passed through corks which are carefully centered, and cemented to a glass slide. In this laboratory, a metal attachment to the stage of a microscope was devised, with supports on either side to hold a slender rod with milled screw heads at the end. A section of the rod is cut away in the middle and provision made for attaching a hair by means of clips in the geometrical axis between the cut ends of the rod. Such an apparatus enables one easily to get the measurements for determining hair indexes or to study variations in the configuration of the shaft. With reference to the general arrangement of hair, a better method than has yet been described for determining and indicating the amount and types of hair in a given region is desirable.

The number of problems relating to the growth of hair under normal or controlled conditions are rather numerous, and it is evident that, unlike some other lines of investigation, further progress here does not wait on new methods or new points of view. Patience and accuracy of

observation should suffice to clear up a number of points which are still unsettled. For the solution of other of these problems, a certain amount of genius may also be necessary. The questions that arise with reference to aberrant growths are essentially the same as those which present themselves to the student of normal growth. But in connection with the former, there are always special conditions or circumstances which often seem to carry some hint as to the nature of underlying factors. A number of problems suggested by such conditions as monilethrix and by alopecia and hypertrichosis have already been discussed. In regard to the latter, the importance of anatomico-anthropologic data might again be emphasized. Much light would be thrown on certain manifestations of this condition if it could be determined whether or not the actual number of hair follicles to a group is increased, and if such regions as the middle of the fingers, which may or may not have hair in normal subjects, show any tendency to respond to the factors for hypertrichosis or alopecia. In other words, it is desirable to know what conditions, if any, are due to alteration in the production of follicles, and what to alteration in the function of follicles already produced. From a theoretic point of view, it would be of great interest to know whether one and the same factor could operate in both ways. To mention one or two other points, it would help materially in the understanding of hair growth if it could be determined whether or not all down hairs have the potentiality of becoming terminal hairs; and, if such should happen to be the case, whether a follicle that has once been stimulated by endocrine or other factors to produce terminal hair will continue to do so in the absence of the initial stimulus or will revert to its previous condition. The sympathetic nervous system and the endocrine glands will probably be found to have a relation to hair production comparable to the relation which they have to most other developmental processes.

From time immemorial man in general has been dissatisfied with certain details of his pilary system. In races with a growth of beard slight enough to make the procedure feasible, the hairs were doubtless pulled out long before the invention of razors or other means of temporary depilation. Ancient records indicate that women of many countries have at times resorted to the custom of partially removing their eyebrows. Women with facial hypertrichosis have no doubt always wished to be rid of their superfluous hair. As yet, however, no entirely satisfactory method of eliminating undesirable hairs has been devised. In some cases they are allowed to remain, lest disturbing them should increase their growth. When not too numerous they are often pulled out. In other cases they are shaved, kept rubbed down with pumice, or removed by chemical methods. Clinically, radium and the roentgen ray have been employed, but the reports indicate that the dosage is too

uncertain and the results too variable to give much hope from these procedures. The electric needle is generally proclaimed as supplying the most satisfactory means that has been thus far devised for permanently removing hair. This clever device is due to the ophthalmologist, Dr. Charles Michel of St. Louis, who first employed it about 1875 for removal of ingrowing eyelashes. The principle of electric depilation involves the killing of the active part of the follicle and bulb by inserting a needle beside the shaft and passing through it a current that will accomplish this result with the least possible injury to the surrounding tissues. The method is painful, slow, and in many cases only partially effective. Its use seems to be avoided as much as possible by all but specialists in this particular line. The lack of a good means of permanently destroying the hair, the inconvenience and uncertainty as to the effect of depilatories containing barium sulphid or other keratin solvents, and the complete ignorance of how to control hair growth leaves the practical phases of the hair problem in a rather unsatisfactory state. This is well brought out in a recent review by Lowenstein, whose summary of the literature for the last ten years shows how slight is the progress that has been made in that time.

The bibliographic list which follows indicates only a small fraction of the matter relating to hair in its different phases. The books and articles included were selected either because they present material bearing directly on the points discussed here or because they contain good references to the literature. A few titles are included because of their incidental or historical interest.

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