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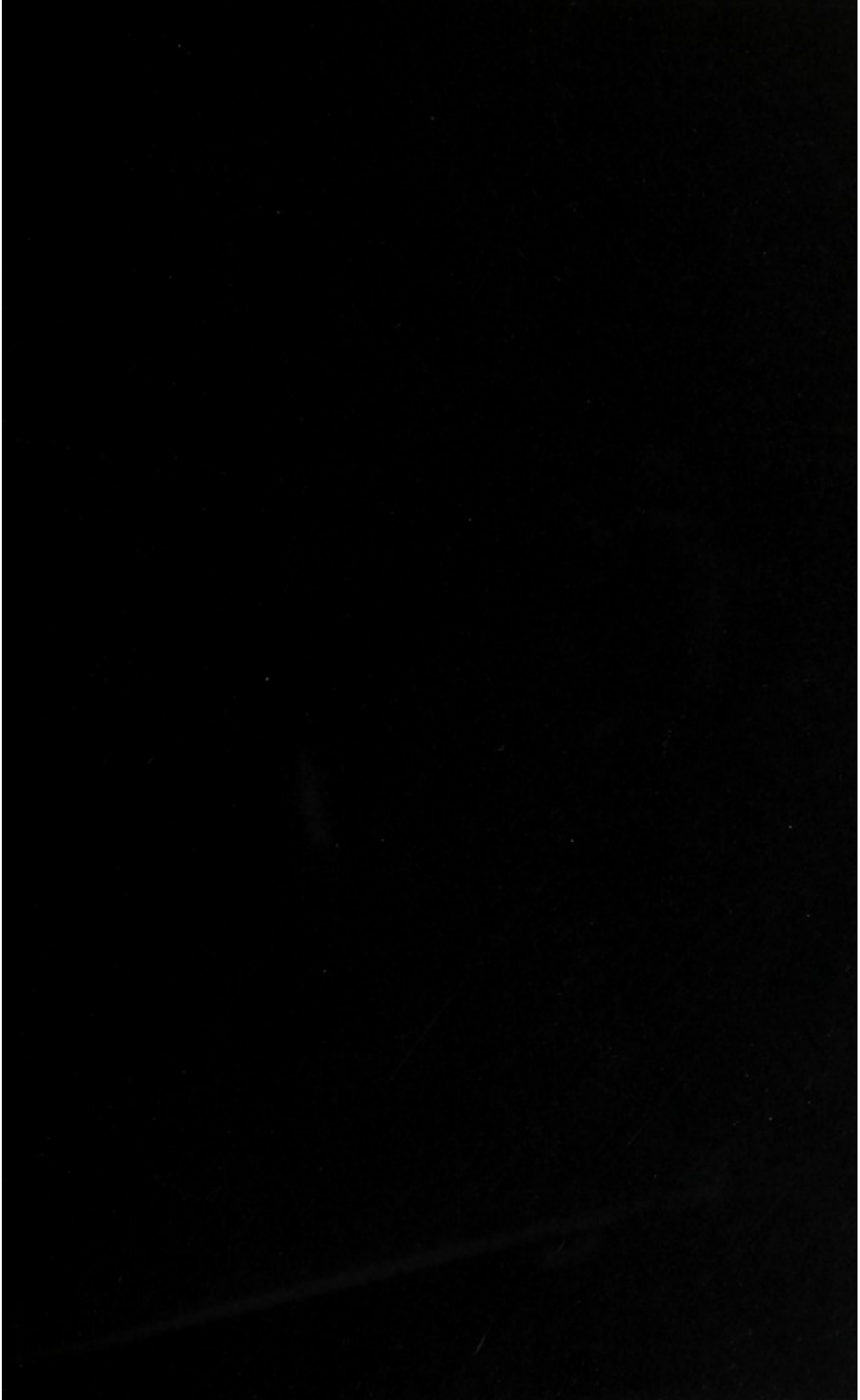

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ERRATUM

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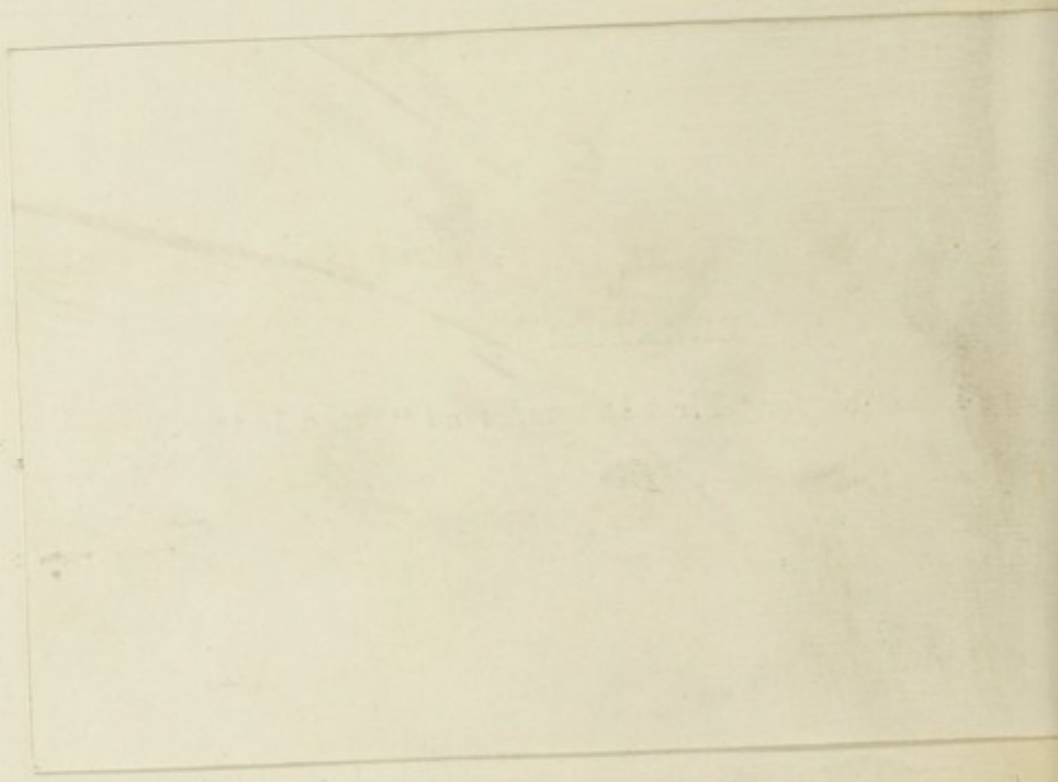
LONDON
ADAM AND CHARLES BLACK
1903



THE DIRECTION OF HAIR IN ANIMALS AND MAN

BY

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AUTHOR OF "USE-INHERITANCE"

LONDON

ADAM AND CHARLES BLACK

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PREFACE

THE purpose of this work is threefold. It seeks to co-ordinate the scattered facts of the direction of the hair in the lower animals and man, to furnish interpretations of most of them on mechanical principles, and to supply an answer to the question, "Can acquired characters be inherited?" It is shown that with few exceptions the hair-streams grow on the animal body *in the lines of least resistance*, and the "resistances" encountered are mechanical. No doubt many of the phenomena here described are intrinsically uninteresting and unimportant. As part of a page of natural history they might never have been recorded. But natural history may become natural science, and until it has done so it has failed to fill its place in the order of Nature. When it is seen that the object here kept in view is the establishment of a fragment of *abstract* truth, many, whose horror of theory is genuine and, perhaps, not unreasonable, may be deterred from further interest in it. But others would prefer to help in laying one stone which shall be hidden in the foundations of the fabric of science than many a course of finer blocks in her rapidly-rising walls. If it be objected that the matters here dealt with are

too trifling to be allowed to weigh in a great outstanding controversy, it may be pointed out that if the mere possibility of the transmission of acquired characters be established, such a truth cannot remain ultimately steriie. In unsolved scientific problems the Experiment of the Finger Post is often a trivial one. If we want a parallel for the interdependence of theory and practical results, a page of naval history supplies one. In the middle of the eighteenth century a Scotch gentleman named Clerk of Eldin, was occupying his mind and wasting his time, as his friends thought, in showing by means of models which he called his "wild-ducks" that the naval tactics of the day were radically wrong. He wrote a book on the subject, which evidently fell into the hands of Rodney or his captains, or both, before the memorable Battle of the Saints in 1782. For the first time in naval warfare Rodney dared to "break the line" and the traditions of naval tactics once for all, with the immediate result of which we are aware, and the ulterior results which issued under "the headlong and yet well-calculated fighting" of Hood, Jervis, and Nelson. Anything more abstract, or even visionary, than the work of Clerk of Eldin, and more practical than its outcome in 1782—and after—can hardly be suggested.

It is obvious that if any considerable proportion of the second division of the subject be recognised as valid, an affirmative answer to the question, "Can acquired characters be inherited?" follows as a matter of course. If as much as this be gained, it will remain for others, more qualified to do so, to show how far Lamarckism must rank in future

among the primary factors of organic evolution. The question at issue is one for inductive study rather than for dialectics, and this is the line that has been pursued here. The ultimate importance of it none can doubt. Romanes, indeed, went so far as to say regarding it that an examination of Weismannism in which the question of the transmission of acquired characters is omitted must prove a case of Hamlet without the Prince of Denmark. It forms an integral part of a great system of heredity invented by a greater biologist, and elaborated during a period of nearly twenty years. But it is being felt by many that the teaching of Weismann is exercising an undue influence over contemporary opinion in this matter, so much so that he and his followers can but tacitly acknowledge, in regard to the principle of selection, "we are contending for our all." Their attitude is no less lofty than that of Montrose, when he wrote :

> As Alexander I will reign
> And I will reign alone,
> My thoughts did evermore disdain
> A rival on my throne.

Weismann's theories of heredity were not taken up with any apparent intention of modifying the current theory of evolution, but Romanes showed how intimately associated are the two matters, and it is becoming clear to many that "evolution according to Weismann" is untenable, from which it will eventually appear that its basis, viz., his theory of heredity, will have also to be surrendered. He made some very double-edged remarks as to the "working hypothesis" of the Lamarckian principle in one of

his latest works:* "A working hypothesis may be false, and yet lead to further progress; that is, it may constitute an advance to the extent of being useful in formulating the problem and in illuminating paths that are likely to lead to results. But it seems to me that *a hypothesis of this kind has performed its services and must be discarded the moment it is found to be at hopeless variance with the facts.*" (Italics not in the original.)

I have to thank the Publication Committee of the Zoological Society of London, the Editors of the *Journal of Anatomy and Physiology*, the Committee of Management of the Anatomical Society of Great Britain and Ireland, and the Editor of *Knowledge*, for permission to reproduce here portions of the letterpress and illustrations of papers published by them.

The illustrations have been prepared for me by Mr. R. E. Holding, and have been throughout made diagrammatic, artistic considerations being sacrificed for the sake of clearness. In many of them arrows have been used to represent the hair-streams of the parts, and have been distinguished from one another according as the shafts of the arrows have single, double, or triple feathers, on a certain principle referred to in Chaps. I. and V. This account of a large subject can only be considered as an introduction. To have given detailed descriptions and illustrations of the immense varieties in the arrangement of hair which are found among hair-clad Mammals would have been confusing and unnecessary at this stage, and with the present purpose in view.

* "Germinal Selection," p. 17, 1896.

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IN ANIMALS AND MAN

CHAPTER I

INTRODUCTORY SKETCH

The individual hairs of the animal body form an acute angle with the surface on which they are situated, with very few exceptions. The chief of these are the orbit where eyelashes are set nearly at a right angle, the muzzle where bristles are found, and the median line of the head and neck where longitudinal crests or manes are formed. The rate of growth is certainly not less than half an inch a month in the lower animals, that being the rate of growth of the hair of man, a structure far less functionally active than the hair forming the pelage of other hairy Mammals. This is a measurable rate of growth, which must be reckoned with in considering the ætiology of the direction of hair in man and the lower animals.

It is a simple matter to describe the various directions taken by the hair on different animal forms, but if one's study of the subject were to end with

description, very little importance or interest would be attached to it. The history of the individual variations found and their ætiology are integral parts of this complex study, if any useful scientific investigation of it is to be made.

Certain data are necessary for this study.

(1) That the rate of growth of hair is an appreciable one.

(2) That the direction of hair can be modified in the life of an individual animal. This is obviously the case on the head and face of man, and may be assumed to be so in lower animals, though not easily shown in particular cases. There are close analogies with this fact in the case of the auricle, the teeth, nails, and phalanges of the foot in man.

(3) The most important is that the original type of hair-direction in the primitive hairy Mammal was simple and uniform, and that it was as follows: The slope was from the tip of the snout to the caudal extremity of the animal, along the head, neck and trunk, and on the limbs from the proximal to the distal ends. This type is abundantly represented in existing Mammals such as **RODENTS, INSECTIVORES** (with the exception of the **Mole**), smaller **CARNIVORES, MARSUPIALS,** MARMOSETS and LEMURS, all of which are long-bodied forms, and most of them with short limbs except **MARSUPIALS.** Many of these groups of animals would serve to represent what must be assumed to have been the hair-slope of the prototype of hair-clad Mammals. A familiar type of these may be seen in the case of the **Otter.**

From the nature of the case this datum cannot

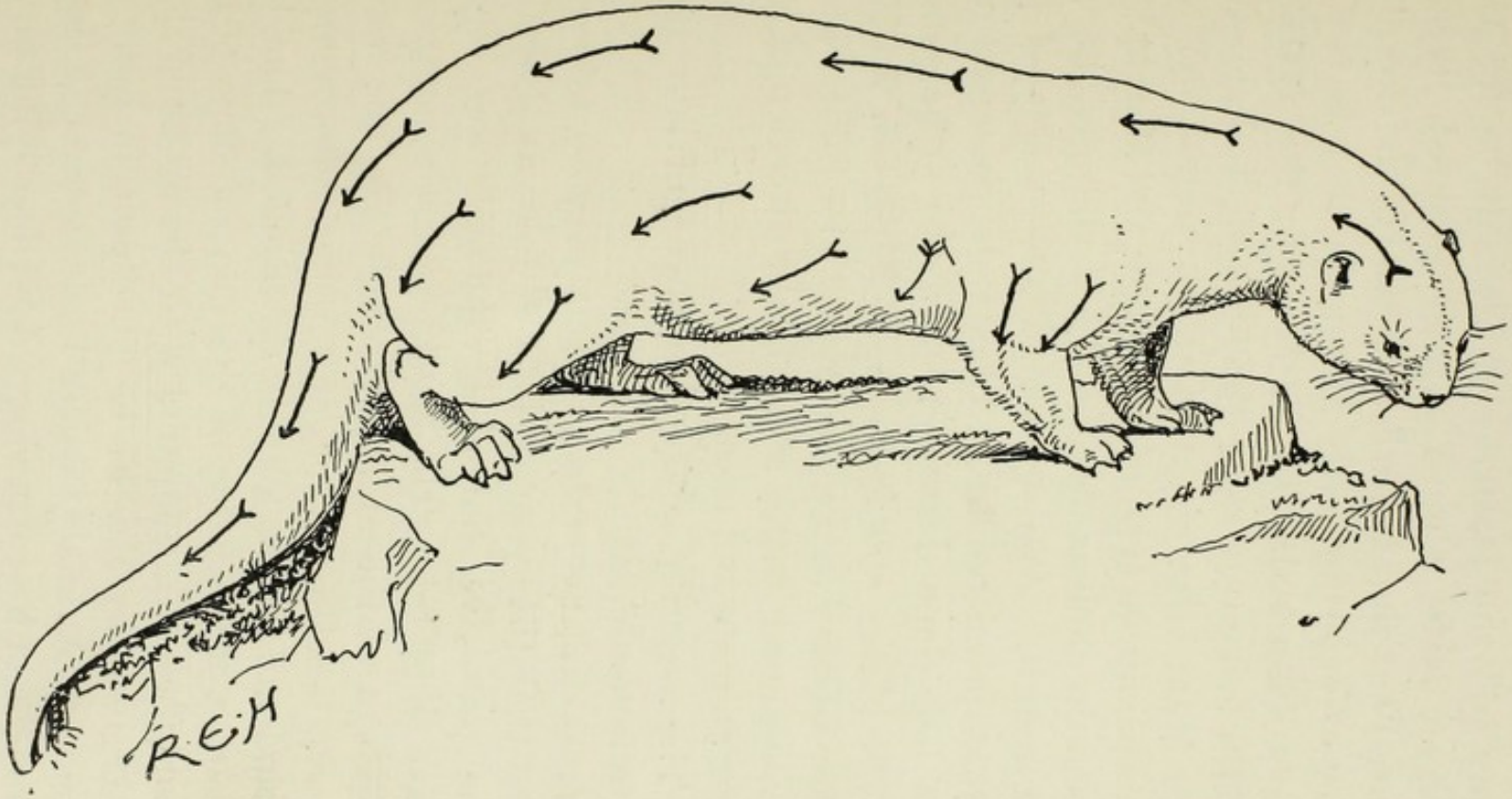


FIG. 1.—DIRECTION OF HAIR IN OTTER (*Lutra vulgaris*), PRIMITIVE TYPE.

be proved, but unless the findings of Comparative Anatomy and the Doctrine of Descent be for this occasion set aside, it must be freely granted. It may be pointed out that there is no animal in the accepted ancestry of existing hairy Mammals that is not of the form described. To go back to the **MONOTREMES** brings us near the hypothetical ancestor of hairy Mammals; *e.g.*, **Ornithorhynchus** exhibits just this primitive type of hair-slope, and Marsupials, with certain obvious morphological changes, hardly depart from it. Analogy would almost compel the view that primitive hairy Mammals possessed the type of hair-slope described when the arrangement of scales, plates and feathers in **FISHES, EDENTATES, BIRDS**, are considered. The First Datum then is assumed in this study of the direction of hair in lower animals and man.

(4) The majority of the phenomena of hair-direction are non-adaptive.

It must first be stated that it may be taken for granted that the original slope of hair, as described on the primitive hair-clad Mammal, was highly adaptive as affording the least possible resistance to the passage of the animal through the air, water, burrows, brushwood, or any other heterogeneous environments which may be mentioned. The best illustration of the value of this general slope of hair from snout to tail, compared with the reversed slope, is that given by Mr. E. E. Thompson in his "Art Anatomy of Animals," where he described the simple experiment of first drawing a dead deer lying on the grass forwards and then endeavouring with the same force to drag it backwards. The remarkable resist-

ance offered by the friction of the hair against the ground at once shows the value to this animal, and by analogy to other animals, of its existing slope of hair.

It will be sufficient simply to state a few instances of the variations of hair-slope to show that this datum must be freely granted, and that most of them are non-adaptive. In the case of a **Domestic Cat,** or any of the larger FELIDÆ, it cannot be a detail of its better equipment for the struggle of life that on its broad short snout there should be a patch of hair on which the slope is from base to tip of the snout, thus forming a singular exception to all the rest of the hair of the face and head.

Again, on the pectoral region of a **Domestic Horse** the hair is disposed in two large symmetrical "featherings," each starting from a whorl in the flexure of the forelimb. This can in no way contribute to efficiency of the animal for its life. So in the case of the whorl, feathering and crest found in the inguinal region there is absolutely no survival-value to be attributed to this small arrangement of the hair. It may be remarked here that neither of these arrangements of hair is found in a **Zebra,** so very closely resembling in form the **Domestic Horse.** The allied instances of the same truth are so numerous that it may be said "*ex uno disce omnes.*"

On the skin of man the illustrations of this point are very numerous. It will be sufficient to quote two. It cannot be supposed that on the occipito-cervical region it is of any importance whatever to the possessor whether the slope of his hair is towards

or from the middle line, each of these arrangements being found in nearly equal proportions in a very large series of human beings, and one of them never found in any of the existing Simian forms. Lastly, neither comfort nor survival-value can be claimed for the singular sudden reversal of hair-slope at the second costal cartilage whereby the original slope is departed from and the hairs at this level begin to point upwards to the neck.

(5) Primitive man was at one period of his history clothed with thick long hair.

(6) Early man commenced at some far-distant period to assume as his predominant attitude in sleep the lateral position, and at a date perhaps still later, to employ some form of pillow for his head; and at some also distant period he commenced to wear clothes.

Three main laws appear to govern the direction of hair in animals.

In the first place, the primitive arrangement referred to, and assumed, is found existing more or less in all hair-clad Mammals, and is not lightly departed from by any individual animal in the course of its development.

Secondly, certain modifications of this primitive arrangement are due to morphological changes in the animal exhibiting them.

Thirdly, all the remaining phenomena of hair-direction are to be explained by the action of mechanical forces acting on the surface of the body.

The major portion of the hairy covering of any animal comes under the First law, and, so far as it

does this, it is a product of natural selection, being an adaptive modification for the greater efficiency of the possessor in the struggle of life, or at any rate a survival from an earlier adaptation which was of service to its ancestors. This is assumed and referred to under the Data. (No. 4.)

The Second law applies to considerable areas of the surface of all animals. In the course of morphological development the primitive arrangement becomes more or less modified without any regard either to survival-value and natural selection, or to the mechanical forces concerned in the Third law. With morphological changes are correlated certain simple departures from the primitive type of hair-slope. One illustration of this change may be here alluded to. A primitively covered long-bodied **CARNIVORE**, such as an **Otter** or **Civet Cat**, differs very manifestly from a short-coated **Domestic Dog**, such as a **Fox-terrier**, in certain areas—*e.g.*, the lateral aspect of the thorax, where the hairs slope almost at right angles to the axis of the trunk, instead of almost along that axis. In such an instance neither is the primitive arrangement found nor is the new type attributable to mechanical forces.

The Third law governs many of the variations of hair-slope in animals, and under it there appear changes of a pronounced character which are neither primitive nor due to morphological change, but to definite, ascertainable, mechanical forces.

From these three laws some light breaks on the otherwise chaotic facts of the direction of hair on the bodies of man and the lower animals, and it is pos-

sible to map out roughly the territories governed by the laws in question. Some animals will exhibit all its surface under the *first* law, others under the *first and second*, and the greater number under the *first, second and third.* This delimitation of frontiers will be reserved for a later chapter. The main purpose of this book is to show how the modifications coming under the third law arise, and to lead up to the demonstration that in this region, at any rate, Weismann's great rule, that acquired characters are never transmitted, breaks down.

It is convenient here to describe briefly those phenomena in the direction of the hair of animals which are claimed to be produced by mechanical forces acting on the surface of their bodies.

They are three in number : **Reversed Areas of Hair. Whorls, Featherings and Crests. Tufts.**

Reversed Areas of Hair may be most simply illustrated by the case of the extensor surface of the ulna of a short-haired **Domestic Dog** as shown in the Figure, or the extensor aspect of the forearm in Man (Fig. p. 10). They are found in various animals and various parts of their trunks and limbs, and they show a reversal of the hair-stream of the part comparable to the "backwash" of a stream of water, and obviously stand as much in need of some explanation as the corresponding phenomenon in a river.

Whorls, Featherings and Crests, being as a rule associated, are grouped together here as one phenomenon.

A whorl consists of a group of hairs which, from some anatomical or dynamical reason, radiate from

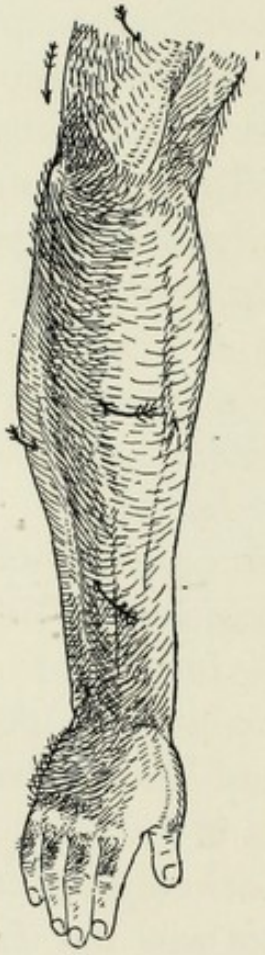
a central point and merge into the adjoining streams of hair in various ways. Whorls are always found opposing a stream of hair, and stand out from the general neighbouring stream so prominently and so variously in similar forms of animals as to suggest that something more than anatomical arrangement of the part involved is at work in producing them. They are most common in short-haired forms, being either absent or very rudimentary in those with long hair. Associated with whorls are two other characters which are more or less frequent, and which must be considered with them. The whorl is generally the starting-point of a feather-shaped arrangement of the hair in the opposing stream, and this passes in a directly opposed course, diverging on each side, and coalescing gradually into the stream, and it is generally terminated sharply by a crest or ridge. Of these three arrangements—a *whorl*, *feathering*, and *crest*—a whorl alone may be present, and nothing more than a star-like arrangement of the hair be found; or this may branch out into a feathering which terminates quite imperceptibly in the opposing stream, or it may definitely be brought to a stop in a crest, which stands out like an obstacle in the course of the general stream of hair.

Tufts differ from whorls very markedly, inasmuch as the latter are areas of *divergence* and the former of *convergence* of hair-streams. Tufts are much less important than either of the two preceding phenomena, being found comparatively seldom, and only on two regions of the body as far as I have seen, on the flank of **UNGULATES**, chiefly the **Domestic Horse**, and occasionally over the extensor

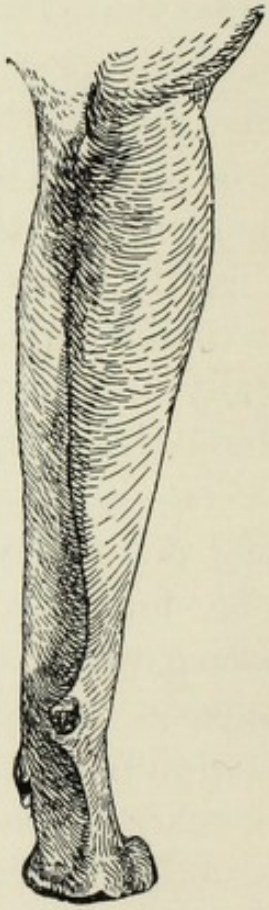
muscles of the hind limb. This tuft is shaped very much like a stack of corn standing in a field, and projects above the level of the surrounding hair-streams. Sometimes there are two tufts in the flank of a **Horse**, with a ridge of hair joining them.

These phenomena will be dealt with more in detail in a later chapter.

FIG. 1*a*.



EXTENSOR SURFACE OF THE FOREARM OF MAN



EXTENSOR SURFACE OF THE ULNA OF A DOG

CHAPTER II

CRITICAL AREAS

When the direction of the hair in the lower animals and man is considered in connection with mechanical causation, it is found that there are several regions of the head, trunk and limbs of any Mammal, some of which are peculiarly open to contact with opposing surfaces, and the others under the special influence of certain active habits of the particular animal form. These regions are here termed Critical Areas.

As a hair-clad Mammal pursues its way through its wild life, its external covering is necessarily exposed much to friction or pressure. Thus an **Otter** in its burrows and in the water, and a **Mole** in its busy underground existence, constantly encounter such pressure and friction. The latter bears traces of its habit of constantly passing backwards and forwards through its narrow burrows in its soft velvety reversible fur, thus differing in a significant point from the Otter In these two instances the points of contact with opposing surfaces are little varied, and they, with many long-bodied, short-limbed forms, are the simpler groups of animals to study. Others, such as a **CARNIVORE**, with

longer limbs and a more developed trunk, pass a more complicated life in a wild state and will meet more varied obstacles. Thus in the sitting and recumbent postures they will bring certain parts of the gluteal, pectoral and abdominal regions and the extensor surface of the ulna into apposition with certain supporting surfaces. The habits of cleaning their fur by licking it with their tongues and by rolling and rubbing themselves against grass, undergrowth, and any other convenient obstacle, and of smoothing down the hair of the snout with their paws from base to tip, are characteristics of many of such animals. Here then are other conditions, which will produce critical areas in the hairy covering.

The different form and habits of **UNGULATES** cause them to present some points of difference as to those regions where contact with external objects is specially felt. Ungulates do not burrow or live under water, but in the course of their lives pass much through forests, undergrowth, high grass, and these will have very much the effect of water and burrows upon their coats.

They do not sit—indeed, I suppose an **UNGULATE** never did sit, except in a circus—and therefore the gluteal region is not open to any special pressure, but they do lie, as do all wild animals, for a large part of their time, and in doing so they offer different regions to the influence of the supporting surface. In sleep an **UNGULATE,** such as a **Domestic Horse,** lies as a rule stretched out on one side or the other, with the various underlying parts indifferently disposed, and from the nature of the position and form of the animal there is no

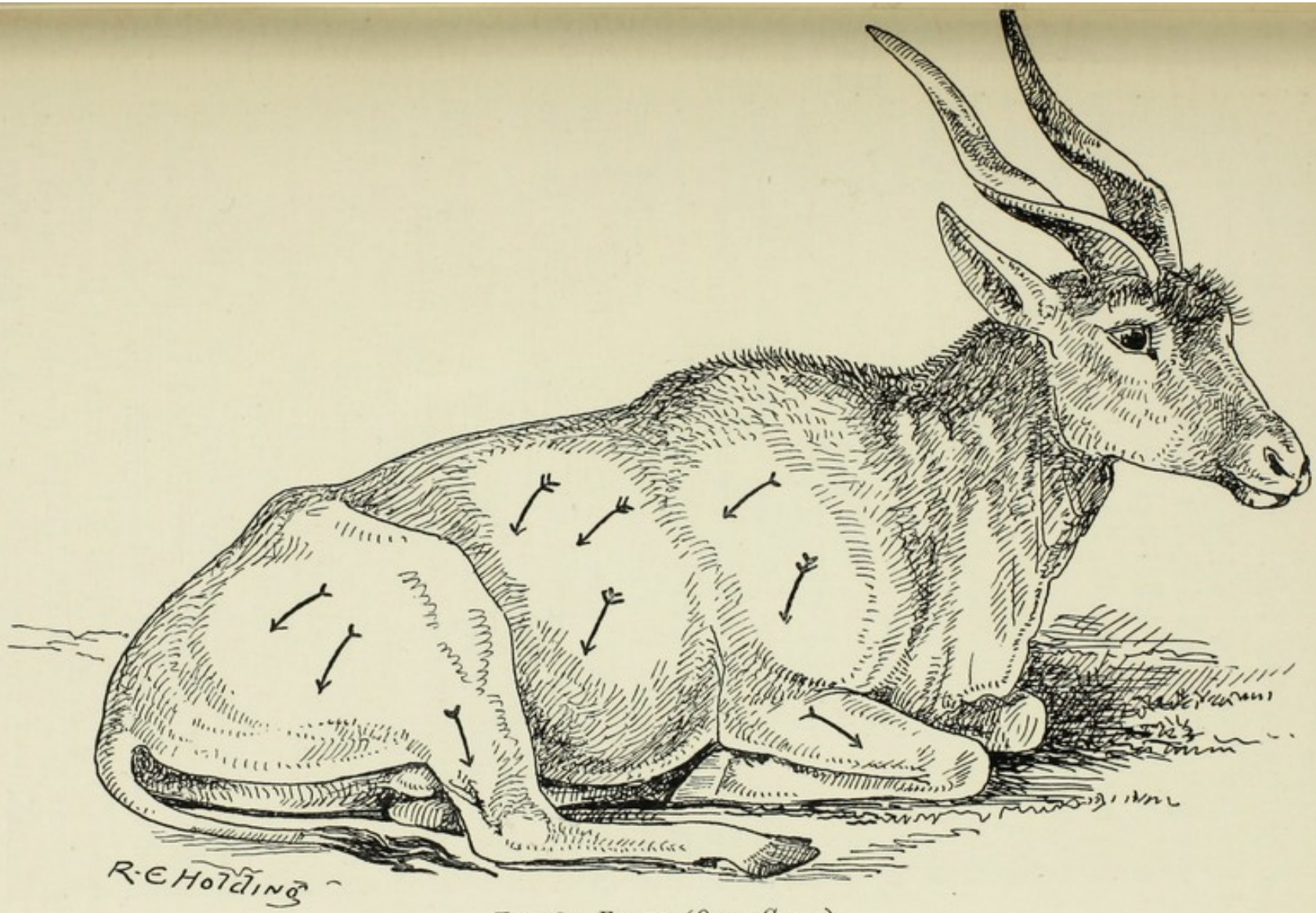


FIG. 2.—ELAND (*Oreas Canna*).

Attitude of Ungulate at rest, showing also morphological change of direction of hair on side of trunk.

influence exercised by this position in modifying the direction of the hair. But it is very different as to the habitual posture of rest which a **Domestic Ox** occupies for such a large portion of its life. Such an animal lies with head raised, either at or above the level of its trunk, fore-limbs doubled so that the carpal joint is completely flexed, the hoof of one side slightly everted, and that of the other, as a rule, under the abdomen. The posterior portion of the thorax and the abdomen rest on the ground, but the pectoral region is raised by the fore-limbs so as not to be in contact with it. The hinder portion of the body of the **UNGULATE** seldom lies in the median plane, but inclined to one side or the other, so that the lumbar and lower dorsal portions of the spine are rotated, and this causes the hind limbs to be on one side, the metatarsal bones extended and in contact with the ground, the "knee" of the animal strongly flexed and closely applied to the inguinal region (Fig. 2).

A typical and predominant attitude adopted by **CARNIVORES** in lying is that the animal, *e.g.*, a **Fox-terrier**, when in a state of partial rest, lies with its head elevated; or, in complete rest, with head reposing on the fore-limbs, and the ventral surface of the muzzle in contact with the flexor surface of the radius and ulna. The fore-limbs, in the case of the **CARNIVORES**, are planted in an extended position, in marked contrast with one of the **UNGULATES** (Fig. 5). Thus it happens that the extensor surface of the **CARNIVORE** fore-limb lies on the ground, the corresponding surface of the **UNGULATE** being in contact with the flexor surface of

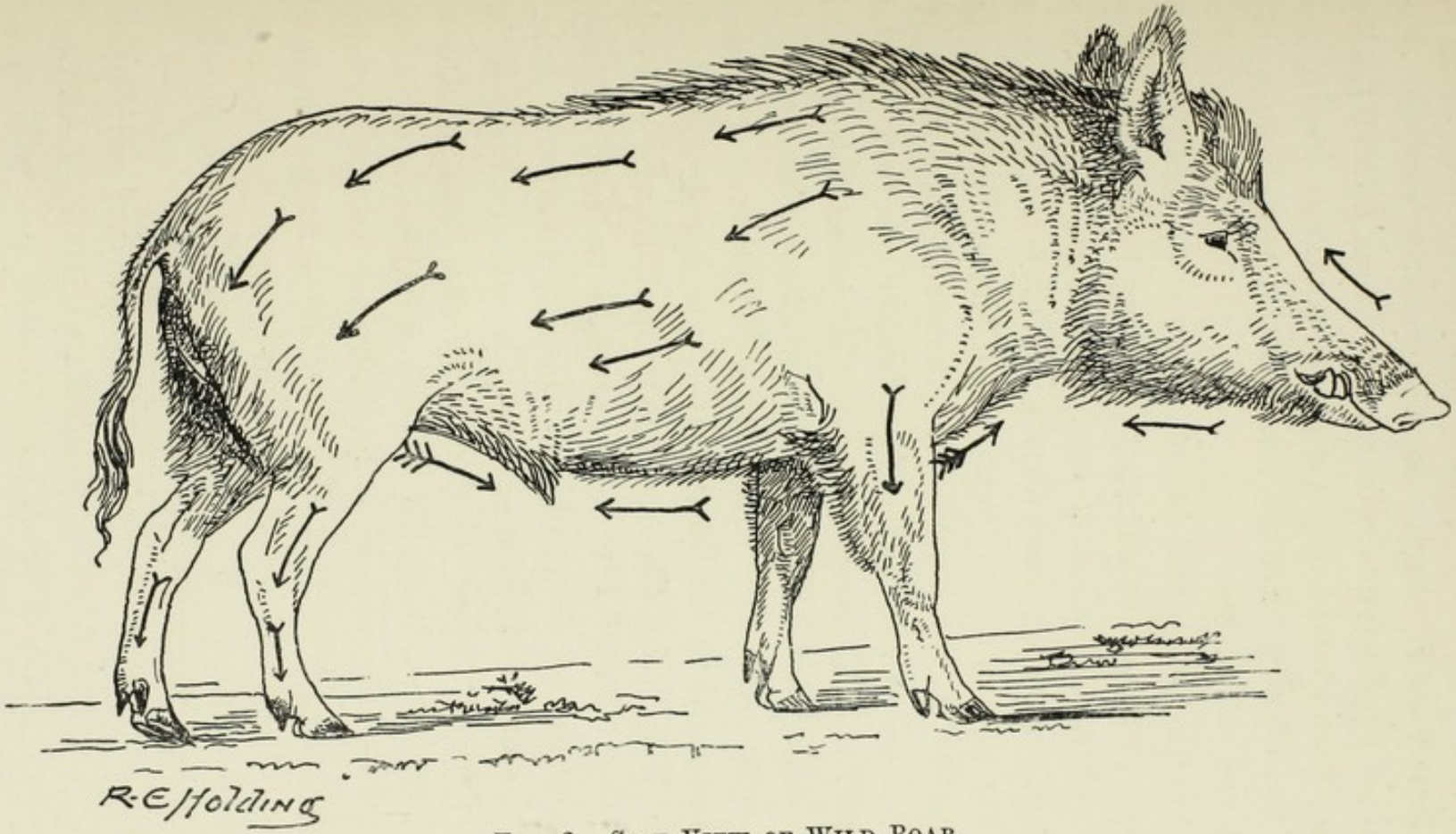


FIG. 3.—SIDE VIEW OF WILD BOAR.

Showing primitive direction of hair except on ventral surface of neck and chest, and on ventral surface of abdomen, *posterior region.*

the metacarpus. There are occasions when a **CARNIVORE**, such as a domestic cat or dog, doubles up its fore-limb and lies as an **UNGULATE** does; but this is far from the common habit, and the limb being relatively short, the surfaces in contact are not large.

This predominant habit of the **CARNIVORES** brings to pass a close contact of the flexor surface of the radius and ulna of each side with the pectoral region. Passing backwards, we find that the projecting thorax and upper part of the abdomen are in contact with the supporting surface, as in the case of the **UNGULATE**. The hinder portion of the **CARNIVORE** shows much the same attitude as the **UNGULATE**, but it is rather less rotated, and frequently the hind-limbs lie extended under the abdomen in the long axis of the trunk.

An **UNGULATE** never sits, and in the case of the **CARNIVORES** this attitude in rest is only found with any frequency in the short-bodied forms. In illustration of this, one may point out that it is hardly to be conceived that a **Horse, Ox,** or **Deer** could sit, and that, to take examples among domesticated CANIDÆ, a **Dachshund** comparatively seldom sits, and that a **Fox-terrier** or **Pug** spends a large proportion of its time in a sitting posture. Such facts are, of course, explicable on purely mechanical principles.

As to the ætiology of the difference of attitudes adopted by the **CARNIVORES** and **UNGULATES**, the general shape of the different types will to a great extent account for it. The **UNGULATE** forms, generally speaking, have a short body, long

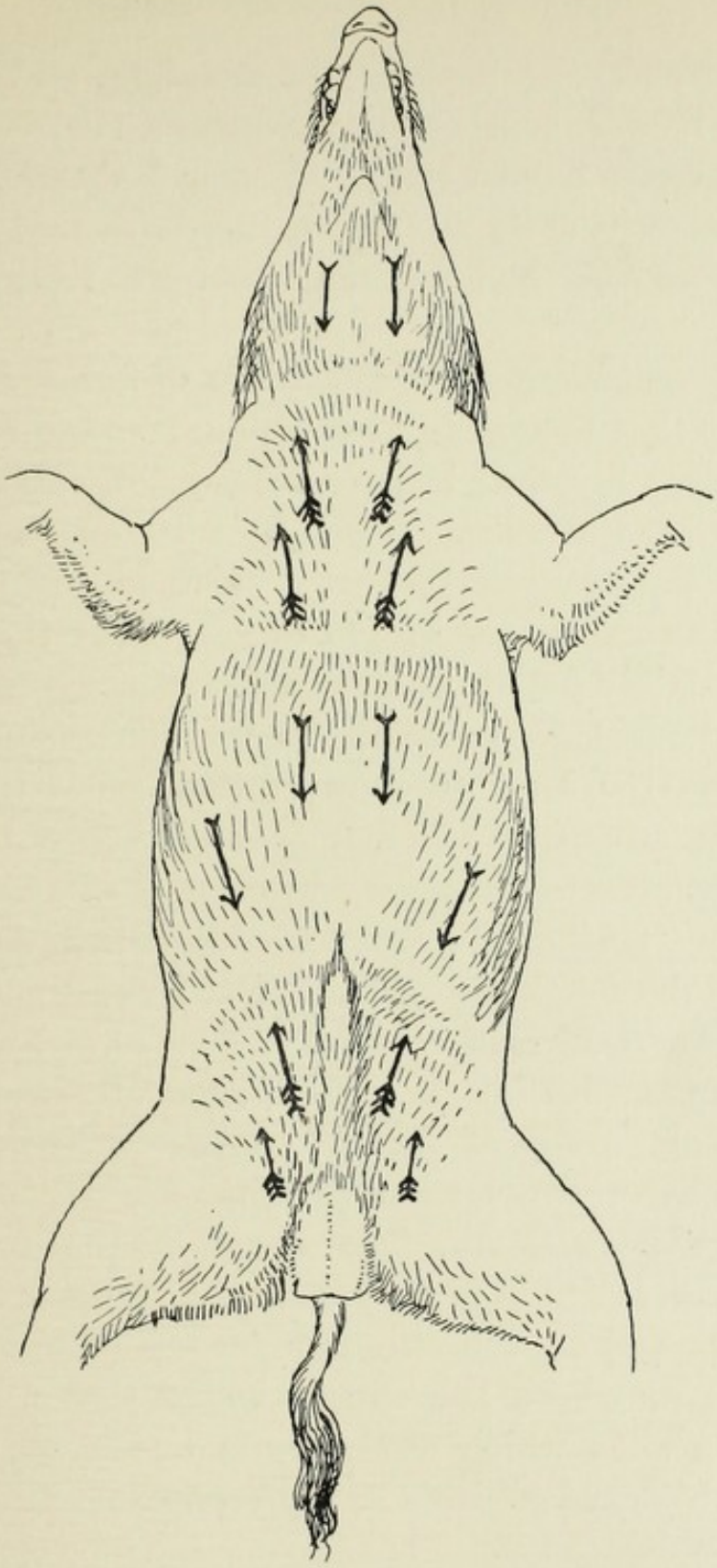


FIG. 4.—VENTRAL SURFACE OF BODY OF WILD BOAR.

Showing reversed forward streams of hair on neck and chest, and on posterior region of abdomen.

legs, very sloping humerus in standing, and a very strong ligamentum nuchæ; whereas the **CARNIVORE** forms have a relatively long body and short legs, humerus more nearly vertical than that of the **UNGULATE,** and an unimportant ligamentum nuchæ.

Of these divergent modifications of forms, I would suggest that the presence of a powerful and efficient suspensory ligament in long-necked **UNGULATES,** attached to the neural spines of the cervical vertebræ, and to the heavy large head, which in many forms bears the additional weight of antlers, is the factor which mainly determines the **UNGULATE** attitude. This ligament of course allows the **UNGULATE** to maintain the level or elevated position of its head without muscular effort, a position which is much more adapted to the general shape of the fore-quarter and the "set" of the head of **UNGULATES** than that of the **CARNIVORE,** with the under surface of the lower jaw resting on the ground. The ligamentum nuchæ of the **UNGULATE** allows the centre of gravity of the heavy **UNGULATE** fore-end to be thrown farther back than is possible with the **CARNIVORE.** The effect of the **CARNIVORE'S** attitude is to produce a forward slide of the fore-end on the extensor surface of the radius and ulna, where the subcutaneous tissue is very loose, a slide which obviously is impossible in the strongly-flexed position of the corresponding joint of the **UNGULATE.**

Among SIMIADÆ numerous groups adopt a corresponding habitual attitude of the forearm; and in **Man** the habit of resting this surface against

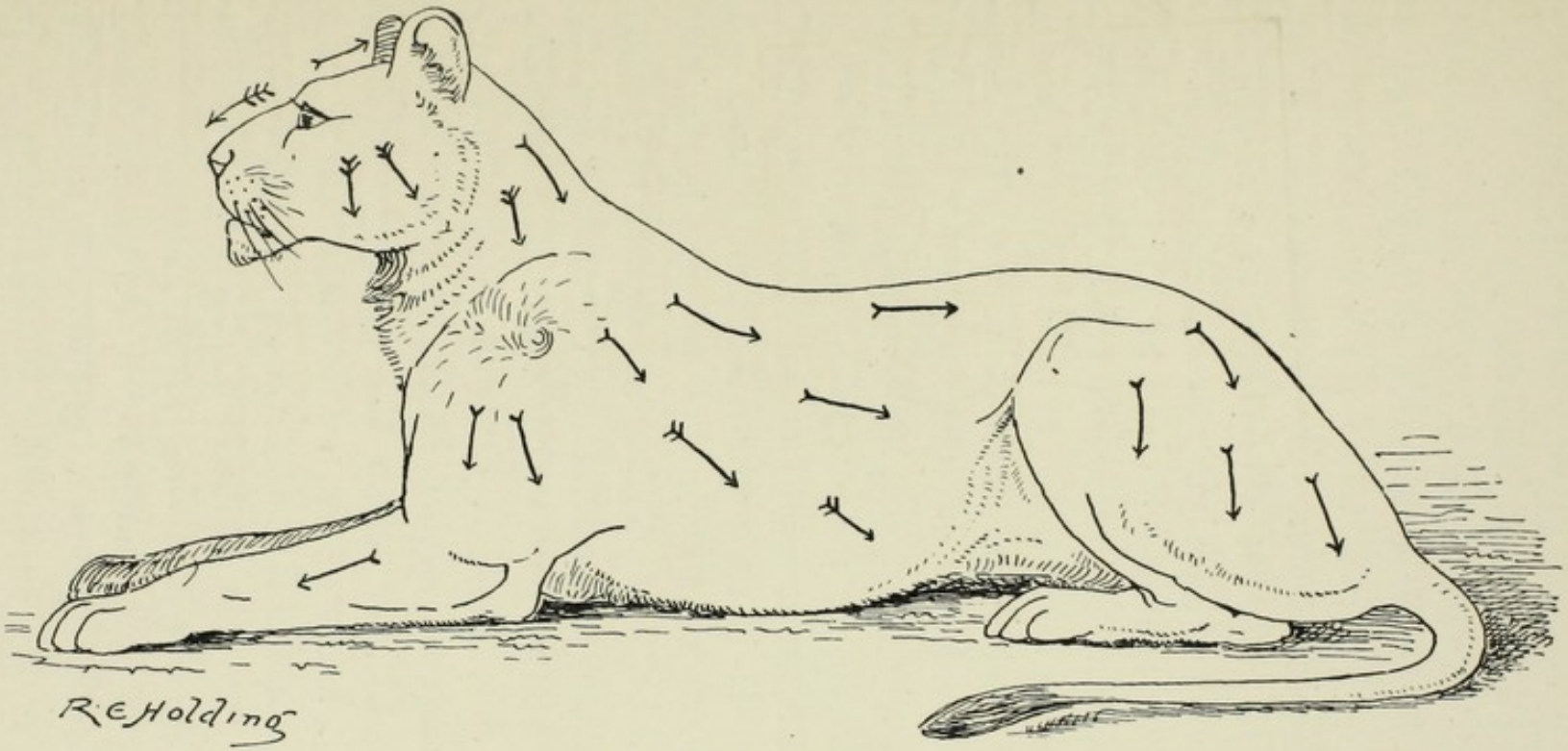


FIG. 5.—LIONESS (*F. Leo*).

Showing attitude of Carnivore at rest, also change of direction on naso-frontal region, and whorl at base of neck.

supporting objects is very common, producing in both cases a similar forward slide.

In addition to the foregoing regions, where direct contact with their external world affects the hairy covering of animals, there are several others where the predominant muscular actions exerted during their lives manifest themselves in changes of the arrangement of hair lying over those regions.

Probably the passive life of an animal is to its active life as three to one in point of time, for most animals have no occasion to be constantly moving in search of food or to avoid their foes. Their defence against enemies is effected largely by such devices as burrows in the earth, hollows in banks of streams, behind rocks in more open places, undergrowth, trunks of trees, or such as protective colouration and mimicry. It is only when this first line of defence breaks down that muscular exertion is required for their protection, and their success in the search for food is more dependent upon cunning than upon prolonged muscular activity. It may be taken for granted that there is little or no consuming desire for muscular exercise in general, and locomotion in particular *per se*, on the part of wild animals. No doubt many of them are compelled to spend a certain portion of their time in the construction of shelters, but this again is occasional. There is one line of defence involving much muscular exertion, though the muscles employed are small. These are the two external muscles of the orbit, the orbicularis and corrugator supercilii. These muscles are incessantly coming into play in the movements of the eyes and the instinctive closing and opening of the

lids in any part of an animal's waking life, and especially when any activity is proceeding.

One has only to watch the habits of domestic animals and to read the accounts of travellers in countries where animals in the feral state abound, to learn that rest, partial or complete, occupies a very large proportion of an animal's life.

The subject of the differing habits of various animal forms might be greatly elaborated, but would needlessly complicate this portion of the subject. Enough has been said to show that there are in all animals we are considering certain regions of their bodies where preponderating muscular activities will come into play, and certain others where very prevalent passive habits tend to leave their impress on the hairy covering. The latter are almost obvious enough to amount to a demonstration by the mere statement of the facts; the former require more detailed evidence.

For such reasons as these the two classes of localities on the surfaces of animal bodies, where active habits on the one hand and passive habits on the other are graphically depicted, are here termed **Critical Areas,** and this conception serves best to enable us to understand the numerous and otherwise unaccountable divergences from a primitive type found on nearly all animals whose forms are advanced in complexity beyond that of any small **CARNIVORE** or **RODENT.**

The hair-arrangement on every **Critical Area** should be open to explanation on mechanical principles. This is the case on the body of man, where the habits of that particular species are so fully

known. In the lower animals the individual habits of each species are less known and less easily studied, and a few of the **Critical Areas** in them can only be explained on general principles applicable to large classes of allied animals. But the more one knows of the daily life of any particular animal the fewer will be the unexplained **Critical Areas.**

The **Critical Areas** of all hair-clad MAMMALS which have been examined furnish two main groups of phenomena and one unimportant group.

A. Centres of disturbance of hair lying over a region where *strong, very frequent, divergent,* muscular action prevails, producing whorls, featherings and crests.

B. Points of contact with the ground or other opposing surfaces, producing reversed areas of hair.

C. Frequent action of *converging* muscular action, producing tufts.

CHAPTER III

CRITICAL AREAS IN LOWER ANIMALS

THE following eleven areas will be considered in lower animals: The **Naso-frontal, Pectoral, Cervical, Axillary** or **Post-humeral, Inguinal, Spinal, Extensor Surface of the Ulna, Ventral and Lateral Surfaces of the Abdomen, Extensor Surface of the Thigh, Gluteal,** and lastly **the Side of the Flank.**

Naso-frontal. The nasal and frontal regions in diverse animal forms are so different in their relative size, and are so difficult to separate for a study of this kind, that they are here taken as one region. An animal nearly always goes head-foremost through its world, whatever that may be, and its snout meets a variety of opposing objects which cannot but modify the hairy covering. A very active use is also made of the muscles of the nasal region in lifting, turning and twisting the upper lip in such actions as those of browsing, sniffing and snorting. In many cases the varieties of hair-slope found here arise from the particular "pose" of the head which happens to predominate. Thus one of the CANIDÆ or CERVIDÆ shows a pointed snout, and the attitude of such an animal's head is very near to the horizontal in both rest and motion. In this case the

premaxillary and nasal region is that which first presents itself to the world of a **Deer** or a **Dog**. If a representative of the FELIDÆ be taken, *e.g.*, a **Lion**, with its short broad muzzle, it is seen that the prevailing attitude* of the head is more directed downwards, the line of the muzzle forming nearly an angle of 45° with the ground. In an **UNGULATE**,

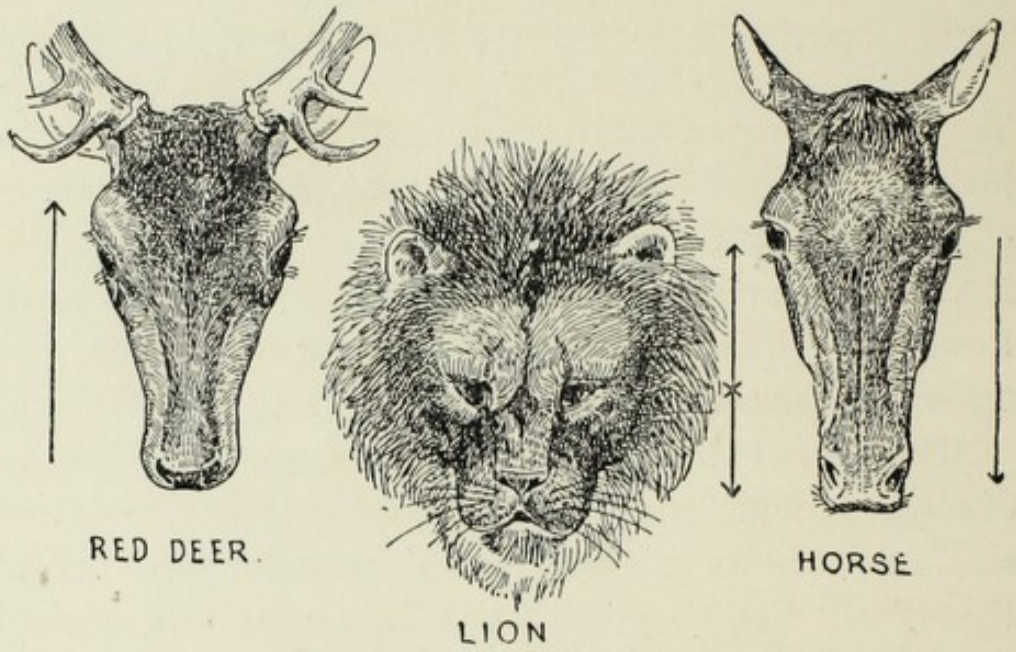


FIG. 6.—HAIR-STREAMS ON NASAL AND FRONTAL REGIONS OF RED DEER, LION AND DOMESTIC HORSE.

(Copied by permission from the *Proceedings of the Zoological Society of London.*)

such as an **Ox** or **Horse**, the frontal region is the foremost because of the more nearly vertical position of the head. This is also the case with many ANTELOPES, but there is no decided rule in their case. Thus there are three chief classes of "pose" of the head of these well-known animals, and if

* "When walking he holds it (his head) lower than the line of his back, and it is only when he first becomes aware of the presence of man that he sometimes raises his head."—SELOUS; quoted in "Mammals," by Flower and Lydekker, p. 511.

prevailing contact with the environments of their lives be competent to produce changes in the hairy covering of their frontal region, which may be compared to the prow of a ship, these three types should present an opportunity for testing the question. As a matter of fact, it is found that the very effects which, on this view, might be expected, are present. In any of the CERVIDÆ the general slope of the hair is in a proximal direction along the muzzle from tip to base (Fig. 6). This is also the case in the CANIDÆ. In FELIDÆ (Fig. 6), even down to the **Domestic Cat,** there is quite a striking small departure from the general proximal slope of the hair on the head found on the broad short muzzle. At the level of the orbits there commences by a central small crest a *distal* direction of reversed hair on the muzzle which passes to the tip, and thus a very curious exception to the hair-slope on the head is produced. This can be familiarly observed in the case of a black **Domestic Cat,** where in a certain light there appears this small patch of hair singularly contrasted with, and standing out, differently shaded, from the rest of the hairy covering. It seems impossible to assign any other than a mechanical cause for such a small phenomenon of hair-arrangement.

In BOVIDÆ (Fig. 6) and EQUIDÆ the general slope of hair is in a distal direction, with the exception of certain whorls which will shortly be alluded to.

It may then fairly be maintained that the examination of the hair-slope on the muzzle of CANIDÆ, CERVIDÆ, FELIDÆ, BOVIDÆ,

and EQUIDÆ fully bears out the contention here held, that the general "set" of hair in this region of the body is to be explained on purely mechanical principles.

In addition to the general arrangement of the hair-stream found on the naso-frontal region, there are whorls, featherings and crests found in most animals, either on the nasal or frontal region.

The **Nasal Whorl** is extremely common, either existing alone, as in CANIDÆ, and forming the starting-point of the stream of hair which flows in a proximal direction to the frontal region, or associated, as in many **UNGULATES**, with a *frontal* whorl, and it is sometimes represented as a rudiment at the junction of the hairy and non-hairy portions of the muzzle. It is the only whorl to be found in many **RODENTS** and aquatic MAMMALS. The nasal whorl, so extremely common in many MAMMALS, such as CANIDÆ, with elongated snouts, is also situated where the traction of the nasalis muscle of each side is found exerting a traction in the direction somewhat opposed to that of its fellow, and this traction is very constantly exercised.

The **Frontal Whorl** is best represented by the universal star seen at about the level of the orbits in the **Horse**, and is found to lie in the line of a stream which is passing from the vertex to the nasal region, but which this whorl very strikingly interrupts. It may present only the star or whorl itself, but most usually passes upwards towards the level of the insertion of the external ears in a feathered form, and often terminates in a crest just short of this level.

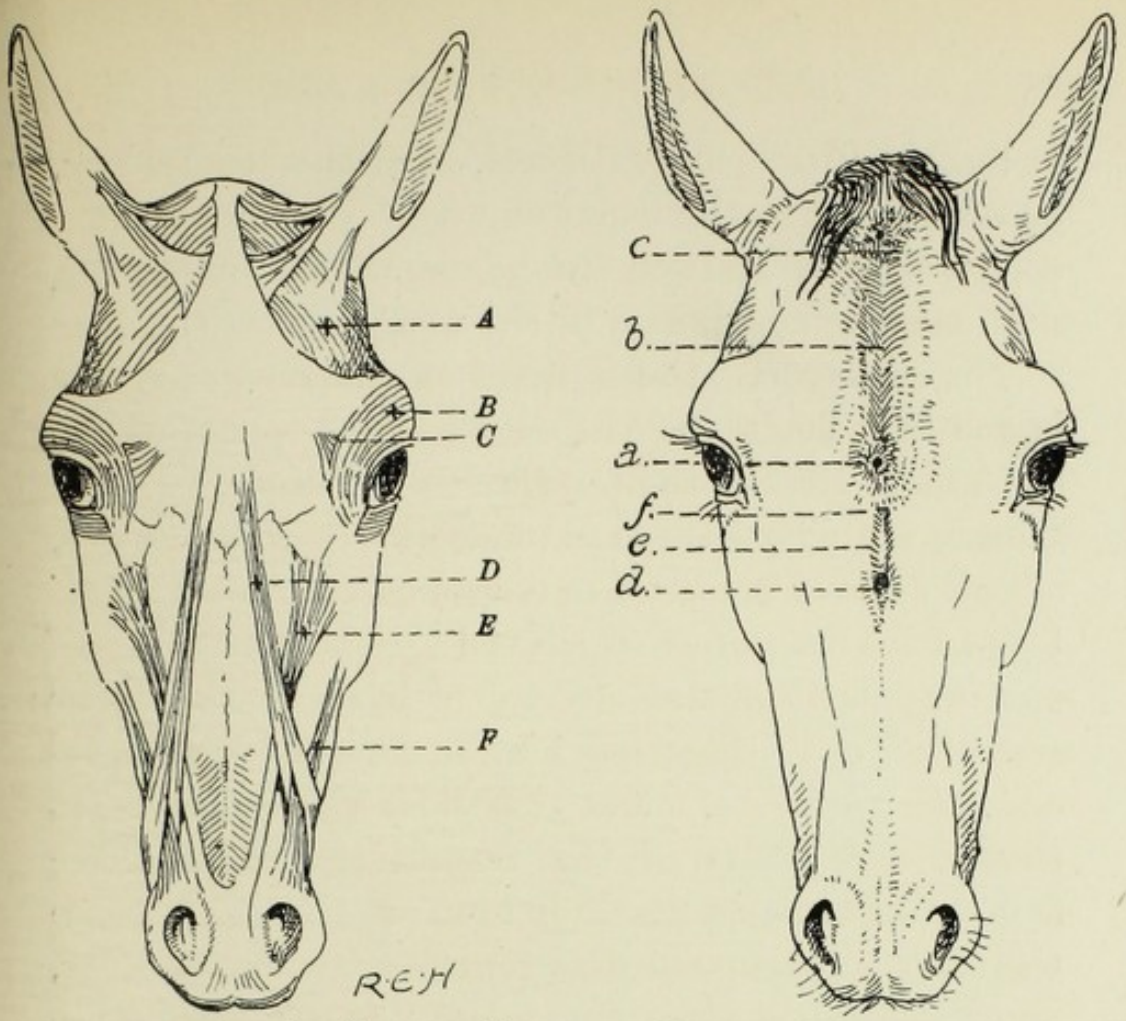


FIG. 7.—FRONTAL REGION OF DOMESTIC HORSE.

Left side :

a, *b*, *c*. Universal whorl, feathering and crest. *d*, *e*, *f*. Occasional supplementary whorl, feathering and crest.

Right side :

A. Temporal muscle. *B*. Orbicularis. *C*. Corrugator supercilii. *D*. Maxillaris. *E*. Nasalis. F. Caninus.

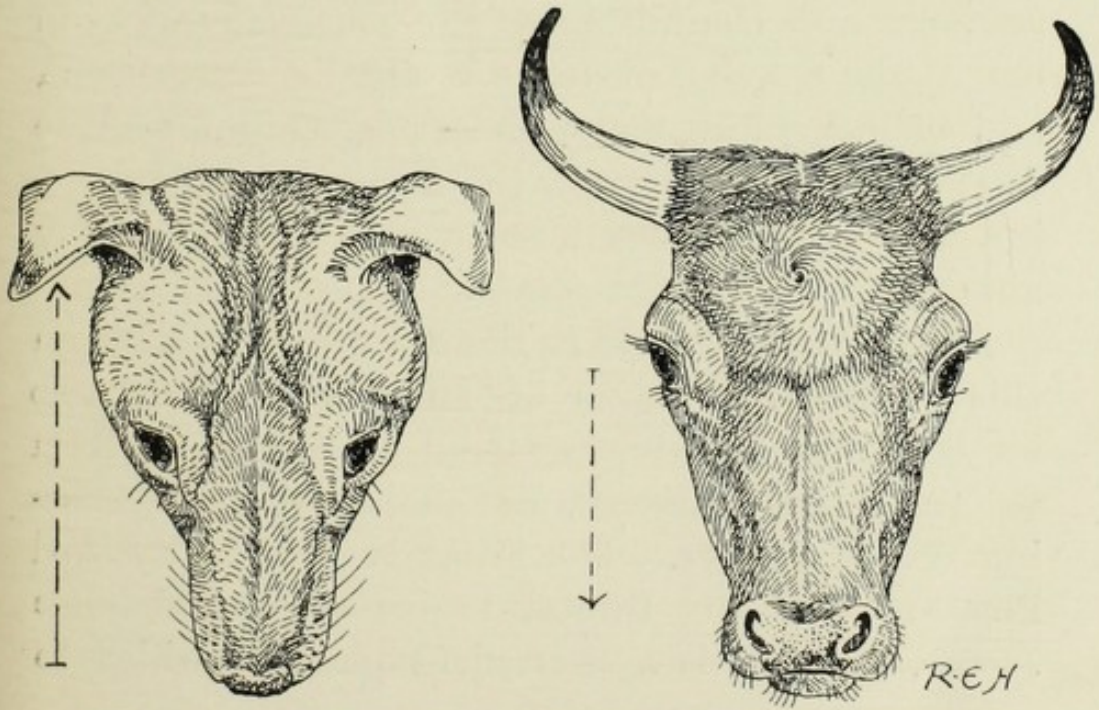


FIG. 8.—HAIR-STREAMS ON NASAL AND FRONTAL REGIONS OF DOMESTIC DOG AND CAPE BUFFALO.

It may be double and bilateral, with two featherings, or there may be the usual whorl at the level of the orbits, and a smaller secondary whorl, feathering, and crest below it, also in the middle line (Fig. 7).

The arrangement of muscles on the *frontal* region is one that lends itself at once to the support of the dynamical view of the production of whorls. In the **Horse**, the whorl is found at the level of the orbits, slightly above or below in a few cases, and is therefore at the very spot where the opposing tractions of the maxillaris muscle of the two sides, the inner fibres of the orbicularis and the corrugator supercilii, are operative. Not only does the whorl lie at this critical point of the frontal region, but the feathering extends upwards towards the place where the external temporal muscles approach one another, and the crest so often found seems to result from the opposition of the temporal muscles to any further extension of the feathering (Fig. 7).

When the main direction of the hair on an animal's naso-frontal region is a proximal one, as in one of the CANIDÆ, there is found a nasal whorl, and when the direction a distal one, as in one of the BOVIDÆ or EQUIDÆ, the frontal whorl feathering and crest are present, and a nasal whorl is usually absent.

I have now shown that there are in operation on this naso-frontal region of an animal's head two kinds of forces, an external or pressure-force from various opposing objects, and an internal or diverging muscular force. The latter is particularly well illustrated in the frontal region of a **Domestic Horse**, and this is a convenient place at which to

consider shortly the main facts of the production of a whorl with its associated feathering and crest, taking this individual region as a type of others. The illustration (Fig. 7) of the layer of superficial muscles which are situated on the frontal of a **Horse** shows strikingly the number of diverging directions in which certain muscles are almost constantly at work,

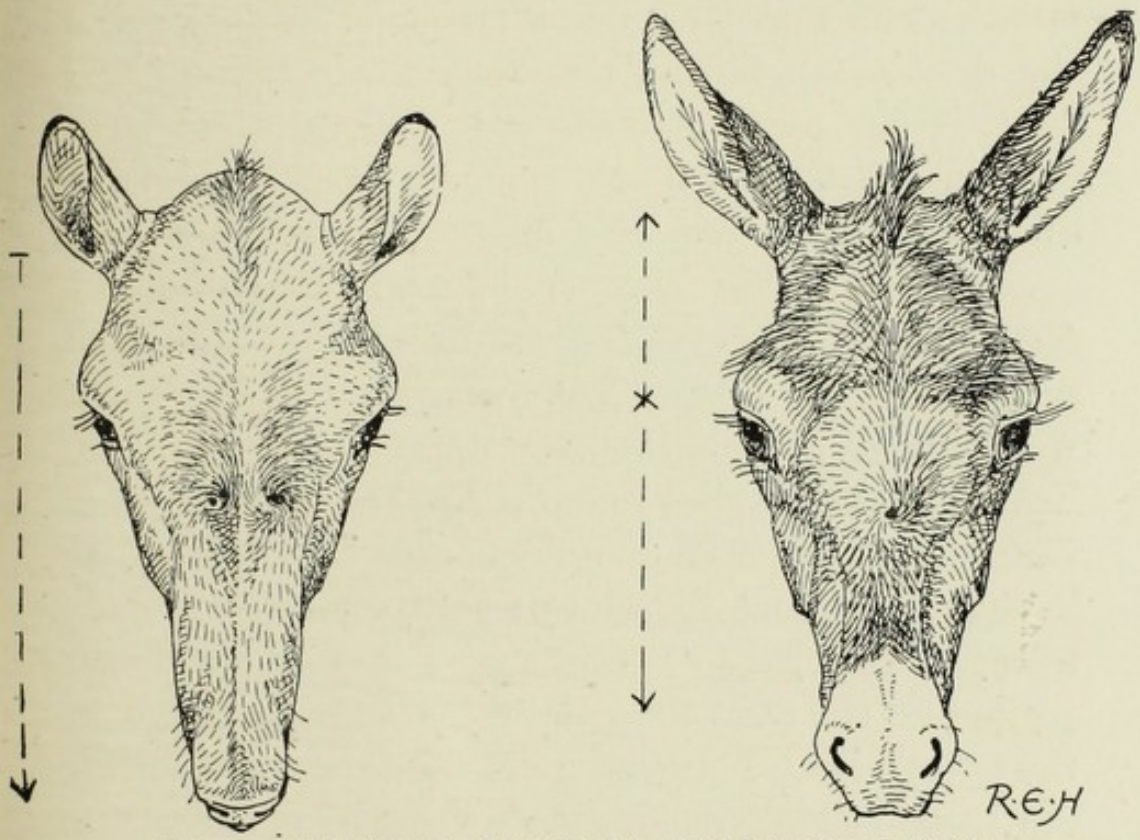


FIG. 9.—HAIR-STREAMS ON NASAL AND FRONTAL REGIONS OF TAPIR AND DOMESTIC ASS.

while a **Horse** is not asleep, and especially when it is in motion. The chief centre of disturbance is at the level of the orbits. Here there are the levator labii superioris et alæ nasi of each side inserted, the orbicularis, the corrugator supercilii, and above the auriculo-temporal muscles of the two sides converge at a spot a little below the insertion of the pinnæ. A glance at the markedly different

line of action of these muscles represented in the figure is enough to indicate how well this region may be called a Critical Area as regards the effects upon the hairy covering of this collection of markedly diverging lines of traction. We have but to recollect the almost incessant action of the muscles of the eyes, the external ears, the temporal muscles and that long maxillaris muscle, which has the double function of elevating the upper lip and dilating the nostril, to see how fruitful of disturbance in the skin over them must be the muscular actions referred to. We may also remember how greatly all these actions become increased in strength and frequency according to the locomotive activity of the **Horse**, increasing in their activity with the pace of the **Horse**.

When the frontal whorl, feathering, and crest which lie over this disturbed area are examined broadly, they are found to lie in an acute-angled triangle, the base of which is a line between the orbits and the apex formed by the approximation of the two auriculo-temporal muscles. The whorl lies on the base of this triangle, the feathering proceeds upwards to the apex, and the apex marks the position of the crest. This arrangement of whorls, featherings and crests in a triangular area with an acute angle at the apex in which the crest forms, and a base on which the whorl forms is almost constant in the various whorls, featherings and crests found in every part of the animal body. I have only found one region where an exception to this arrangement is present, and that is on the neck of the Horse, where a broad, spreading and nearly rounded

feathering is found on the ventral surface proceeding at right angles to the long sterno-mastoid and hyoid

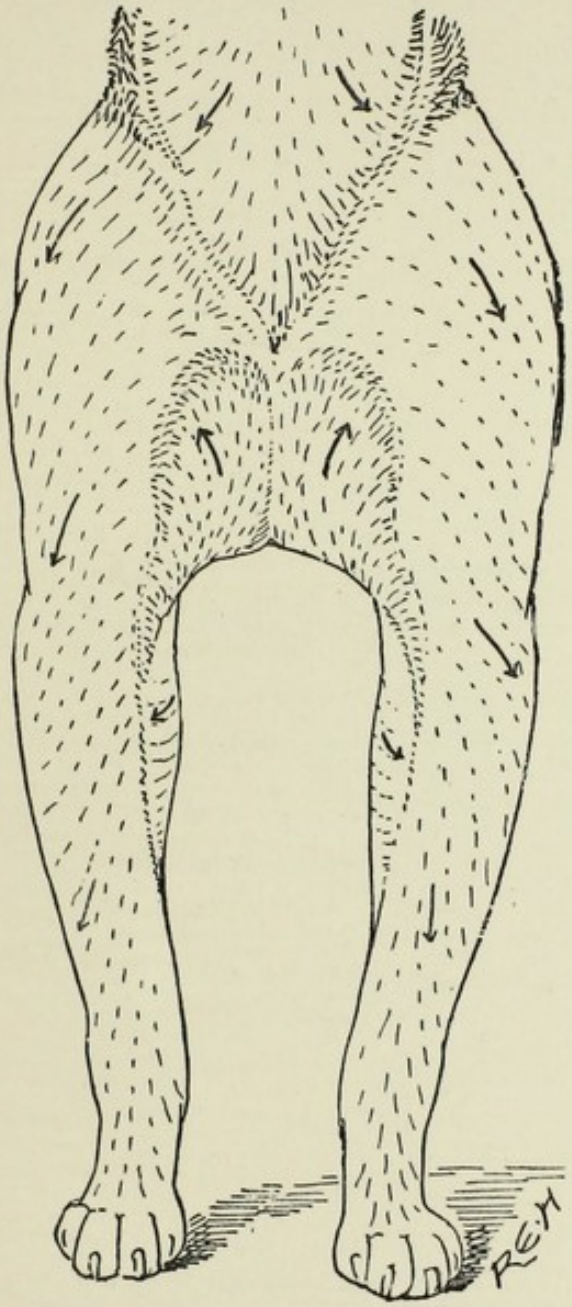


FIG. 10.—PECTORAL REGION OF DOMESTIC DOG, SHOWING REVERSED AREAS OF HAIR.

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muscles. This particular whorl will be referred to in its own proper place. There is another instructive

fact as to the triangular space in which whorls, featherings and crests are found, and that is that the more persistent, uniform and well developed the

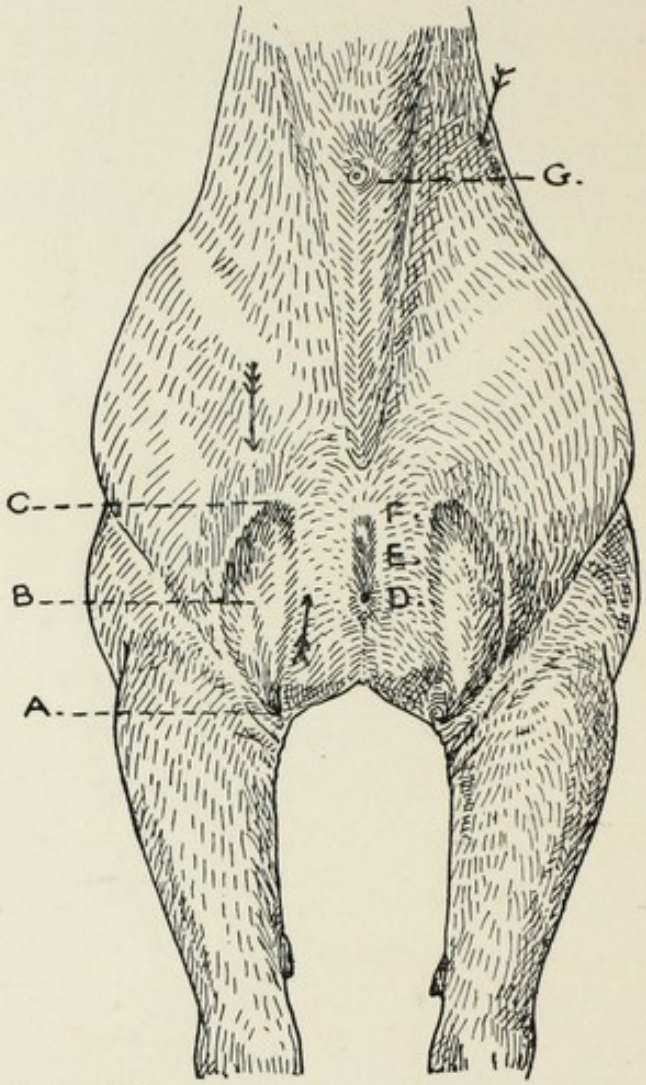

FIG. 11.—FRONT VIEW OF DOMESTIC HORSE, PECTORAL REGION, SHOWING HAIR-TRACTS, WHORLS, FEATHERINGS AND CRESTS.

A, B, C. Universal pectoral whorl, feathering and crest.
D, E, F. Rare central whorl, feathering and crest.
G. Occasional whorl.

whorl, feathering and crest, the longer is the base of the triangle, and consequently the less acute the angle which forms the apex. Illustration of this may be gathered from the constancy, size, and per-

sistence of those in the frontal, pectoral and inguinal regions, all of which form in triangles where the base is much wider than those occu-

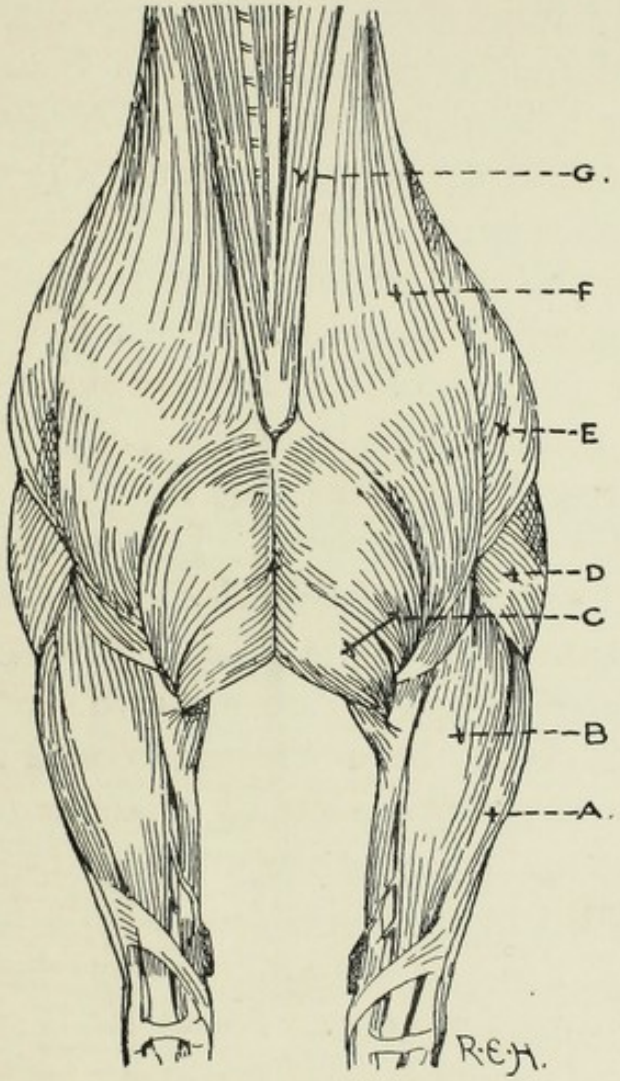

FIG. 12.—FRONT VIEW OF DOMESTIC HORSE. PECTORAL REGION, SHOWING SUPERFICIAL MUSCLES.

A. Extensor communis digitorum.
B. Extensor carpi radialis.
C. Upper and lower portions of pectoralis major.
D. External triceps.
E. Supra spinatus and infra spinatus.
F. Cephalo-humeral.
G. Mastiodeus.

pied by the axillary, spinal and cervical whorls, featherings and crests.

The **Pectoral** region resembles the fronto-nasal

in the fact that it is one where both the active and the passive habits of animals are pictured, some showing effects which can only come from prolonged pressure in a prevailing attitude, others such as can come only from strong, very frequent, divergent traction of underlying muscles. In Chapter II. the prevailing habits in rest of **CARNIVORES** and **UNGULATES** are described, and will not require further notice here.

In the pectoral region there is seen a marked impression, which corresponds with the pressure of the flexor surface of the fore-limbs as far as this comes in contact with it in lying, and the result is that an area of hair is directed forwards against the general stream of the chest. This is well shown in an ancient sculpture of two Molossian hounds in the Capitol Museum in Rome. In **UNGULATES** this reversed area of hair is also common, but numerous exceptions have been shown to exist.* In the **Domestic Horse** this pectoral arrangement is more marked than in any other animal, and quite constant; and it is probable that in this instance the arrangement of hair has a different mechanical cause, namely, a dynamical one. The attitude of the Horse in rest does not lend itself markedly to the production of this arrangement; but the constantly locomotive life of the horse does afford adequate reason for a reverse direction of the hair-stream by means of strongly divergent traction of underlying muscles. It is interesting to compare this whorl, feathering and crest of the pectoral region of a Horse with what is found in the closely allied **Ass** and **Mule**. In the

* *Proc. Zool. Soc.* 1900, p. 636.

Horse it is large, symmetrical, never absent, especially marked in high-stepping **Horses**, whether Cart-horses or Horses selected because of their high action in trotting. Its size, indeed, is a measure of the activity of the pectoral muscles and flexors of the fore-limb. In the Ass it is often absent, and, when present, it is rudimentary; in the Mule it is more frequently present than in the **Ass**, but still rudimentary. These degrees of development of the pectoral whorl, feathering and crest in **Horse**, **Ass** and **Mule** correspond closely with the locomotive habits of the three animals.

Like all such general rules, these have their exceptions, and no simpler instance of an exception can be examined than that of the SUIDÆ, in which family the prevailing habit in rest brings the pectoral region and the flexor aspect of the ulna into contact, and this passive habit is shown on the hair of the SUIDÆ in a marked reversed area of hair in the pectoral region (Figs. 3 and 4). This kind of reversed area is the rule, withvery few exceptions, in **CARNIVORES**, but is relatively rare in **UNGULATES**, the **UNGULATE** attitude in rest not bringing the two surfaces mentioned into contact. In the Appendix the distribution of the reversed areas of hair, and whorls, featherings and crests in various animals are given in detail.

The **Cervical** region is markedly a critical area as to the effects of muscular action upon the production of whorls, featherings and crests. The more *passive* influences of posture or pressure do not come into question in this part. The slope of hair is primitive and uniform, except where whorls are produced, or

in those animals, such as a few **CARNIVORES** and many Ungulates, in which a longitudinal crest or mane is formed. But whorls, featherings and crests are liberally and very irregularly distributed in this region, the **Domestic Horse** being pre-eminent, as it is elsewhere, in the number and variety of these phenomena. Our type-example, the **Domestic Horse**, shows no fewer than five, any of which may be rudimentary and ill-formed, and any of which may in other cases be completely developed. The singular point about these found in the cervical region of a **Horse** is that not one of them is constant, frequently an individual Horse showing none, and another showing all of the five whorls with associated featherings and crests. The situations in which they are found are, at the edge of the mane, at the junction of the splenius and sterno-mastoid muscles, on the ventral surface of the neck not far from the lower jaw (the particular instance previously referred to), the median line at the root of the neck, and between the sterno-thyroid and sterno-mastoid muscles. It may be remarked generally that all these are displayed most frequently by those which have the best muscular development, and that the locomotive habits of a **Domestic Horse** markedly influence the movements of its neck muscles, as can easily be seen in any powerful specimen in rapid motion. When this is watched we see that every step of the animal produces a jolt of the flexible neck, and in addition to the jolt it very frequently raises its head or twists it to one side or the other. Such actions give full opportunity for disturbance of hair-arrangement over the muscles which lie in divergent direc-

tions, and when we bear in mind the fact that while trotting briskly a **Horse** takes about 6000 steps in an hour, and in walking 3000 to 4000, and in galloping probably about 9000, we appreciate the great degree of muscular activity that is displayed by a **Horse** in these muscles in the course of the active part of its life. In the casual movements of the neck of a **Horse** in action much will depend on its temperament, whether they are very frequent or not, some animals of a restless, excitable disposition twisting and jerking their heads nearly all the time they are in motion. The particular whorl, feathering and crest which has been referred to as lying across the line of the sterno-mastoid muscle is the only exception hitherto found to the rule that these phenomena of hair-arrangement are found in a triangular space between muscles. It is found very much more often in Cart-horses than in any other class that I have examined. This fact, when looked into, is not so strange as it might seem, for the **Cart-horse** mainly does its draught work at a walking pace, and it is noticeable that a **Horse** in walking, especially uphill with a heavy load, nods its head in a vertical plane at every step.* Another that trots or gallops does not nod its head except by accident, so to speak : it is not part of its locomotive gait to nod its head at each step,

* This small fact bears upon the question here under consideration, and is also interesting in itself. If a troop of cavalry horses out for exercise be watched, it will be seen that when they are walking at the usual quick pace of such horses every one nods its head with each step, but that out of a considerable number a few will be seen ambling gently to keep up with the others, and these do not nod their heads. Also a horse nods its head in walking uphill much more manifestly than when walking downhill, and this is the case, generally speaking, according to the amount of effort needed by the animal.

as it is with a Cart-horse or other **Horse** whose proper pace is that of walking. This ceaseless nodding of the head during walking flexes and extends the upper rather than the lower cervical vertebræ, where the whorl in question is found, and it is a fair conclusion to draw that this action of the **Horse** in walking is responsible for this somewhat aberrant whorl, feathering and crest in its exceptional position.

It may be allowable here to employ a geological term applied to a river, and to say that as yet, on the Domestic Horse, none of the cervical whorls, featherings and crests has attained its "regimen." In other parts, such as the frontal, pectoral, inguinal region, characters have been developed which must take rank among the specific characters of this species. These have attained their "regimen," and others, such as the cervical and axillary, are on their way to that result.

The distribution of cervical whorls in other animals is peculiarly variable, and they are not very frequent. The Lion, Tiger and Leopard show a constant whorl with forward feathering and crest at the root of the neck on each side, which produces a remarkable and rather broad area of reversed hair in the otherwise uniform slope of this region. This whorl is clearly connected in these great FELIDÆ with that action of the panniculus concerned in erecting the mane, or hair of this region where the mane is often found. Among Ungulates a cervical whorl is found in certain BOVIDÆ and ANTILOPIDÆ, but no rule is to be discovered as to its distribution. In some GIRAFFES there is also a

cervical whorl, feathering and crest at the level of the seventh cervical vertebra, where a very great degree of flexion of the long neck of the animal is constantly occurring. (See Appendix.) There is a region of reversed hair, which is a continuation up to the neck from the spinal region, seen in the **Domestic Ox** and certain other BOVIDÆ.

The **Axillary** or **Post-Humeral region.**

In this critical area the more passive influences of pressure on the hair or friction are not represented, but it is an area with considerable opportunity for the active influence of strong, divergent muscular action to manifest itself.

The whorls, featherings and crests found here are very variable, being almost entirely confined to **UNGULATES**, and in the **Domestic Horse** in particular it occurs in about one out of every fifty **Horses** examined. This was the proportion in a very large series extending to several thousand in number.

It also varies much in individuals of the same species. It may exist in the three stages of whorl, or whorl and feathering, and whorl, feathering and crest.

Whorls in this region are so rare outside the **UNGULATE** order that, after an extensive search for it in other hair-clad Mammals, I have been only able to find two instances in which it was present, and then only in a rudimentary form : one was a mongrel **Dachshund**, which showed a definite whorl, without any feathering, in the hollow just behind the mass of muscles surrounding the shoulder-joint, and the other, also in a long-bodied mongrel,

apparently a cross between a **Fox-terrier** and **Dachshund.** The axillary region surrounded by the great masses of the triceps and the fibres of the latissimus dorsi, the pectoral and great oblique muscles, shows markedly the conditions of diverging traction of underlying muscles.

Some instructive facts appeared in statistics published* regarding this particular region. Out of the very large series of **Horses** examined, eighty-seven in all were found to show an axillary whorl, feathering and crest, and of these *fifty-seven were in* **Cart-horses.** This is the more striking because the proportion of the **Cart-horses** examined to other breeds was very small. In connection with this we must note that the range of action of the shoulder-joint in the **Cart-horse** preponderates considerably over that of the carpal and metacarpo-phalangeal joints, and this joint has a decidedly wider range than in most other breeds.

There is no difficulty on our theory in accounting for the whorl, feathering and crest in this region, though the infrequency of its appearance compared with that of the inguinal and pectoral whorls on the flexor aspects of these joints is striking. Flexion is undoubtedly a much more powerful action in locomotion than the extension which occurs in the axillary region. It may be noted that the whorl, feathering and crest in this part is one of those on the **Domestic Horse** which is at the present time in process of development. It is relatively common (Appendix) in wild OVIDÆ, and this is rather significant when the important function of the fore-

* *Proc. Zool. Soc.* 1900, p. 683.

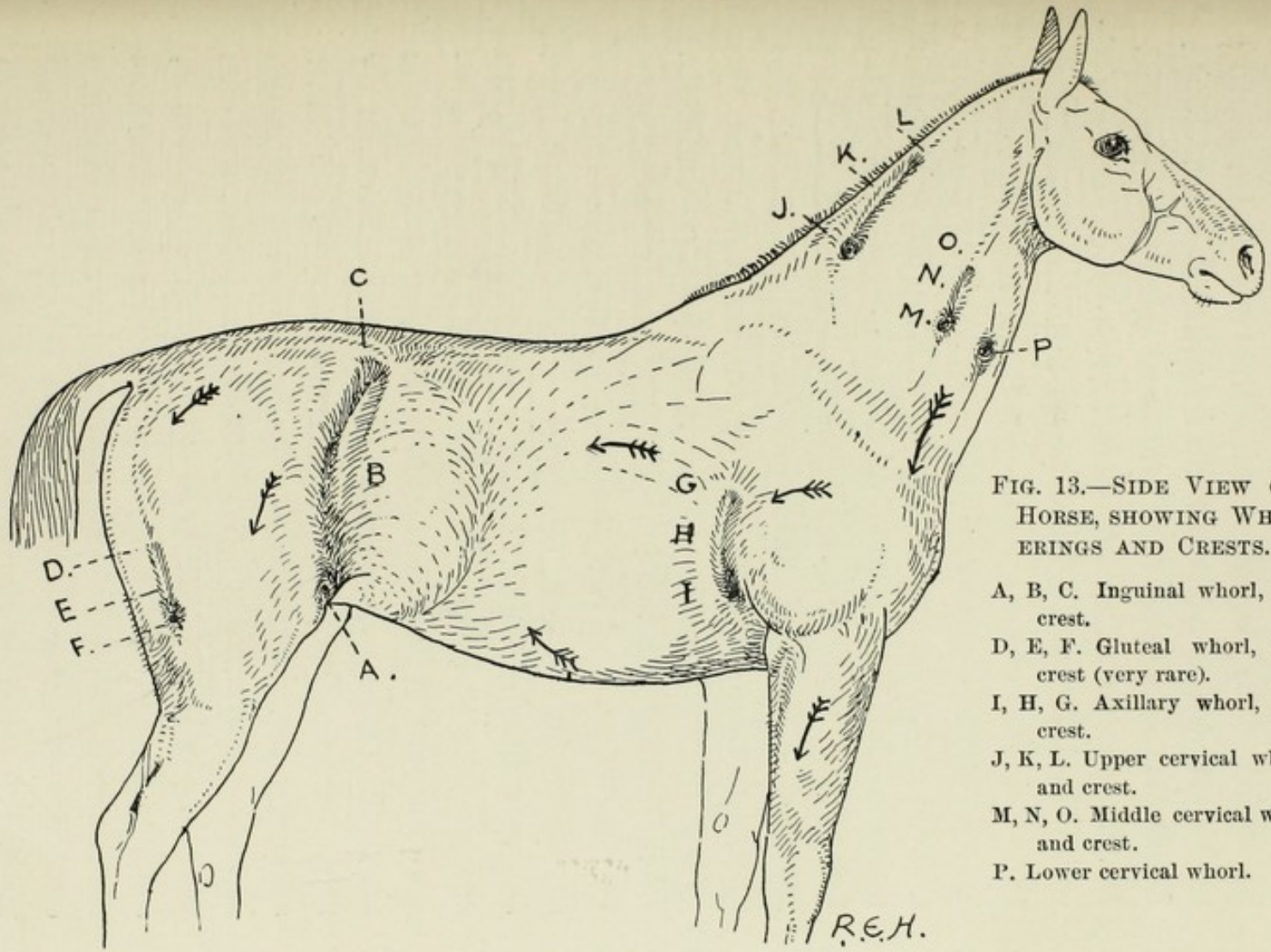

FIG. 13.—SIDE VIEW OF DOMESTIC HORSE, SHOWING WHORLS, FEATHERINGS AND CRESTS.

A, B, C. Inguinal whorl, feathering and crest.

D, E, F. Gluteal whorl, feathering and crest (very rare).

I, H, G. Axillary whorl, feathering and crest.

J, K, L. Upper cervical whorl, feathering and crest.

M, N, O. Middle cervical whorl, feathering and crest.

P. Lower cervical whorl.

limbs in these animals is borne in mind ; it is indeed much commoner in them than in other **UNGULATES** except the **Horse.**

Inguinal.—We again have here only the motor phenomena to consider, but the whorl, feathering and crest are so constant and highly developed in a **Domestic Horse** as to rank as a specific character. In the course of examination of a vast number of individual **Horses** I have never found it absent, and the least-developed specimen was fully half the length of the ordinary feathering.

This graceful arrangement of hair on a **Horse's** flank is the best known of these phenomena. The feathering presents a direction slightly concave forward and passes upwards in the hollow of the flank, dividing the trunk of the animal from the great rounded mass of muscle of the hind-quarters. It commences at the fold of skin which passes from the lower part of the abdomen to the hind-limb by a whorl or vortex of hair. This radiates and expands into a bilateral and symmetrical expansion shaped like the barbs of a feather. The latter proceeds upwards in the inguinal hollow as far as the level of the iliac crest, where a projection covered by muscles is always to be recognised, and here it abruptly terminates in a ridge or crest. The crest is very noticeable in all **Domestic Horses**, and lies parallel with the long axis of the trunk. Above it, and on either side of it, are seen the hair-streams from the back of the animal, breaking away like two currents of water on either side of an outstanding rock, the anterior stream passing with a wide curve forwards and downwards along the side of the

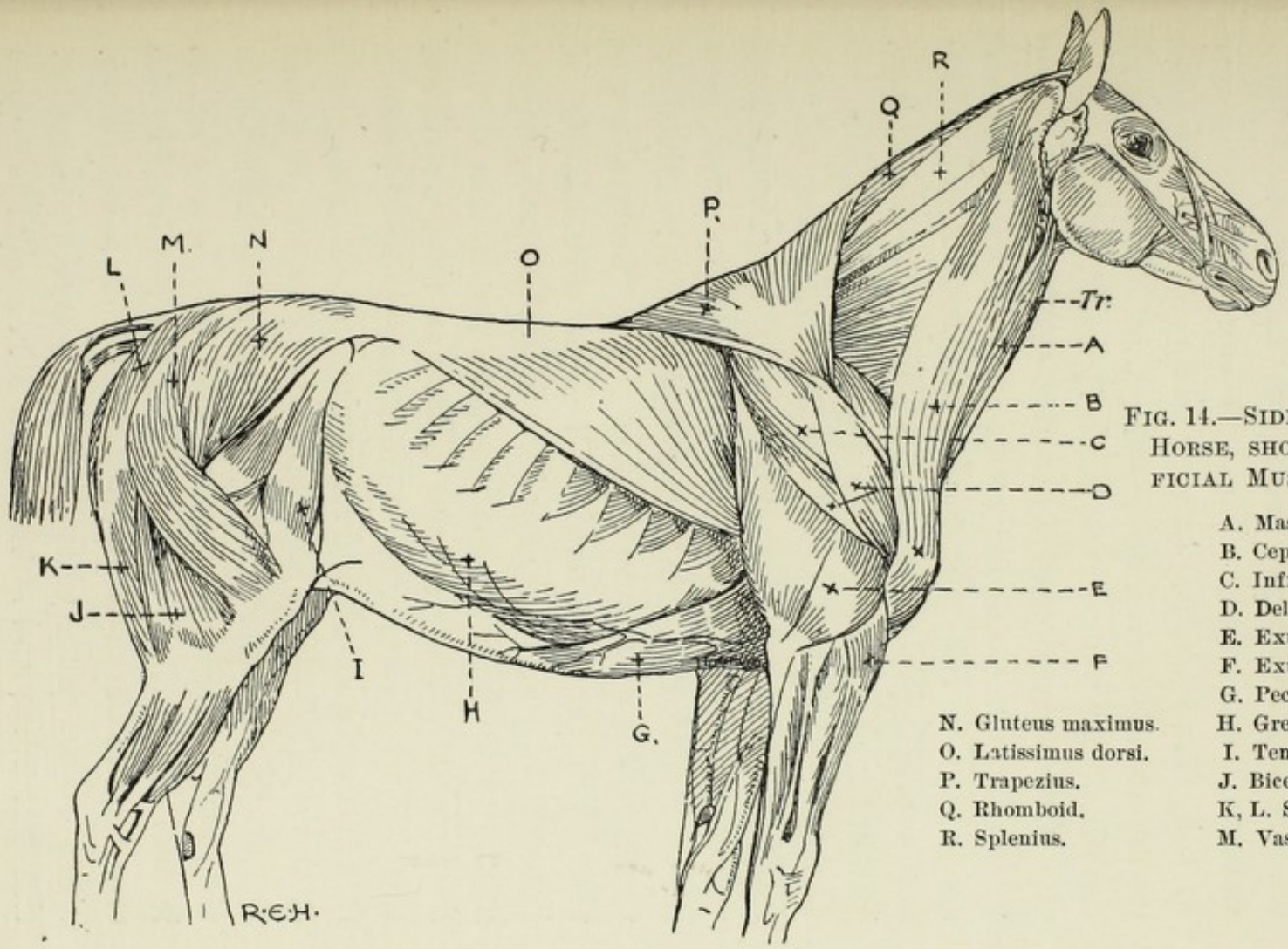

FIG. 14.—SIDE VIEW OF DOMESTIC HORSE, SHOWING CHIEF SUPERFICIAL MUSCLES.

A. Mastoideus.
B. Cephalo-humeral.
C. Infra-spinatus.
D. Deltoid.
E. External triceps.
F. Extensor carpi radialis.
G. Pectoralis major.
H. Great oblique.
I. Tensor.
J. Biceps.
K, L. Semitendinosus.
M. Vastus longus.
N. Gluteus maximus.
O. Latissimus dorsi.
P. Trapezius.
Q. Rhomboid.
R. Splenius.

abdomen, and the hinder one more directly in its original course along the great swelling mass of the hind-quarters. A better idea of the actual arrangements of the hair-streams will be gathered from an inspection of the coat of any common **Horse**, whose coat is not too long, than can be conveyed by a written description. The symmetry and constancy of this arrangement is very striking and demands explanation. It is here suggested that this and certain other whorls, featherings and crests represent the idea of a pedometer because of the close way in which the degree of locomotive activity is registered according to the persistence, size and constancy of these otherwise uncalled-for arrangements of hair. When a few **Horses** in the act of trotting are watched, and the accompanying diagram of the main muscles of the **Horse** and the commonest whorls, featherings and crests is borne in mind, it is seen at once that the very conditions required to produce some departure from the ordinary slope of the hairs in the inguinal hollow are present, if, indeed, it be a possibility that underlying divergent muscular traction should influence the course of the living and growing stream of hair on that portion of the skin which lies over the area affected. If, also, a few **Horses** be watched as to the degree and extent of the "jolt" which occurs at every quick step, and the sharp limitation of this to the area included in that of the whorl, feathering and crest—ceasing, as it does, abruptly and significantly at the level of the crest of the ileum—the *modus operandi* is very clear. The forward range of the "jolt" is much wider than the backward, and marks out most closely the degree

of the forward curve taken by the anterior hair-stream, which descends from the crest. In passing, one may note here a very small and unimportant point, but one which is of some interest. During or after a short shower of rain the flank of a **Horse** presents a curious distribution of the moisture. At the very point where the proper forward stream from the feathering joins the main stream of hair from the thorax and abdomen, a definite line of darker moist hair is seen, and the moist surface is confined closely to the anterior part of the trunk, and separated from that of the hollow of the flank. This line of demarcation very clearly indicates the position where the forward "jolt" in rapid action terminates.

The arrangement of hair described here is the best, because the most familiar, of the "pedometers" displayed by animals on their bodies.

Attention to the facts of the **Horse's** life, and certain related or contrasted facts of the lives of other animals, will show the reasons for which such hair-arrangements are looked upon as registers of long-past and present activities of the species in question. The **Domestic Horse** is found to be the best specimen for the study of animal pedometers, and by comparison of this species with all other known hairy MAMMALS it is found to be as much better furnished with pedometers of the kind indicated as it is greatly in advance of them as to the frequency and rate of its locomotive activity.

There are two closely related animals, the **Domestic Ass** and **Mule**, which ought to show this inguinal pedometer, if mere heredity, or some variation

incidental to the group of animals, could be fairly invoked to account for it. These also are locomotive animals, but in a degree very much less than the **Horse**, and their pace is of a quieter and less free character. What, then, do we find in them as to the size and persistence of the inguinal pedometer? In the **Ass** it is absent (the writer has met with one exception), and in the **Mule** it is variable, and occupies less than half the area of that in the **Horse.** These facts agree very closely with the hybrid character of the **Mule**, and with the differing locomotive activities of **Horse, Mule** and **Ass.** Przewalsky's **Horses** show a whorl and feathering of an oval shape and limited size, very much like that of the Mule. The **Onager** (*Equus onager*), closely resembling these three domestic animals in form, shows an inguinal whorl or pedometer large and well defined, though much less so than in the case of the **Horse**, which is in keeping with its character for remarkable fleetness and activity. **Zebras** of the three forms, Mountain, Grevy's and Burchell's **Zebras**, show no whorl here at all, in spite of their close resemblance in size and form and *power* of locomotion to the **orse.** Their wild lives, lived only for their own sake and not for that of man, have been only locomotive in the intermittent way which is incidental to all wild life.

The **Domestic Ox,** and most of the BOVIDÆ, show no inguinal whorl, and in the case of the former we can explain, from our knowledge of its slowly-moving action and general heaviness, this negative fact.

Among the BOVIDÆ certain *Antelopes, Gazelles,*

and SHEEP exhibit a more or less defined inguinal pedometer, and these are given in more detail elsewhere.*

The inguinal and pectoral regions are the two most important on the MAMMALIAN body for the study of the dynamical theory of whorls, featherings and crests, and the **Domestic Horse** the most convenient MAMMAL, inasmuch as it not only displays these two main whorls better than any other animal, but that it also is the locomotive animal *par excellence*. It will be useful at this place to compare briefly the **Horse** and **Zebra** in the two respects of hair-slope and locomotive habits.

If a **Common Horse** of the hackney type and a **Zebra** were skinned and the bodies of the two animals then examined, I suppose a competent anatomist would not be able to distinguish one from the other, so closely do these two allied species of the EQUIDÆ, one wild and the other domesticated, resemble one another. But in regard to this as to many other questions, *form* is not to be considered alone. Apart from their skins the two animals might not be distinguishable, but when whole they could not be mistaken, even if colouration were not taken into account. The colouration of the hair of the two forms is strikingly different, but, in its humble way, the difference of the two forms in regard to hair-slope is striking enough. The **Domestic Horse,** in different specimens taken from a large number, will exhibit whorls, featherings and crests in five regions, frontal, pectoral (in two parts of this region),

* *Proc. Zool. Soc.*, London, 1900, p. 686.

axillary, cervical (five parts), gluteal, making ten whorls in all. I have examined many **Zebras** and find no constant whorl in the whole surface of the hairy covering beyond a very ill-developed frontal and minute cervical one. The mere numerical difference is not the only important one, but the insignificance of the size of the two whorls found in **Zebras** and the constancy and marked development of those of the **Horse** are not less striking. I submit that these two animals carry about on their hairy coverings indubitable records of their habits and those of their nearer ancestors. Attention to the facts of a **Domestic Horse's** life and certain related or contrasted facts of the lives of other animals, of which the **Zebra** may be taken as a type, will show the reasons for which these arrangements of hair in whorls, featherings and crests are looked upon as registers of long-past and present activities of the species in question. The **Domestic Horse** has been produced by man out of a wild plastic stock with some such ancestors as the **Wild Horse** (Przewalsky's) lately brought to Europe, by a process of selection during many generations, first in its Central Asian cradle and later all over the civilised world. It has been as much made by man for his purposes of locomotion, draught and traffic, as a locomotive engine has been made by him. The one has been produced by the laws of applied physics, and the other by those of biology. Its locomotive life is mainly not for itself, but for the needs of higher creatures, who have availed themselves of its potentialities provided by nature. The **Zebra** shows none of those phenomena which are here termed "pedometers," and its habits

also differ from those of the **Horse** in the simple but fundamental point that the former lives the ordinary active life of a wild animal for its own need, and the **Horse** shows not only this activity, but has super-

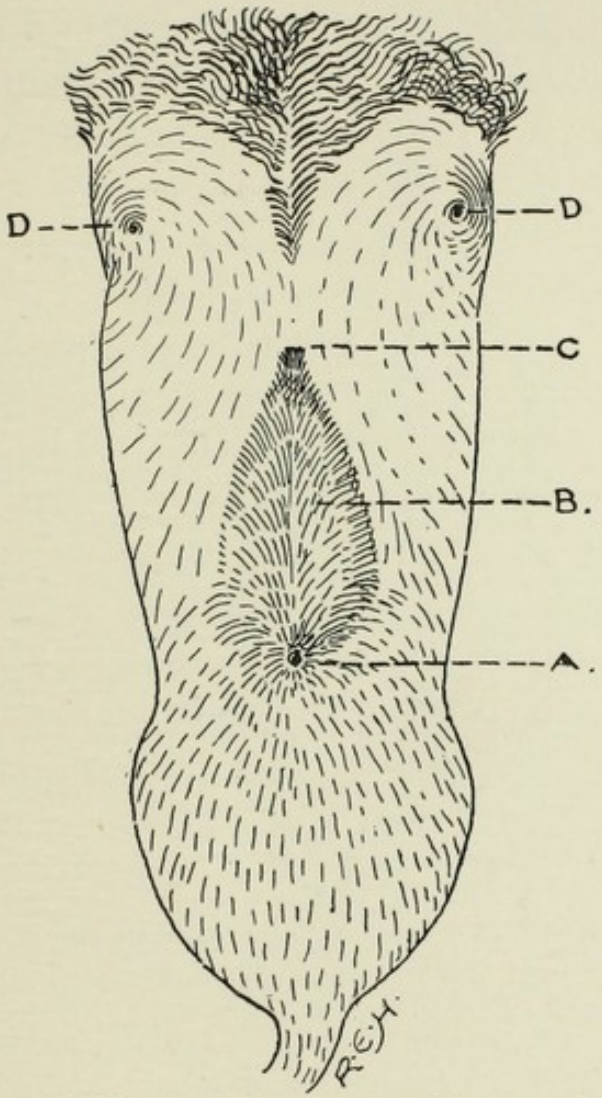

FIG. 15.—VIEW FROM ABOVE OF BACK OF LION.

Showing whorl and expanded feathering and crest A, B, C, and cervical whorl D.

added to it by man's domestication all the locomotive life of a beast of burden. It carries about on its body the brand of its servitude to man, which is at the same time its only claim to existence in its present development.

The **Spinal** region shows few peculiarities of hair-

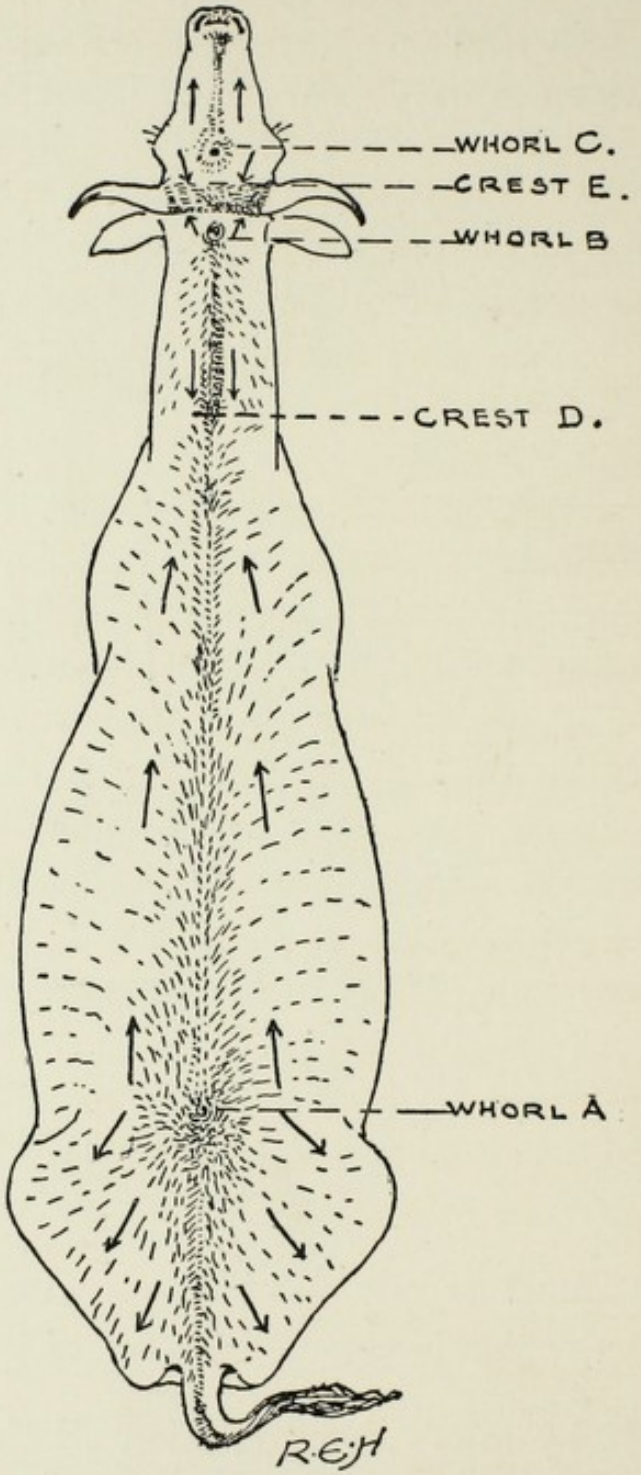

FIG. 16.—VIEW FROM ABOVE OF BACK OF OX.

slope, and these are not very important. Two well-known animals, the **Lion** and the **Domestic Ox**,

furnish marked examples of change of the primitive direction of the hair in this critical area.

On the dorsal region of a **Lion** a very good whorl, feathering and crest is developed, and lies in a central position, the whorl being over the lumbar region, and from this point a broad feathering expands forward and laterally, and reaches a crest at about the mid-dorsal level. This arrangement of hair is peculiar to the **Lion**, and is found in no others of the FELIDÆ. It must have a close connection with the strongly developed panniculus carnosus, as was seen in the case of the mane which is erected by this muscle and the bilateral whorl, feathering and crest found at the root of the neck in the great FELIDÆ. The **Domestic Ox** exhibits certain definite departures from the primitive arrangement, which are best studied by a view from above of the head, neck and back of a calf. Commencing in the middle line at a point behind the level of the horns, one finds situated there a whorl, the feathering of which continues forward on to the parietal region.

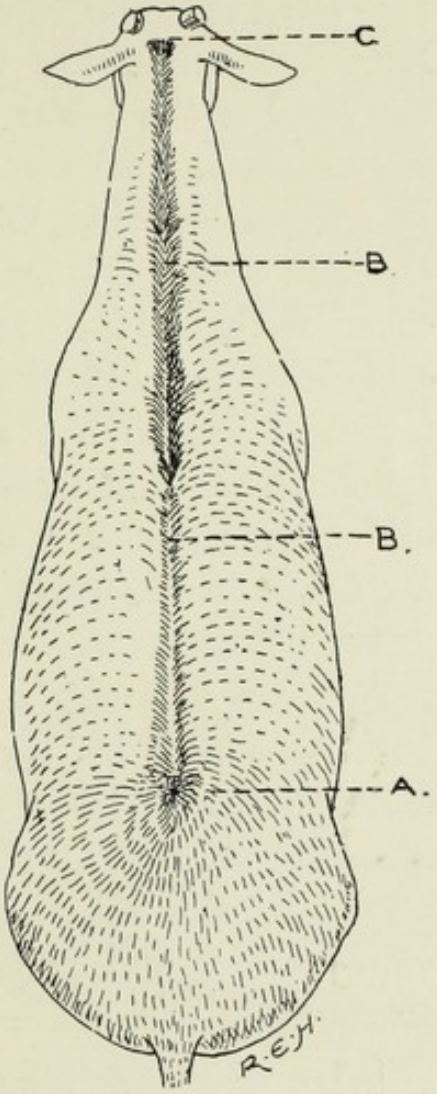

FIG. 17.—VIEW FROM ABOVE OF BACK OF ORYX BEISA.

(Copied by permission from the *Proceedings of the Zoological Society of London.*)

Behind it the primitive or normal direction of hair continues until another crest is reached at about the level of the junction of the cervical and dorsal vertebræ. Tracing the hair in a caudal direction, this crest is found to be the terminal crest of a very long feathering, the whorl of which is situated at the level of the lower lumbar vertebræ. From this whorl the central stream of hair proceeds again in its normal direction, after its two interruptions, on to the tail, where it is arranged in a central longitudinal crest with lateral streams. Certain BOVIDÆ, especially ANTILOPIDÆ, show similar arrangements of hair in the middle line of the spine, the most marked and familiar of which is **Oryx Beisa**, and a few cases of a bilateral whorl and feathering are found in the lower dorsal region.

Whorls and forward featherings in the spinal region are not very common, and would appear to be determined by the activity of the panniculus carnosus employed in defence of the animal against flies and various insects. This function is also subserved by the tail, so that an animal possessing an efficient tail, and presenting, in a spinal whorl and feathering, the evidence of a very active "fly-shaker," as it is popularly called, is well adapted for existing in areas where flies abound. It is worth noting that such animals as CERVIDÆ, OVIDÆ, *Capra*, *Gazelles*, with few exceptions, present neither efficient tails nor this particular evidence in the hair of a very active "fly-shaker," but that many of the larger ANTELOPES, true OXEN, and GIRAFFES present both efficient tails and evidence of activity of this superficial muscle in whorls, featherings and

longitudinal crests or manes. Some of the most marked instances of spinal whorls and manes have been studied, and measurements taken from the root of the tail to the tip, and from the same point to the situation of the spinal whorl. These measurements of seventeen species and twenty-nine specimens are given,* by which it is shown that animals with well-developed manes and spinal whorls and featherings also possess efficient tails, though the distance between the root and tip of tail, and root of tail and

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* The species examined and the measurements were as follows :

	From root to tip of tail.	From root of tail to spinal whorl or end of mane.
Connochætes gnu	32 inches.	29 inches.
„ *taurinus*	24 „	28 „
Oryx gazella (2 specimens)	30 „	14 „
	31 „	14 „
„ *beisa* (2 specimens)	26 „	15 „
	25 „	12½ „
Hippotragus niger	20 „	38 „
„ *equinus*	25 „	36 „
Oryx beatrix	17 „	10 „
Cobus unctuosus	15 „	18 „
„ *kob*	12 „	23 „
„ *leche* (3 specimens)	12 „	25 „
	9 „	15 „
	9 „	15 „
„ *senegamus* (3 specimens)	10½ „	19 „
	8½ „	16½ „
	9 „	12½ „
„ *vardoni* (3 specimens)	9½ „	15 „
	9 „	19 „
	5½ „	8 „
„ *thomasi* (2 specimens)	9½ „	15 „
	13 „	20 „
„ *leucotis*	7 „	13 „
Cervicapra arundinum (3 specimens)	19 „	14 „
	12 „	17 „
	12 „	20 „
„ *fulvo-rufola* (2 specimens)	9 „	15 „
	8 „	12 „ (young)
Felis leo	37 „	20 „

whorl or end of mane, in some forms, does not correspond closely, which one would hardly expect.

Mr. Lydekker has drawn attention to a difficulty there is of accounting for marked differences of hair-slope in this region in closely allied forms, showing that the Asiatic and African **Buffaloes** differ entirely in this respect from one another, and that no difference in form or habits known to us can be assigned as the reason for this. Mr. Oldfield Thomas also exhibited recently specimens of Bush **Duikers** from British East Africa, in which the direction of the hair of the nape of the neck was backwards (or primitive), and pointed out that in this respect the East African form differed from the closely similar West African **Duiker.** Here, as in Mr. Lydekker's case, no immediate explanation of the differences of hair-slope in similar forms is forthcoming from the *known* habits of the species. But the light which is thrown upon the arrangement of hair in many other animal forms is so clear, when the theory of use or habit is brought to bear upon them, that one is justified in expecting that in these unexplained cases more light will come with more knowledge of the facts. We can at least imagine how closely allied species or even individuals in a species may differ very strongly in certain habits, which may be sufficient to reflect themselves on the hair-slope of an animal. It certainly is so in the case of man.

Of the eleven critical areas chosen for examination six have now been considered from the dynamical side, the influences at work being either those of active locomotion or of active muscular exertion in the parts concerned.

Five others now remain to be studied from the point of view of *passive* habits in the animals presenting them. They are directly connected with pressure at certain points of contact between the ground and the animal's body. We have then to consider

(1) **The Pectoral Region.**
(2) **The Extensor Surface of the Ulna.**
(3) **The Ventral and Lateral Surfaces of the Abdomen.**
(4) **The Extensor Surface of the Thigh.**
(5) **The Gluteal Region.**

All of these show instances of reversed areas of hair.

(1) **Pectoral.**—A reversed area of hair is present in so large a number of MAMMALS that it is sufficient to enumerate the chief forms in which it is absent. These are chiefly **UNGULATES.** In **CARNIVORES** it is generally present, but in many long-haired forms it cannot be distinguished. In numerous species of the SUIDÆ, in which the scanty hairs are sufficiently closely set, there is a very persistent reversed area of hair in the pectoral region, and judging from the characteristic attitude in rest and the length of time devoted to rest by the Domestic Pig one cannot escape the conclusion that this reversal of the primitive slope is solely caused by the attitude referred to (Fig. 3, p. 15 ; Fig. 4, p. 17).

(2) **Extensor Surface of the Ulna.**—This small region is open to very different influences in different animals, and presents also a great variety of arrangements of the hair in those forms. It is also of historic interest on account of the great importance attached to it by Mr. Wallace and the late Professor

Romanes, who claimed the hair-slope on this surface as a vestigial character in man, though of this there are considerable doubts.*

Judging from the direction in which the hair slopes on all the other aspects of the anterior and posterior limbs, one would suppose that here, on the extensor surface of the forearm, the slope would follow that of the rest of the anterior limb, and resemble that on the corresponding surface of the posterior limb. On the flexor surface of this limb-segment in all animals it follows the ordinary slope, but on the extensor surface there are great varieties found, and all degrees of reversed slope, from carpus to olecranon process, appear in different forms of animals. In such as a short-haired **Dog**, an **Orang** or **Man** there is a reversed slope along the length of the whole ulna. In a **Domestic Horse** or certain ANTELOPES the distal fourth alone presents a partly reversed slope trending towards the radial border. Between these two extremes there are all varieties of what may be called, for convenience, the exceptional type. The reason for provisionally calling this type exceptional is that a marked *reversed* slope such as this may legitimately be considered to need some exceptional interpretation. The term "normal type" may be applied to that slope on the extensor surface which passes in a uniform distal direction, in keeping with that on other surfaces of the limb. This is found very largely in **UNGULATES**, and a list of the exceptions to this rule among **UNGULATES** is given in the *Proceedings of the Zoological Society of London*, June 19, 1900, p. 686.

* *Nature*, vol. 55, p. 236.

It is unnecessary here to dwell minutely on the distribution of these two types among kindred or differing forms. It is sufficient to state that the two main types exist in the MAMMALIAN orders to an extent that would not be expected from the close similarity of structure presented by those forms, which show marked differences in respect of this character.

We find the **CARNIVORES**, certain **UNGULATES**, the **PRIMATES**, including **Man**, presenting this reversed exceptional slope on the extensor surface of the forearm. One is then led to ask what habits are common to these various and diverse forms of animal life. Among the **CARNIVORES** there is a very prevailing habit of planting in front of them their fore-limbs, when at rest, with the head raised, or resting on the limbs. This attitude is most familiar in the "couchant" **Lion.** Doubtless many **CARNIVORES** also fold their fore-limbs when at rest, so that the manus and carpus are in contact with the extensor surface of the ulna. But this is not common, and is greatly more characteristic of **UNGULATES**. The effect of this prevailing attitude on the slope of hair on the under surface of this limb-segment is clearly to cause a backward direction of the hair covering the skin over the loose subcutaneous tissue found here. The resultant of the downward force of the weight of the fore-end of the animal, and the forward slide allowed by the loosely attached skin over the ulna, is a force which clearly acts in the direction calculated to produce the reversed slope of hair found to exist. A similar combination of forces is found acting on the extensor

surface of the forearm in MONKEYS, ANTHROPOID APES, and **Man**, on account of their habits of resting this portion of the limb against certain objects when in a sitting posture. The exceptional type of slope would also be accentuated in APES and MONKEYS by their arboreal habits in tropical forests, in which heavy rains would fall for hours at a time along their forearms as they grasp the boughs of trees. This is most notable in the **Orang**, with its profusion of long hair on its forearm, hanging from the carpus directly downwards on all aspects of this limb-segment. In this particular instance the action of gravity alone would be very efficient in directing the slope of hair as described, the hair here being extremely long. This does not negative, but rather supports, the Lamarckian view of the facts before us.

In the case of the normal type so generally seen in **UNGULATES**, the habit of folding the anterior limb when at rest, so that the manus and carpus lie in contact with the ulna, is seen in CERVIDÆ, BOVIDÆ and EQUIDÆ. In this case the contact of the opposed surfaces makes no change in the uniform slope from proximal to distal extremity, and no slide or movement can occur to alter it. The exceptions to this rule are found in the cases of those **UNGULATES**, such as certain ANTELOPES, DEER and **Horses**, which assume this attitude at rest, but slightly evert the hoof, so that a partial divergence of the stream, generally about one-fourth of its length at the distal end, to the radial border, is found. That this occurs in the wild forms is shown by the shape of the hoof, which renders it necessary

and by the specimens both of adults and young arranged in the attitude of rest at the South Kensington Natural History Museum. Surely it is enough to allude to these last-mentioned cases to prove beyond doubt that rain-tracks have no connection with such facts, but that *moving pressure* in the animals which present the exceptional type, and *absence of moving pressure* in those with normal type, meet all the facts of the case. This amounts to a Lamarckian interpretation of an insignificant point of distribution of hair, and it is difficult to see what other is possible. In certain areas the hair-slope might conceivably be looked upon as "a character borne along various lines of evolution in the wake of other characters, notably of muscle-arrangement, whose changes are of major importance," but in this region such a view is untenable.

(3) **The Ventral and Lateral Surfaces of the Abdomen** show little interference with the normal slope of the animal's hair caused by its attitudes in lying. It is, perhaps, not unnecessary to point out this fact, because in such a study negative facts may weigh considerably in support of a positive contention, if explanations in accordance with these be forthcoming. When lying on the ventral surface of its abdomen, an animal rests very little on the thorax because of the support of the fore-limbs ; and in this position any tendency to slide forwards which may exist serves but to confirm the normal slope of hair from cephalic to caudal extremity, and thus the absence of any marks on the ventral surface, due to the recumbent position, is fully accounted for.

On the lateral aspect of the abdomen there is found in nearly all **CARNIVORES** and **UNGULATES** an area of reversed hair, where the "knee" of the animal rests in flexion, during lying and sitting, against the flank. The extent of this area is variable and is usually marked off by a margin, showing where the general backward and downward direction of hair on the flank is interrupted by the pressure of the flexed hind-limbs.

(4) **The Extensor Surface of the Thigh** presents in many animals on its inner aspect the marks of pressure against the ground in a reversed area of hair, passing upwards and outwards to meet the downward and inward slope of the stream which comes from the outer half of this limb-segment.

(5) **The Gluteal Region** is the only one where the posture of sitting is indicated in the arrangement of hair. It is obvious that, when an animal sits, there is no point of contact of the body with the ground, except the tubera ischii, the digits of the limbs and the metatarsal bones. Animals accustomed much to the sitting posture present a whorl in the gluteal region lying exactly over the tuber ischii of each side; and it is a breach of the "law of parsimony" to look for any other cause of this whorl than the pressure of the weight of the animal's body on the hair over this prominent region.

In almost all the **CARNIVORES** and **UNGULATES** the hair on the gluteal region curves over this rounded surface, taking a course in the long axis of the limb itself, as in a **Horse**, or very often in the long axis of the trunk, as may be seen in a short-haired **Dog**. The sweep of this gluteal stream towards

the perineum is interrupted by the whorl mentioned, in a few animals which sit, such as short-haired **Dogs** and many of the **SIMIIDÆ**, though in most of the

FIG. 18.—GLUTEAL REGION OF DOMESTIC DOG, SHOWING WHORLS OVER TUBERA ISCHII AND OPPOSING HAIR-STREAMS ON BACK OF THIGH.

(Copied by permission from the *Proceedings of the Zoological Society of London.*)

latter it is rather a bare area or callosity than a whorl, but equally significant as to causation. In all such **UNGULATES** as BOVIDÆ, EQUIDÆ, CERVIDÆ, OVIDÆ, CAPRA, TAPIRIDÆ, and in FELIDÆ,

URSIDÆ and most wild CANIDÆ—animals in which the sitting posture is either impossible, inconvenient, or little adopted—it is conspicuous by its absence.

For the explanation of these reversed areas of hair the description of the typical attitudes of certain animals given in Chapter II. is sufficient.

Tufts are only to be found in two situations, as far as an extensive search has shown, and these almost confined to the **Domestic Ox** and **Horse.** One of them, which is rare even in a large number of **Horses**, but very common in the Ox, may be called the gluteal tuft, as it lies over the great extensor muscles of the hind-limb, the biceps and semitendinosus, just where the gluteal region, properly so called, terminates. The other, which may be called the inguinal, is very common in **Horses**, and lies about at the level of the lower edge of the great oblique muscle of the abdomen—a little above or below this point. This is sometimes associated with a second tuft, lying on the ventral surface of the abdomen, and the two are then joined by a definite ridge. The appearance of this tuft is very much like that of a stack of corn in a field, and it stands out with converging streams surrounding it. It is itself a *converging* phenomenon, and is thus to be contrasted with the *diverging* arrangement of hairs which goes to form whorls. Tufts in these two regions may have different explanations. The inguinal tuft is situated at a very critical area of the trunk-streams of hair. This point can only be appreciated by observing a **Horse** in somewhat rapid motion, and a thin muscular specimen is the best

for this purpose. As each step is taken the lower margin of the great oblique muscle where the inguinal tuft lies is seen to be drawn rapidly upwards, making the muscle for the moment lie exactly straight instead of in its usual slightly curved direction with convexity downwards. This region partakes in the "jolt" referred to in connection with the inguinal whorl, and it is the spot where the continuation downwards of this jolting movement of the superficial tissues abruptly terminates. As this jerk takes place at every step of the **Horse**, and, as remarked before, there are about 6000 steps an hour in the case of a trotting **Horse**, it may be well calculated to produce some modification of the direction of the hair over a small area so critical. This single tuft, or double tuft with ridge between, also marks the exact limit of the region where, as before mentioned, the tracks of a rain-shower are seen to terminate. The view that we have in this instance a critical area is thus corroborated, and it belongs to the group coming under dynamical principles.

The gluteal tuft is very rare in the **Horse**, common in the Ox, but when it occurs is bilateral and rather noticeable, as it stands out from the smooth rounded extensor surface. There is no adequate cause for this tuft in the normal actions of a **Horse**, but there is a factor which may have the necessary influence in producing it. That is the very frequent upward pull of the kicking-strap in the case of a domesticated **Draught-Horse**. It may be well at this point to refer briefly to the effects of the harness upon the hair-slope of animals that wear

it in the course of their life's work. If one endeavours to trace the effects of pressure on the arrangement of hair on animals, it may well be asked why it is that the pressure of harness on the coat of such an animal as the **Horse** does not produce changes in the direction. It is a fact that, except the gluteal tuft, no hereditary modification of the hair of a **Horse** is produced by all the complicated pieces of harness which **Domestic Horses** have worn for some thousands of years. In the first place, most of the harness used does not produce friction *against* the stream of hair in any region except three, and that is enough to account for the negative results. The three places where harness does more or less oppose the hair-stream are the side of the neck, where the reins constantly move up and down ; the flank, where the traces also often come in contact with the coat in a similar way ; and the kicking-strap, where at every one of the 6000 steps taken by a trotting **Horse** this piece of harness is more or less rubbed up against the downward stream of hair over the hamstring muscles. *This is the very spot where the rare gluteal tuft is found.*

It would seem that in this case the great rule is not absolute that influences in the nature of mutilations (as this might be broadly termed) do not produce transmissible changes in the hair.

As to the gluteal tuft which is so commonly found in the **Domestic Ox**, an explanation taken from observation of its habits is forthcoming. As mentioned, the **Ox**, during the numerous hours of the day in warm weather when it is employed in browsing and moving slowly about in search of food, is almost

constantly flicking its tail* on to its back for the purpose of removing flies. As the tail is raised it sweeps over one gluteal region or the other, frequently grazing the surface where it projects. Considering that this monotonous regular force may be applied as often as 8656 times in a day of eight hours, it is not extravagant to claim that it has an effect on the hair-slope such as the kicking-strap of a **Horse's** harness is held to produce.

* Observations have been made as to the frequency with which an Ox will flick its tail in moderate summer weather and in a wind-swept situation in England. Different specimens were found to repeat this action as often as 348 to 1082 times per hour.

CHAPTER IV

CRITICAL AREAS—MAN

Those who have not paid any particular attention to the matter are not aware that, in addition to the well-known hairy regions of the human body, every inch of skin is clad with fine hairs except the palms of the hands, soles of the feet, the ungual phalanges of the fingers and toes, and one or two small and unimportant areas. This distribution of hair, with the small exceptions mentioned, is sufficiently peculiar to require a little further reference here. If man be the child of the monkey, it follows that his ancestors possessed at one time hair on all the phalanges of foot and hand, as is found to be the case on a large series of the existing MONKEYS of the New World and Old World that I have examined. **Chimpanzees** show very much the same distribution of hair in these regions as **Man**, but a young **Orang** examined by me showed hair exactly like that of lower MONKEYS,—*i.e.*, on all the phalanges of foot and hand, and on the two terminal phalanges of the *hand* the hair was worn down and bristly, even though the animal was quite young. These facts are referred to more in detail in *Nature*, vol. lxiv., p. 351, where I pointed out the strong

support they give to the doctrine that use, and consequently disuse, of a certain character or structure tends to be inherited. If the facts be not conclusive, they are at least strongly suggestive of the view that repeated friction of the hair in these exposed positions tends to a wearing away of hair which becomes congenital.

The hair of **Man's** body varies from a covering so fine that a good lens is required for the discovery of the individual hairs, to a profusion of long hair of a Simian character, reaching its maximum in the Ainu, or hairy aborigines of Japan.

It is proposed in the present chapter to study the direction of the human hair-streams and the causation of their numerous peculiarities. Broadly speaking, these streams, according to their range, show two facts about man: first, what he has been; secondly, what he has done; or, in other words, his ancestry and his habits of life.

The direction taken by the hair covering the human body is a matter already well elucidated by the elaborate descriptions and illustrations of Eschricht in 1837,* and by C. A. Voigt in 1857,† who both made numerous observations as to the hair on the human fœtus. To these I have nothing to add of any importance after numerous examinations of hairy young human subjects and a few fœtuses. It appears that on all parts of the human body where it exists, the hair slopes at an acute angle with the plane of the adjoining surface and always in a definite direction, which is constant for

* "Archiv fur Anat. und Phys.," 1837.

† "Denkschriften der k. k. Akad. zu Wien," 13, 1857.

each region, the only exception to this being the eyelashes.

Eschricht gives some rather crude suggestions as to the reasons for the various directions found, depending upon the distribution of the vascular system; but this attempt he did not carry far, on account of the want of correspondence of the branching of the vascular system with the direction of the hair. He also speaks of the attractions and repulsions at certain points to which the ends of the hairs incline, saying that the lines of attraction are the prominences of the surface, especially where the skeleton stands out more sharply, so that the skin is more hardly pressed. But his attempts at explanation are not important, though the descriptions are clear and good.

Voigt undertakes a more elaborate attempt to account for the variations and peculiarities found on the body. Without going minutely into his theories, it is enough to say that he makes the "diverging whorls," "converging lines" and "boundary lines," for which he supplies definitions, to depend upon a necessary and mechanical cause, viz. the gradual enlargement in three dimensions—length, breadth and thickness—of the developing embryo. He says the lines of direction of growth of the embryo are not straight, but bent and sinuous, because they are the result of a very complicated growth in length, breadth and depth of the soft parts just beneath the skin, also of the bones. The growth of the skin itself also has to be taken into account, as it forms over the hollowed, rounded and bent surfaces of the body, and is thus stretched

in the course of growth. He says also that it is clear that the portion of the rudimentary hair within the follicle will be drawn by the gradual stretching of skin in a sloping direction, and the portion external to the follicle will follow this direction. A view of this kind renders the hair-slope a necessary character peculiar to the human embryo, and one dependent on the course which the enlargement of its various parts takes in early intra-uterine life. He also shows that on certain regions the rate of stretching due to more rapid enlargement is relatively quick, and on others—*e.g.* the axillary and inguinal regions, where the growth is quiet, the stretching is slow. He describes all the regions of the surface of the human body where hair is found, and the theory is applied to each. In accounting for "radiating whorls," he goes to the vegetable kingdom for analogies, and refers to the law of spirals and screw-forms found in leaves, branches, stems, flowers, and certain allied phenomena, for support of his views.

It will be seen that the views of Eschricht and Voigt as to the direction of hair on the body of **Man** have an allied basis—viz. the necessary arrangement of the hair in most complicated ways, entailed by the special anatomy of this particular species. For them the arrangement follows as a matter of course, and in all cases. It is easy to see that Voigt's theory may fit the facts closely, and it is ably worked out. But it is also easy to see that the fundamental position—viz. that the stretching of the skin produces the change of position of the developing hair-germ from the perpendicular to the

sloping direction, and that this depends for its variations upon the contiguous anatomy—is not necessary. On a surface such as that of the human embryo, subject, even before its birth, to constant slight pressure, and much more so in after life, no other than a sloping direction of that portion of the hair which is external to the follicle could occur. If this be so, the portion within the follicle would of necessity be drawn in a sloping direction also. This consideration as to the general cause of the slope of hair would render Voigt's theory unnecessary, however ingenious the particular applications of that theory may be as to certain modifications found in many regions. But as a matter of fact they do not fit in all respects those varieties found in **Man**, and certainly not in the very numerous variations of hair-slope found in other animals, as I have shown elsewhere. To take an instance in one particular animal. The **Mole**, being a Vertebrate and a MAMMAL, has sufficient resemblance in type of structure to **Man** or other lower animals to require that it should share as to its hair-slope in the results claimed as being produced on the hair follicles in **Man** by his development. But, as is well known, the skin of this animal possesses that unusual quality of hair resembling velvet, and has no fixed slope of hair, as is the case in most other animals, for the simple reason, it may be presumed, of its burrowing habits.

In the case of **Man** it is conceded that most, if not all, of the directions of slope found in the fœtus are also found to continue through life, with very little modification here and there from secondary

causes. It is legitimate then to assume from analogy (in the absence of accurate observations among fœtal MONKEYS and higher **Apes**) that in the case of **Man's** supposed nearest congeners, the slope found in adult APES and MONKEYS approximates very closely to that of the fœtal animals. The striking peculiarities of hair-slope found in **Man**, and the equally striking simplicity of slope found in APES and MONKEYS, would on the theory of Voigt differentiate **Man** sharply from those animals supposed to resemble closely his ancestral stock. But Man is so closely allied in type of structure to a representative of the Simian family, that on Voigt's theory similar peculiarities of slope ought to be found in these two closely similar animals. This is not so; in fact the difference in many respects is startling. If we were compelled to accept Voigt's theories of hair-slope as proved, we should also have to reject the Simian ancestry of **Man**, and it was this consideration that induced me to look furtner into the matter of the hair-slope in **Man**. It may be going too far to say that in that case we should have to reject the prevailing view of **Man's** ancestry, but I can see no escape from the dilemma that we should be constrained to reject either that view or another which by many is held nearly as tenaciously —the non-inheritance of acquired characters. It is inconceivable, and not indeed contended, that natural or any other form of selection can have operated to produce the whimsical peculiarities, if one may so term them, which we find existing on the human body. They cannot be due to sexual selection. And if they cannot be due to natural selection

a fortiori, they cannot be vestigial; for, not existing on the assumed ancestors of man, nor possessing any survival-value if they had existed, the vestigial view of them is estopped. It seems that there is no account of the peculiarities in question to be given than that they are due to the inheritance of characters acquired by habit or use in ancestors, whose hairy covering was in a plastic state—in effect, that they are the result of Lamarckian factors. This I propose to maintain by the consideration of several regions of the human skin, in which departures from the general slope of hair found in more primitive groups of the ANTHROPOIDEA are observed. Briefly and roughly it may be said that the trend of the hair-streams on these is from the cephalic to the caudal extremities of the head and trunk, and from the proximal to the distal extremities of the limb-segments.

The point which strikes one first in examining the course of these hair-streams is the very complicated direction taken by them on the head, neck and trunk and upper extremity, and the equally marked simplicity of the direction of those on the lower extremity. This is a general fact which must be borne in mind, and it will be referred to more particularly when the causation of hair-direction is considered.

If man be descended from a Simian stock he has modified in a remarkable manner the length, texture and direction of his hairy covering. With the former qualities we are not here concerned. The direction which his hair pursues shows little remains of the primitive type. There is indeed a larger area

of hair to be apportioned to the results of morphological change on the one hand, and of use and habit on the other, than is the case in any other animal. This will be more appropriately considered in the section which deals with the delimitation of hair-tracts. **Man** may thus be said to exhibit a greater number of critical areas on his skin than any of the lower animal forms.

We will first consider certain of the habits of **Man** which bear upon the direction of hair on his body, and then proceed to the more detailed description of the facts of hair-direction found in the various critical areas.

Certain Habits.—From the point of view here adopted **Man** has advanced very much beyond his Simian ancestors as to the complexity of his habits. more so even than the **Domestic Horse** has gone beyond his **UNGULATE** congeners and predecessors. His attitudes in rest are more varied than those of any of the ANTHROPOID APES, which are the only group of existing animals capable of showing to us now what the original hairy covering of primitive man must have been, as to direction and arrangement. Man sits as an APE does, but occupies in the sitting posture much less of his time than these arboreal creatures, and his attitude is much more that of resting on one support and leaning his back against another. Our Troglodyte ancestors cannot well have been luxurious persons, but even they must have had many hours of their strenuous lives sufficiently free from the hunt for food and combats with foes to allow them frequently, when not asleep, to lean against the trunk of a tree, the side of a cave,

or some bank of earth, which is an advance upon the sitting posture of the APE. When we come to the case of modern Man the opportunities for such aids to repose have been obviously much increased. The difference in this respect between **Man** and the APE is a result of the erect posture acquired by the former which has produced a straighter vertebral column and a less crouching attitude in sitting as well as in standing.

In the recumbent attitude of man the changes as to actual position are not so great, for other animals habitually lie on their sides in sleep. But from an early period **Man** has employed some kind of pillow for his head, and the more this contrivance is elaborated and appreciated the more persistently are the head, neck and upper part of the thorax elevated above the horizontal until comfort is arrived at. By this simple addition to the habits of the lower animals a fresh passive force is introduced, the trunk and lower limbs tending continually to make a certain downward sliding action of the head, neck, and thorax.

Thus, in the two main attitudes of rest **Man** has acquired habits which from obvious mechanical principles are calculated to alter the hair-slope found on his body.

Other habits, which **Man** does not share with any lower animals, include such as the methods employed by him in dressing the hair of his head. The three places where we find there is frequent mechanical interference with the primitive or Simian direction of hair are the parietal, frontal and occipito-cervical regions. The process of parting the hair either in

the centre or to the right or left of the median plane necessarily affects the arrangement of hair on the vault of the skull, the forehead at the edge of the scalp, and in the occipito-cervical region, during the lifetime of the individual. On the occipito-cervical region there are two influences which can affect the direction of the hair. On the one hand, the primitive or Simian slope may persist if no dressing of the hair except combing and brushing the hair downwards be carried out; and on the other, if any form of gathering up the hair in this region be adopted, as in any of the numerous methods of dressing of the hair found in different countries, the change of slope from the primitive type is the same in all cases, viz. that the streams of hair from the two sides are drawn to the centre. These will be described in a later part of this chapter.

The last habit of **Man** which, from our point of view, distinguishes him from his "hairy, arboreal, ape-like" ancestors is the wearing of clothing in some form or other. In the most primitive times the upper limit of clothing would be much the same as at present, and whatever rough skins of animals were employed for taking the place of the original hair would terminate round the neck, and the lower limits would by gradual development of clothing more and more surround the lower limbs also, and eventually some form of foot-covering would be invented by early **man.**

These various simple habits of **man**, those of lying, sitting, dressing of his hair and clothing his body, are habits of the "passive" order, influencing the hairy covering mostly in the way of friction in

a certain direction. We do not find in **Man** the various phenomena of hair-slope dependent upon locomotive activity. He, being not under the governance of any superior terrestrial overlord, has not been domesticated in the same sense as that in which he has treated so many lower animals for purposes of locomotion. Accordingly **man** shows no

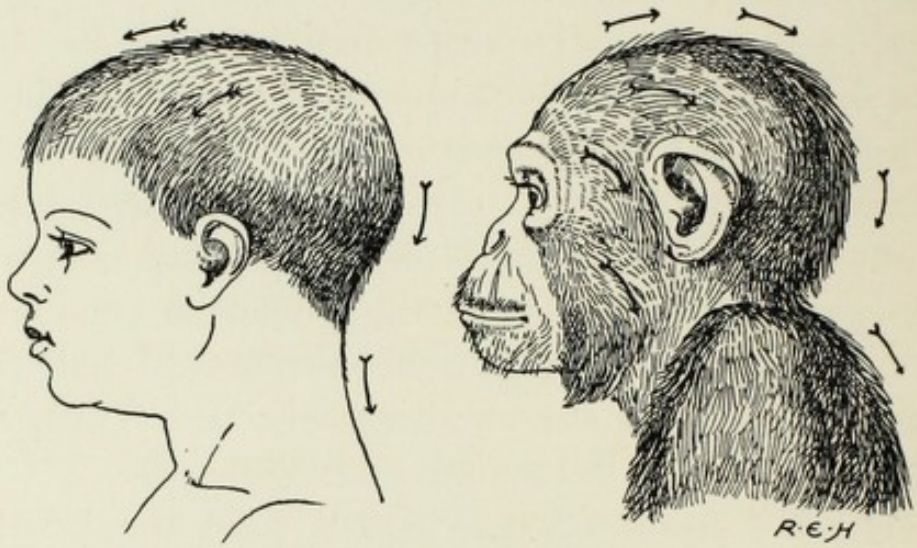


FIG. 19.—COMPARATIVE VIEW OF HEADS OF BOY AND YOUNG CHIMPANZEE.
Showing departure from primitive type in case of man.

more locomotive or active habits than his own life requires, and as a matter of fact one does not find on his body any critical areas connected with motor phenomena.

In the next place, the various critical areas in **Man** will be described seriatim, and certain diagrams given to illustrate differences found in those areas between **Man** and his assumed Simian prototypes.

HEAD.—There are here three regions where critical areas are found, depending upon the manner in which the hair in those parts has been interfered with.

First, over the posterior fontanelle the familiar

whorl or "crown" is always present and may lie to the right or the left of the middle line, seldom quite in the middle line, and it is double in a certain number of persons, one whorl lying on each side of the middle line.

There is no clear evidence that on the vertex the method of dressing or parting the hair has left any marks on the arrangement of hair in the fœtus or new-born infant. This is uniformly directed from the radiating whorl or crown on the vertex forward over the vault of the cranium to the edge of the scalp, diverging towards each side and posteriorly passing downwards. In all cases it follows the rounded outline of the head, thus being not quite in a longitudinal line. The absence of any congenital marks of the endless variety of methods of dressing the hair, of which this upper region of the head has been the seat, is perhaps as significant as if there were occasionally found certain common variations—for this reason. The study of the direction of hair brings out a general rule, borne out by other phenomena in nature, that, apart from variations of a *biological* sort, which are not here being considered, the original characteristics of an organism are not lightly departed from as the result of use or habit, and if, as on the vault of the cranium, a very considerable variety of directions of traction, or other forces, are in operation, primitive conditions remain unaffected. If any preponderating force or traction, as in the case of the hair, be exercised in an animal or its ancestral line, modifications will result. This distinction is to be observed all through this study of the hair of animals and **Man**.

During the life of an individual man or woman the direction of hair here shows a tendency to lie according to the way of parting and dressing the hair, but there is no constancy in the position at which the parting is made. Most women in England, when they part their hair at all, part it in the centre, but many forms of dressing the hair involve no parting. Among men during more recent times, since the hair has been worn short, the rule is that the parting is to the left side. This is obviously so at the present time, and a series of one hundred cases in men which I examined show the results one would have expected from ordinary observation, viz. thirteen of these parted their hair on the right side; nine in the centre and seventy-eight on the left side about eighty per cent. would, I believe, represent the general proportion. With such facts as these existing now, and the endless varieties of parting the hair that must have been in operation in past ages and other nations, it is obvious that no constant results can be expected in the infant.

On the head of certain MONKEYS, notably the **Bonnet Monkey,** there is a natural central parting of the hair, and in many Ungulates with large active pinnæ there are whorls found somewhat irregularly. Professor Lankester * has suggested from the case of *Okapia* that the whorls and other arrangements of hair on the heads of MAMMALIA may furnish data for systematists. Judging, however, from a study of the hair in other regions, and numerous groups of MAMMALIA, it is more probable that these facts of

* On O-Kapia. *Transactions Zool. Soc. of London.* Vol. xvi. Part vi.

hair-arrangement on the frontal nasal and parieta, regions, when worked out, will indicate differences of habit and use in the animals concerned rather than contribute taxonomic distinctions.

At the **Frontal** border of the scalp it is different and variations are found frequently and fairly constantly. A series of observations have been made as to these, and I may say that they are truly congenital modifications, inasmuch as the cases from which they were taken were those of children whose ages varied from a few hours to six years, and in all cases the operation of secondary causes was eliminated.

They relate to the border of the frontal region found at the edge of the scalp, and this position will be seen, on consideration, to be specially open to the incidence of certain mechanical forces. At the border of the scalp the chief point of interest as to the direction taken by the hair coming from the vertex is the difference between the modes in which it is parted. The main direction of hair on the frontal region between the scalp and the eyebrows is towards the temporal region, and it takes a sharp curve at the upper border downwards and to the temporal region, and at the lower border upwards and in a similar direction. On account of the convex outline of that portion of the cranium where the scalp ceases, the hair-streams here must part in one way or another. But it is noteworthy that the ways in which they do part group themselves into three leading arrangements, the most frequent of which is that the parting is on the left side of the middle line. This parting may also be found to the right of and in the middle line, and certain other

rare arrangements are found, some of which are noted in the diagrams. These are the situations where the streams of the scalp divide and pass to the right and left, as I believe, from the effects of methods of parting the hair in many generations in certain ways. In this frontal region the termination of the parting which was ineffectual on the vault of the cranium is effectual, and it is obvious here that some forces preponderate over others in producing certain fairly constant results.

Fig. 1 shows the direction of hair to be entirely downwards, and such partings as exist are central.

Fig. 2. Here all the direction is also downwards, except for a very singular reversed feathering of the hair to the right of the middle line, representing a right lateral parting.

Fig. 3. In this case the direction is all upwards from the frontal region, and the hair here meets that of the scalp and radiates from the middle line upwards and outwards.

Fig. 4. Direction downward in central stream, with two lateral upward streams.

Fig. 5. This is far the commonest arrangement, the direction being all downwards, with parting to the left of the middle line.

Fig. 6. Here the parting is on the right of the middle line. In the majority of cases the direction is downward, and more rarely upwards.

Fig. 7. Rare and singular form seen only in very young infants, with V-shaped arrangement, the borders of which are upturned. This arrangement in a young subject has a most suggestive resemblance to the triangular area seen on the forehead of a bald

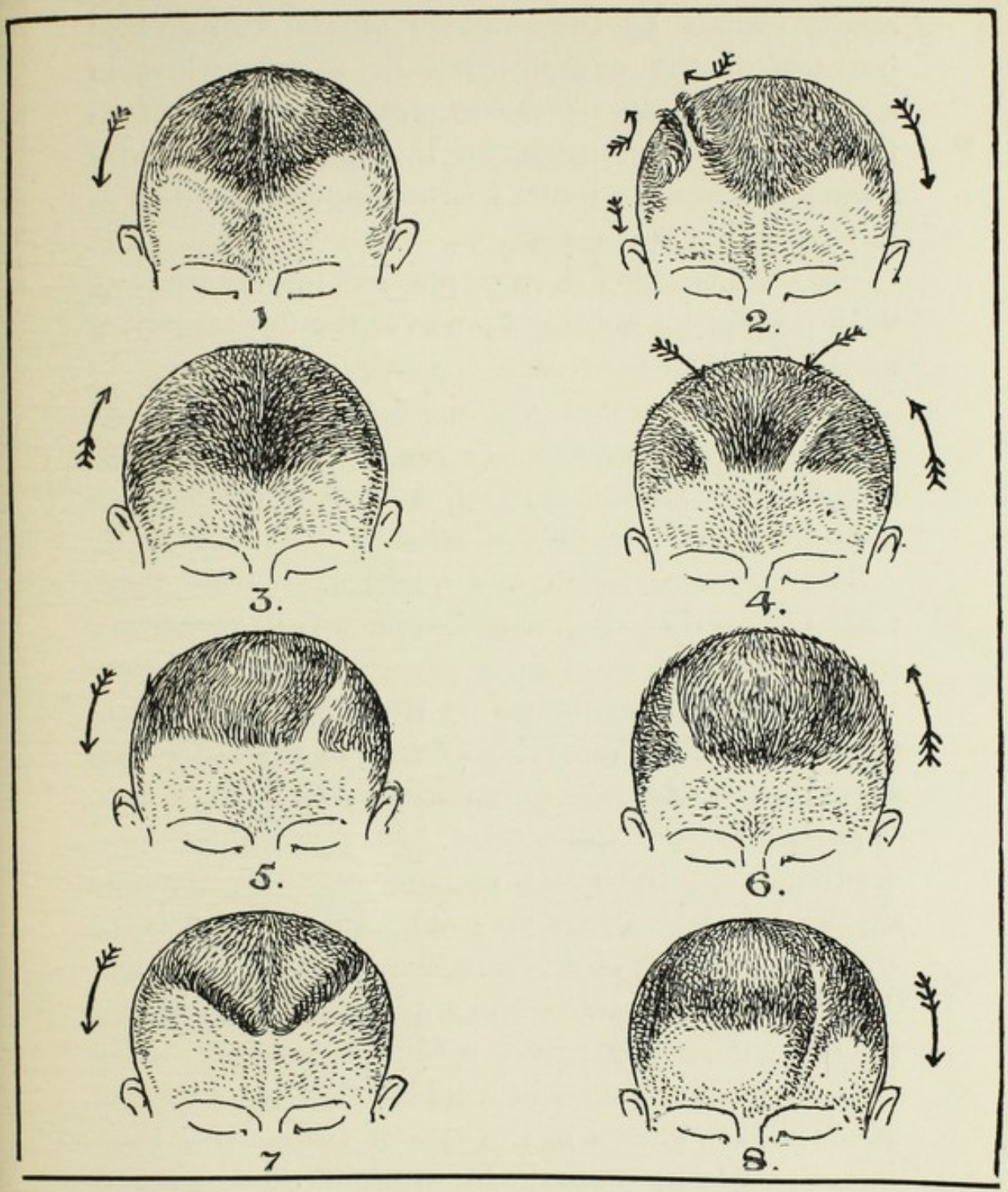


FIG. 21.—HAIR-STREAMS ON FRONTAL REGION OF YOUNG HUMAN SUBJECTS SHOWING VARIATIONS AT BORDER OF SCALP.

(Copied by permission from the *Transactions of the Anatomical Society of Great Britain and Ireland.*)

adult, formed by the junction of the two frontal portions of the occipito-frontalis muscle when in strong action; the latter occupies exactly the situation of the former, suggesting that constant muscular action causes the curious hair-arrangement which is inherited in a few cases.

Fig. 8. Direction downwards, left lateral parting, with perceptible continuation over the frontal region as far as the eyebrow.

Out of 70 cases examined specially for the purpose, 45 showed the left lateral, 17 the central, 6 the right lateral parting, and two the curious **V**-shaped arrangement indicated.

The inference which one would draw from these facts of hair-direction, doubtless not very numerous, but representative of a very large number of cases not so carefully examined, is that probably most of them, certainly some, are produced in the individual by inherited effects of dressing the hair in ancestors. The frequency of the central, left, and right lateral partings, and the great preponderance in numbers of the left lateral, are very suggestive of the three common methods of dividing the hair in this region. Whatever significance they possess, they do not point to inheritance from a Simian ancestry, being entirely unrepresented in ANTHROPOID APES or MONKEYS, except in the case of the central parting of a **Chimpanzee.** In most of these animals the hair on the frontal region passes from the superciliary region right over the low forehead and backwards over the vault of the cranium in one uniform stream. There are a few exceptions to this, as was stated previously.

A second portion of the **Frontal region** shows some peculiarities, which, though very small, are worthy of notice. A very singular and well-marked break in the stream forming the eyebrows is seen in all hairy subjects, and lies always over the spot where the outer attachment of the corrugator supercilii draws in the skin in knitting of the brows. This break in the stream would appear to be caused by the traction of the underlying muscles on the skin, rather than by any adaptation of the hair to the shape of the superciliary ridge. Close to the spot where this break in the eyebrow so commonly occurs is also found the common bilateral wrinkle due to the action of the corrugator muscle.

The direction of hair indicated in the figure, where the streams of the two sides frequently decussate across the middle line, is probably due to the constant action of the corrugator supercilii. If this curious break in the hair-stream of the eyebrows be more closely examined, in a great many cases it is impossible not to be struck with the frequency with which it occurs only on the left side, or with which it is more marked there than on the right. In the course of examining the matter apart from statistics this little point obtruded itself upon my notice, and when it was further looked into in 200 consecutive cases the following results came out. There were in all 14 cases with the break most marked on the right, 33 in which it was equally marked on the two sides, 153 in which it was most marked on the left. Thus in 76·5 per cent. the break was more marked on the left side, a result which is quite in accordance with general observation of a very much larger

number than these 200 consecutive persons. The reasons for this curious fact cannot be discussed here, as it requires further investigation.

Whether these small phenomena at the level of the eyebrows be produced by the means suggested or not, the arrangement is at least remarkable and entirely unlike anything found in APES or MONKEYS. In considering the facts of the hair-direction on the human body, it is necessary to bear in mind that some of the most suggestive of these are fugitive in character, some being only observable in infants for a few months, and then being obliterated for the rest of life; others are more manifest at the age of puberty in a hairy subject. But from the point of view of inheritance, they must possess a measure of significance, whatever be the age at which they occur, and however fugitive their character.

The **Occipito-cervical** region affords an interesting field for testing the question of the mechanical production of changes of hair-slope, and is decidedly a critical area. Two very different arrangements are found. They are plainly visible in the fœtus, but may be traced in male subjects whose hair is kept short, and furnish one of the most interesting cases of divergence of type. Of the two varieties (with numerous small modifications of each), I have ventured to call one the Normal and the other the Abnormal type, for a simple reason which will appear later. The normal arrangement is that the stream of hair descends from the occipital region in the middle line parallel with the long axis of the spine. On each side of the middle line the stream passes in a curving direction to the lateral aspect of the neck,

where it joins an opposing stream from the ventral aspect. There are, of course, many degrees of divergence from the middle line; in some cases the stream will in its whole course not diverge far from this line, in others it passes so sharply to the side of the neck as to be almost at right angles to the long axis of the spine, and in a few exceptional cases one side of this region will have a stream passing in the

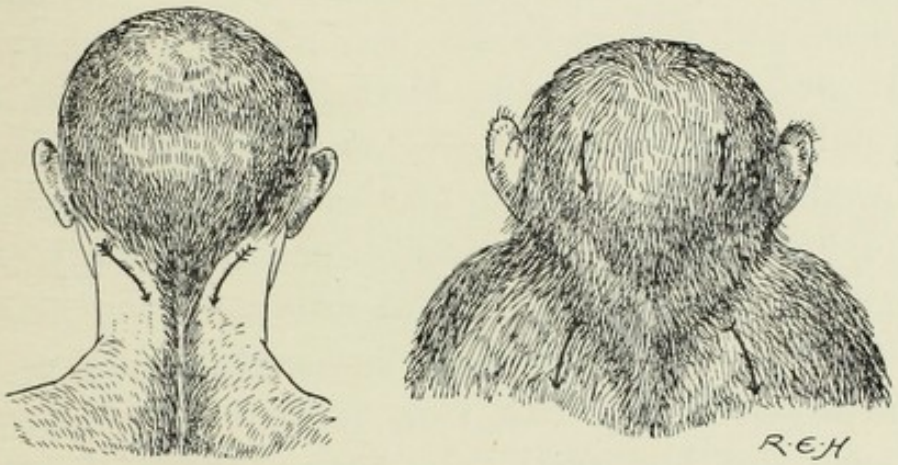


FIG. 21.—COMPARATIVE VIEW OF OCCIPITO-CERVICAL REGION IN MAN AND APE.

Showing in Man the acquired and altered slope, in the Ape the primitive arrangement; the latter in Man, not figured, resembles closely that of the Ape. The human arrangement here figured is termed *Abnormal*.

Normal direction, and the other half will assume the *Abnormal* direction and pass *to* the middle line. The *Abnormal* type is a departure which is shown by the central and lateral portions of the occipital stream, instead of diverging as they descend, converging sharply *to* the middle line, forming with the vertical portion one united stream, so that the portions of this stream passing the mastoid region become as sharply directed to the middle line as these in the Normal type are directed from it.

These different types are well known to hairdressers, and are very simple in their arrangements. It is worth noting that the figures of Eschricht and Voigt each give only one of these arrangements, and not the other, as if that were the normal one, a conclusion which might easily be arrived at from the examination of a few fœtuses. The discrepancy is accounted for by examining a considerable number of adults, especially those whose hair is cut short. I examined 627 cases for this purpose, and found that 306 presented the Normal and 321 the Abnormal type; of these, 47 were females, and 24 showed the Normal and 23 the Abnormal type. I should say that among English persons, at any rate, from a much larger general study of the matter than these 627 cases, this difference fairly represents the proportion of the two types. These terms, Normal and Abnormal, have been employed because, on the view of **Man's** descent from a Simian stock, the so-called Normal type would be the one he would inherit. It is remarkable how uniform this type is among all the ANTHROPOID APES and MONKEYS living and dead, that I have examined. In not a single case have I been able to find the Abnormal type. This, then, is characteristic of **Man**, and is absent from his supposed nearest congeners now existing.

As to the interpretation of these two types, one may say at first that a single case such as this militates strongly against the theory of Voigt as to the production of the slope of hair, in this region at any rate; and similar other cases will appear in other regions. I would submit that the

remarkable difference of type found here, and which lasts throughout life, being less marked in infancy than later, is due to the inherited effect, through numerous generations, of the method adopted in dressing the hair. There must have been a time when neither primitive man nor woman dressed their hair at all. Again, in later times, with increasing attempts at culture, the women would in some fashion or other dress what they now call their "back hair." This would of necessity involve some drawing together, and perhaps drawing upwards of the two streams which fall from the sides of the head. At this stage, Man, if he attended at all to his hair, would employ some form of combing downwards. From analogies of various kinds, one would suppose the attempts at ornamentation would be much earlier in women than men. Such a force acting through numerous generations could hardly fail to confirm the Abnormal type of slope in the descendants, and the mere combing downwards of hair would confirm the Normal type in other descendants. Whether this strange difference of type, now found in English people, be due or not to the inheritance from male or female ancestors respectively, the equal division of the numbers examined as to this character is at least suggestive. To estimate the effect of the tying together and plaiting of a woman's hair, one has only to examine the case of one whose type is a Normal one, and to see the sharp inward turn of the hair which is sufficiently long to be caught up, and the outward or lateral course of those hairs which have been too short to be caught up.

Lateral Aspect of Neck.—There occurs here a peculiarity of slope not found in APES and MONKEYS. In them the stream passes on each side with little or no alteration of direction from the face to the pectoral region. In **Man** the stream from the face passes similarly without much divergence until it reaches the level of about the middle of the anterior triangle of the neck, where it meets, near the middle line, in a slightly oblique direction, an ascending stream from the pectoral and anterior cervical regions. At this point the opposing streams coalesce and together form the stream found on the dorsal aspect of the neck, and merge into the stream which descends from the occipital region. The coalescence of the two streams on the lateral aspect of the neck produces that reverse of slope so well known practically to those who shave their beard.

Pectoral Region.—In **Man,** as in lower animals, this region is critical as regards the incidence of mechanical forces. In lower animals it has been seen how both the more passive habits of friction and pressure affect the direction of hair, and how active locomotion, especially in the **Horse,** produces whorls in this region. The arrangement of hair is remarkable and confined, as I believe, to Man. It is stated in Lydekker's "Royal Natural History" that something of this arrangement is found in the **Gorilla,** but this is not the case in the four specimens lately at South Kensington, either in the young **Gorilla** or the three adults.

In *Nature*, Feb. 13, 1902, I recorded two cases of persons, aged 28 and 33, with especially smooth, hairless skins, who presented certain isolated hairs

standing out from the skin with remarkably persistent direction. In one case there were two long hairs, each an inch and a half in length, just above the Sternal Angle, pointing upwards towards the neck; in the other case there were three hairs, each an inch long, pointing downwards, and situated just below the Sternal Angle. The only interest in these two cases is the fact that a few stray hairs, separated from one another in position by less than the breadth of a costal cartilage, can maintain their original and divergent directions with such persistence. These two cases correspond exactly with what is found by a simple study of the hair-streams on the pectoral region (see Fig. 22). At the level of the Sternal Angle there occurs a division of the hair-streams, by which one pursues its normal and ancestral course down the sternal groove and over the pectoral muscles, and the other stream divides from it at the level of the Sternal Angle, and passes vertically upwards to the neck in the middle line, and over the clavicles it slopes towards the middle line till it reaches the level of the upper border of the larynx.

These facts are so unlooked for from the point of view of comparative anatomy that an interpretation must be sought, and a few simple anatomical considerations will perhaps make the subject clearer.

The adult human sternum presents almost constantly an angle which may be observed through the soft tissues, unless there be an unusual amount of fat, or the thorax be an ill-developed one, and it is situated at the junction of the manubrium with the body of the sternum. A projection corresponding

to this angle is found along the second costal cartilage and the adjoining portion of the second rib on each side. In a few cases a similar but less pronounced angle is seen at the level of the third costal cartilages. The joint between the manubrium and the body of the sternum* constitutes the true Sternal Angle, and the latter appears to be formed by the deposition of bone on the anterior surface of the joint. The Sternal Angle corresponds to those transverse lines of junction between the segments of the body of the sternum, the first of which forms the occasional second Sternal Angle. It is only in advanced age that complete ankylosis takes place in this joint, and therefore much later in life than the other segments become fused.

The Sternal Angle is sufficiently prominent to have been carefully noted and represented by the sculptors of antiquity, as may be seen in most of the statues in such galleries as those of Rome and Florence, and a very few of these show also the second Sternal Angle, to which reference has been made. A fairly well-defined angle is present in the sterna of the **Gorilla, Chimpanzee,** and **Orang,** and of these genera of APES the **Chimpanzee** shows it in the most marked degree.

Such a break as this in the even contour of the sternum must have some mechanical origin, and it seems most probable that it is connected with the difference shown by the first two ribs on the one hand, and the remaining true ribs on the other, as regards their respective directions of movement in

* "The Varieties of Ankylosis by Bone in Different Parts of the Skeleton." Joseph Griffiths, M.A. (Cantab.) F.R.C.S., M.D. (Edin.). P. 313.

respiration. The nearly transverse position of the two first ribs, and consequently smaller degree of rotation, is compensated for by the raising of the sternum in inspiration, which necessarily affects the movement of these ribs more than the others, and greater freedom of movement is afforded to them by the premesosternal joint. In this view of the Sternal Angle the advantage conferred by the very late ankylosis of this joint is recognised, and it may be looked upon as a critical level in the thorax, marking the spot where the expansion of the chest-wall changes slightly but definitely from one plane to another. This is recognised superficially and roughly by placing the chest-piece of a straight stethoscope on the second costal cartilage while the person examined is breathing deeply, and then on the third cartilage, when the direction taken by the ear-piece is clearly seen to bend upwards in the former case, and either horizontally or downwards in the latter.

The attachments of some of the extrinsic muscles of respiration round and about this Sternal Angle bears out the same view of its production, for, on the one hand, there are the three strong scaleni muscles elevating and fixing the first two ribs, and on the other, the triangular sterni, inserted into the cartilages of the sixth, fifth, fourth, and third ribs, and slightly and variably into those of the second and first ribs, depressing the respective costal cartilages. This arrangement of muscles grouped round the Sternal Angle, pulling very much in opposite directions, provides the anatomical conditions calculated to keep up the movement of the joint

under consideration later than in the rest of the sternum.

These simple anatomical statements have been made because they are necessary to the particular point dealt with here.

An arrangement of hair so peculiar as this at the level of the Sternal Angle (which I may repeat is not shared by any other animal possessing a Sternal Angle) is almost certainly connected with the function of respiration in some way or other. But inasmuch as this hair arrangement is not found in

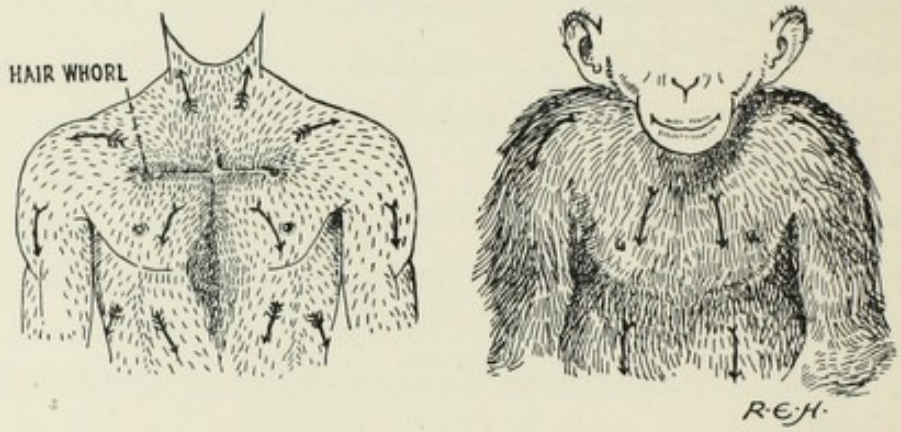


FIG. 22.—COMPARATIVE VIEW OF CHEST OF MAN AND APE.

Man's nearest existing congeners, although they, too, possess a Sternal Angle, some other ætiological factor must be sought for it. I would suggest that the effect of the pressure of clothing on the underlying skin is competent to produce this change in the direction of the hair, and that probably it is the efficient cause. During inspiration in the sitting and standing postures, or in locomotion, the weight and friction of clothing on the upper portion of the chest-wall clearly tends to pull on the ever-growing stream of hair, drawing it over the sternum upwards, and in the subclavicular region upwards and towards

the middle line. In expiration the chest-wall is almost entirely removed from any pressure or friction of clothing, so that any reverse action on the hair-stream, which might be supposed to be exercised by expiration, does not take place. Below the joint which forms the Sternal Angle the changing direction of the ribs during respiration is not calculated in the same degree to draw the stream of hair upwards and contrary to its ancestral trend.*

Dorsal Region.—This is a critical area in connection with two of the habits of Man, those of lying in sleep and of sitting with his back supported against some surface. In all the ANTHROPOIDEA that I have examined, except **Man**, the trend of hair maintains its primitive direction, which accords closely with their habit of so generally assuming the erect position, or one approaching it. But on a hairy human subject, especially one not too old, it is found that the hair slopes in a direction not far removed from a complete reversal of that on the corresponding surface of an APE or MONKEY. The streams of hair which curl round the thorax and lumbar region from the ventral surfaces, to form those of the dorsal region of the trunk, pass at first in a direction at right angles to the median plane, and then, when

* Wiedersheim touches on this subject in his "Structure of Man," translated by H. and M. Bernard (1895), pp. 22, 23, 24, 25. He there refers the whorls found on the pectoral region of man to the supernumerary teats occasionally found above the normal mamma, and quotes two cases from Herr Otto Ammon, one with a single pair and the other two with three pairs of supernumerary teats. The former showed these whorls in the region of the teats above the normal mamma, but Wiedersheim makes the significant admission that those *below* that situation do not form vortices. This is exactly what would be expected, for the arrangement which I have indicated is simply the normal one found in all persons who are sufficiently hairy. It has nothing to do with supernumerary teats.

near the angles of the ribs they begin to assume a direction which it would be impossible to have expected, from analogy in other animals. These streams pass now in a sloping direction towards the neck at an angle of nearly 45° with the vertebral column. This is the direction taken by the dorsal streams, but the lumbar continue nearly at a right angle, without much change. The dorsal streams continue their course towards the upper part of the spine, till they reach the mass of extensor muscles bordering the vertebral furrow, and here make a very sharp curve away from the neck and towards the coccyx, rapidly joining with the central stream which comes from the occipito-cervical region. Also, at the neural border of the axilla, the hair slopes towards the coraco-clavicular joint and spine of the scapula.

This striking change of slope is certainly not inherited from any known member of the Simian family, and is in almost direct opposition to that found in all other MAMMALS. As a matter of fact, it is *in direct opposition* to the slope of the corresponding hair-streams on a **Dog** or a **Horse**.

As to the ætiology of the slope found on the dorsal region, and round the neural border of the axilla, it is not difficult to see a force which acts very consistently for about one-third of man's whole life in a manner calculated to produce it. In sleep, **Man** spends so much more of his time lying on his side, and with his head more or less raised on a pillow, that this attitude may be taken as the predominant one. Little reflection is required to show one that the attitude referred to necessarily tends to produce this slope on account of the tendency of the body to

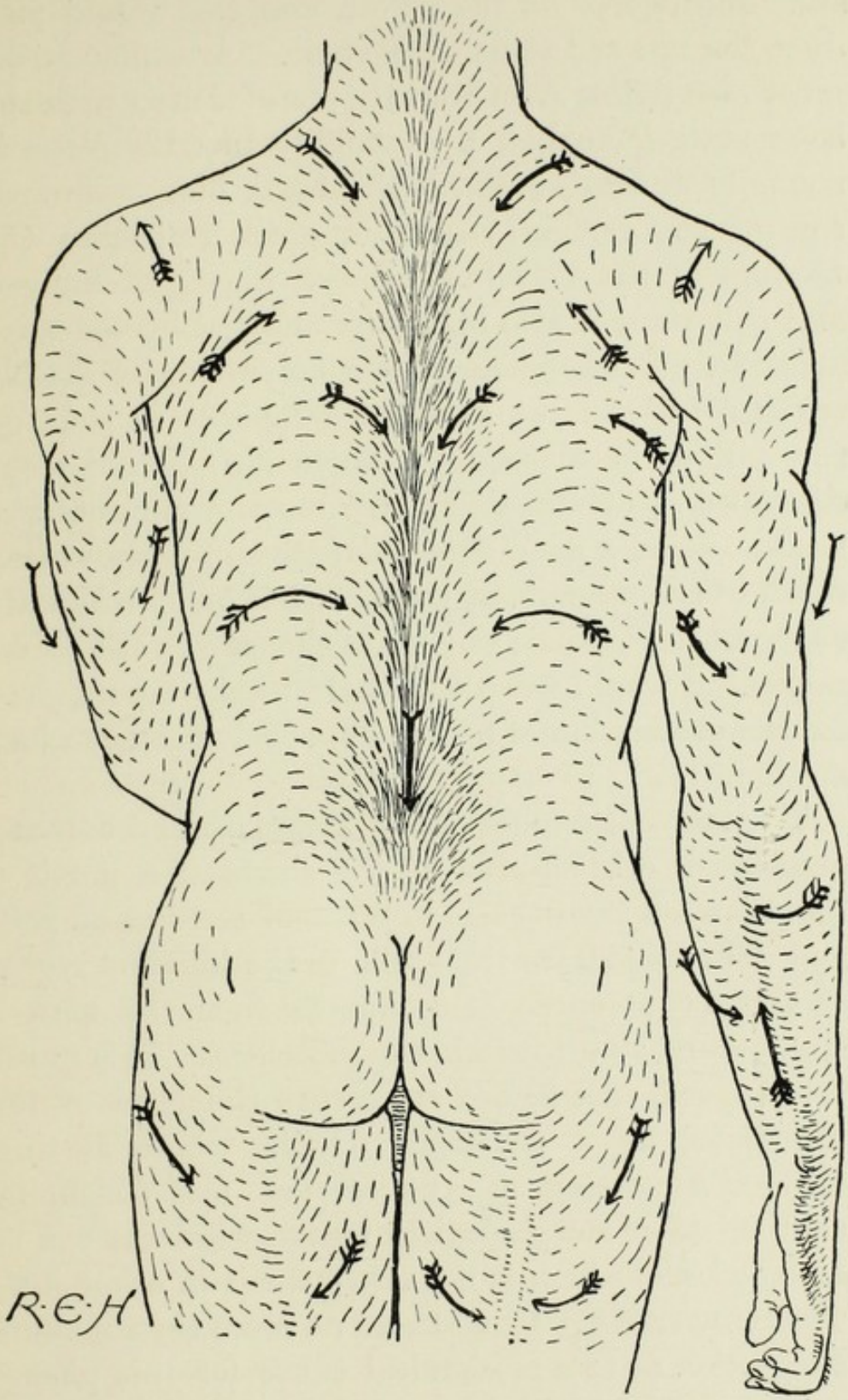


FIG. 23.—BACK VIEW OF TRUNK AND UPPER EXTREMITIES OF MAN.

slide downwards off the pillow, and this would produce the upward slope of the hair. A similar result must also follow from the attitude of sitting with the back resting against a support. But the slope is not only upwards towards the head, but is inwards toward the vertebral column, until it reaches the borders of the vertebral furrow, where it changes, and this slope is also obviously affected by the same attitude. Passing also to the scapular and deltoid regions, one can see how the tendency to slide off the pillow in sleep contributes also to the slope described as existing. In certain hairy subjects who have suffered a good deal from illness, necessitating much of the recumbent position, I have seen greatly exaggerated upward sloping of the hair on the dorsal region. I would submit that the mechanics required for the production of a very unexpected slope of hair are here ready to hand.

The Lateral Aspect of the Thorax and Abdomen presents a critical area in the shape of a parting-line between the dorsal and ventral streams of hair, and it extends from the axilla to the inguinal region at about the centre of Poupart's ligament with a slight convexity towards the umbilicus. This line is interrupted, just before it reaches the level of the umbilicus, by a radiating whorl. There is thus formed a parting of the stream for which no anatomical or morphological reason whatever can be assigned, and which is not represented in other **ANTHROPOIDEA**. One can do no more than make a suggestion as to a mechanical cause for this phenomenon. The attitude in sleep, referred to as the prevailing one, brings with it a position of the arm

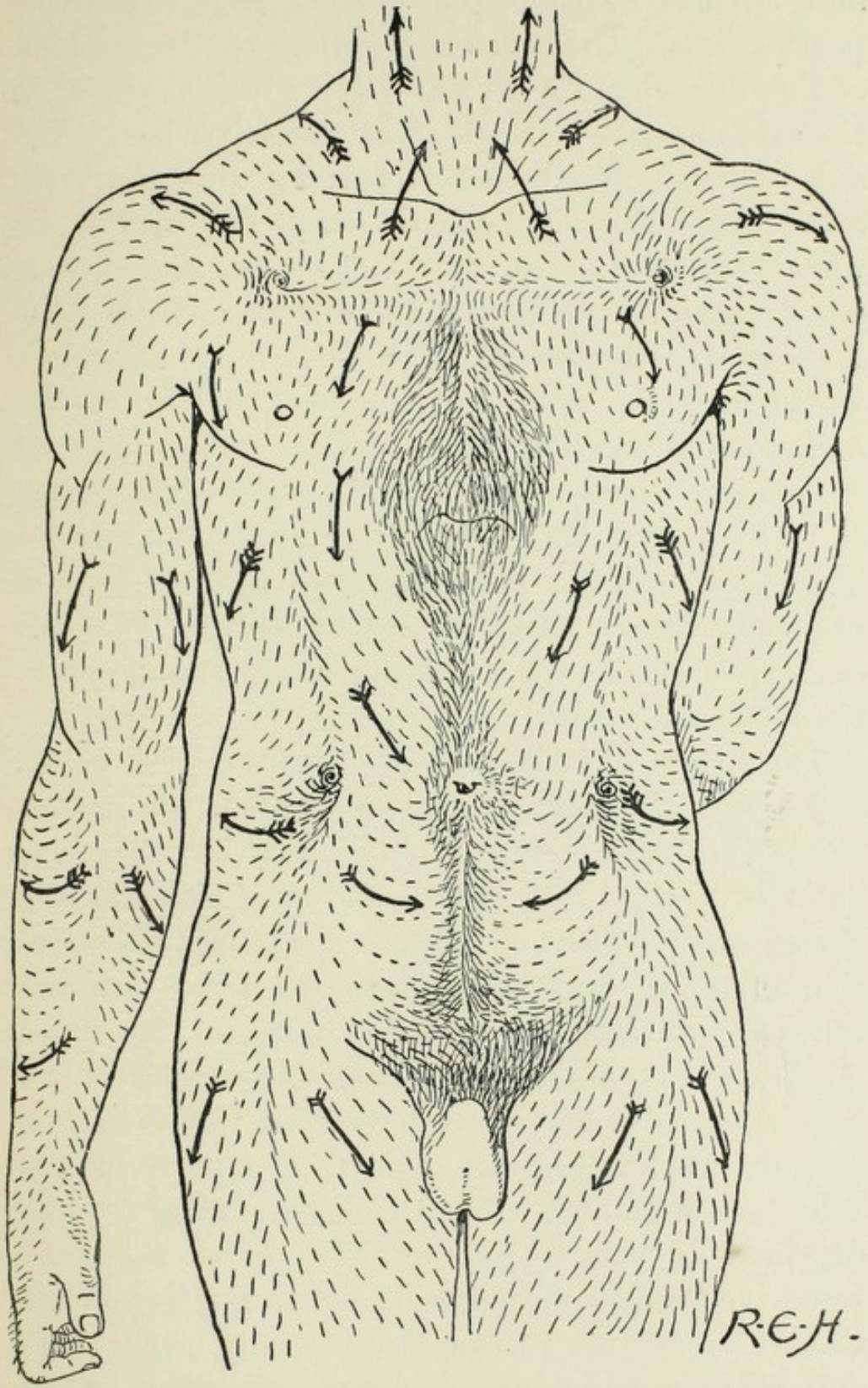


FIG. 24.—FRONT VIEW OF TRUNK AND UPPER EXTREMITIES OF MAN.

and forearm which has a striking relation to this parting-line. The arm rests exactly in the position of this line when the person is lying on his side—*i.e.*, the arm opposite to the side on which he lies. The axis of the limb follows this parting until the radiating whorl, described as existing at the level of the umbilicus, is reached, and this whorl corresponds closely with the position of the elbow-joint when the limb is slightly flexed. The forearm, if extended, would also lie over that further portion of the axillary-inguinal line which reaches to the inguinal region, but would not do so when the limb is flexed. It is suggested that the steady pressure during a large portion of the hours of sleep of the weight of the limb, with necessary frequent shifting forwards or backwards, would have the effect calculated to produce such a parting.

The **Limbs** of **Man** present certain critical areas, and a very slight examination of them brings out one broad fact which is highly significant from our point of view. The deltoid region of the arm and the extensor surface of the forearm present a direction of hair far removed from the primitive one, and of these two the latter is shared more or less by all *Anthropoid Apes* and many lower Monkeys and has been dealt with in detail,* whereas the former is entirely unlike that of any other species of the **ANTHROPOIDEA.** On the lower extremity the direction of hair is somewhat modified from the primitive type by morphological changes, but on the whole of this large surface there is only one limited area where a critical area is found, and this is on the

* *Nature*, vol. lv. pp. 236, 237, 238.

upper third of the extensor surface, and is very much like what exists in many other **ANTHROPOIDEA**. The contrast in the direction of hair in these two limbs of **Man** is striking, and this is still more so when the half of the body below the waist is compared with the upper part of the trunk, neck, head, and upper extremity. Simplicity is the marked characteristic below the waist, complexity elsewhere. This broad fact is not without a special meaning, for in the case of **Man**, nearly all the habits referred to as calculated to produce critical areas in his hair-slope are concentrated on the head, chest, back, and upper extremity, whereas on the lower half of the body none of these is calculated to operate upon the hair except the attitude of sitting, which produces just the one change of direction of hair which would be expected, viz. that referred to at the upper third of the extensor surface of the thigh, a habit and a critical area which are both shared by Man's nearest congeners, the higher *Apes*, and some lower MONKEYS.

Such a contrast as this in the direction of hair in the two divisions of the human body requires, or even demands, an explanation. I submit that the absence of certain of the special habits **Man** of which operate on his hair-slope, and the negative effect of such clothing as **Man** has worn for a large series of generations on the lower part of his body supply the needed explanation of these broad facts concerning his limbs. If the mechanical interpretation of the facts be allowed elsewhere, then the simplicity of type on the lower half ceases to be mysterious, and the complexities found on the upper find adequate support.

The **Deltoid** region, when viewed from the side or back, is shown at once to be related in its direction of hair to the adjoining surfaces of the dorsal region and posterior border of the axilla (Fig. 23). The hairs which pass over the swelling mass of the deltoid muscle are disposed in a line which is first directed upwards towards the outer end of the clavicle and then at right angles to the long axis of

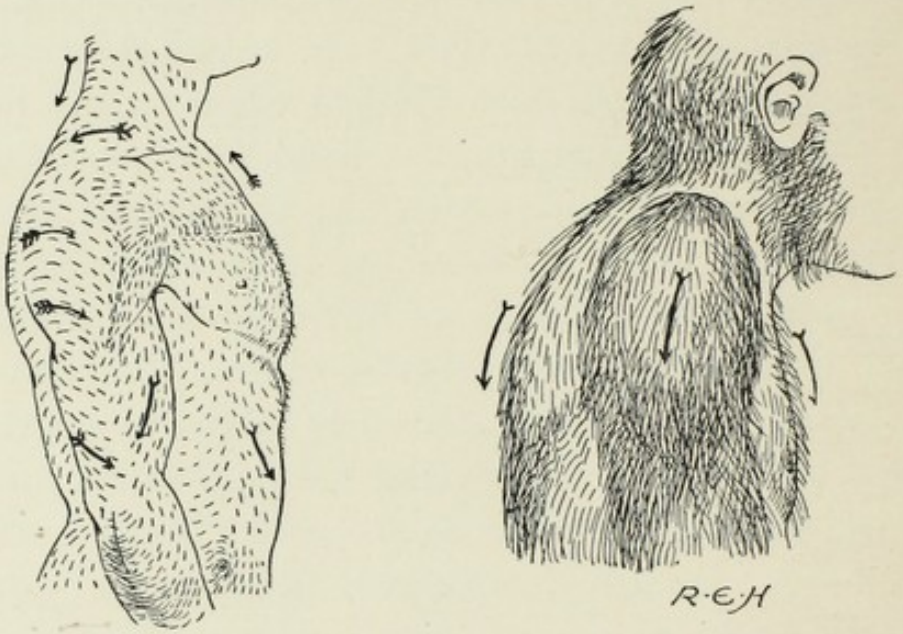


FIG. 25.—COMPARATIVE VIEW OF DELTOID REGION IN MAN AND APE.

Showing change in Man from primitive type.

the humerus. They pass round the outer border and meet those coming from the inner aspect of the limb, and a coalescence of the two streams takes place at about the middle of the flexor surface. Where the deltoid is inserted into the humerus, producing a depression in the contour of the limb, there is a very striking and decided change of the hair-slope, and at this point the hairs commence abruptly to turn downwards and to resume the

normal course along the distal half of the arm. This arrangement of the hair on the arm is quite human, and no other member of the **ANTHROPOIDEA** shows anything approaching it (Fig. 25).

It is eminently a critical area, and when considered in relation to the streams of the dorsal region the explanation of this singular divergence of type in **Man** is at once apparent. It arises evidently from the habit of sleeping on one or other side, so characteristic of **Man**, and the tendency of the hair here, as well as in the dorsal region, is to be drawn more or less upwards. The manner in which this force, operating for about a third of **Man's** lifetime, is calculated to produce the change described will be best gathered by a reference to the figures.

On the **Extensor Surface of the Forearm**, more especially along the line of the posterior border of the ulna, there is a narrow stream of hair formed by a coalescence of the two streams which divide on the flexor surface, pass towards the wrist at first, then curve round the axial and pre-axial borders respectively till they lie at right angles to the long axis of the limb. At a point varying from one to two inches from the distal end of the ulna commences the reversed curl, which results in this narrow stream passing straight towards the olecranon process, and terminating in a converging whorl on the proximal side of that process. This area is one which has been rendered classical by the attention paid to it by Dr. Wallace and the late Professor Romanes. They have claimed it as a vestigial character in **Man**, and it has figured as such in "Darwin and after Darwin." This claim for the

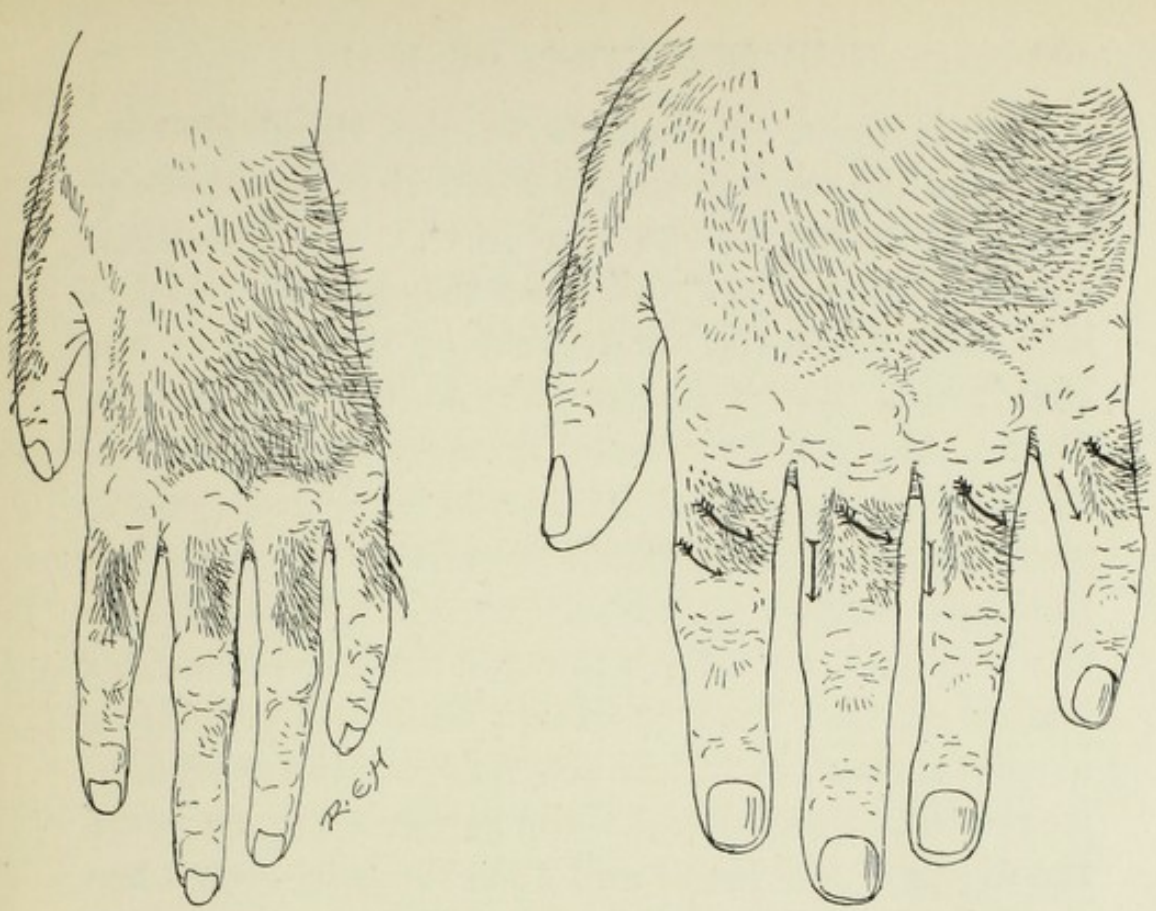
curious arrangement of hair (vol. i. p. 89) on **Man's** forearm was that which led me to commence the systematic investigation of the direction of hair in **Man** and the lower animals. It is impossible to attach much importance to this particular region as showing a vestigial character. If this be allowed here, similar claims must be advanced as to other parts of **Man's** hair-slope, till one is brought face to face with the dilemma that one finds the vestigial theory fitting in with the facts in a few regions only, and that a larger number of changes of type which **Man** has acquired, and in which he altogether differs from other **ANTHROPOIDEA**, will not by any means agree with the theory; and further, that these require the abandonment of the Weismannian position that acquired characters are not inherited.

It is contended that the arrangement of hair on the extensor surface of the forearm is vestigial, and is a relic of the thatch-like disposition of hair which **Man's** ancestors possessed in this limb-segment, and that this arose through natural selection, and was calculated to run off the rain in tropical forests as the animals sat on boughs of trees. It is true that many of the higher *Apes* and MONKEYS do spend a considerable portion of their lifetime seated among the branches of tropical forests in which torrential rain is common, but I submit that it is a case of stretching the selection theory to breaking-point to maintain that the arrangement of hair over the extensor surface of the ulna in **Man's** ancestors was governed by natural selection because of the advantage to them which such a thatch-like tract of hair would confer on them in tropical rain. It leaves out

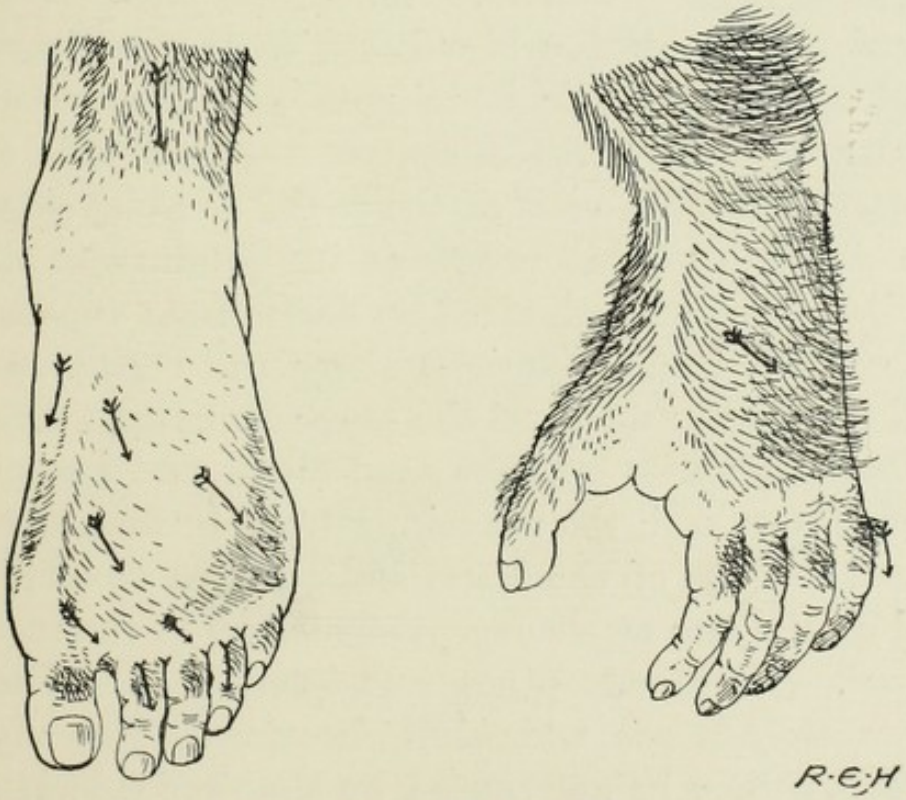
of account the fact that the arrangement of hair on the forearm of two at least of the *Anthropoid Apes* is very similar on the *flexor* surface to that of **Man.** In the **Gorilla** and **Chimpanzee** the hair-streams simply part and pass to their respective borders of the limb, as in the case of **Man.** In the **Orang** the whole forearm is clothed with a remarkable covering of long hair all sloped towards the elbow. Why, it may be asked, should selection provide the running off of rain from the extensor surface so fully in all the four genera and so imperfectly on the flexor surface of two of the genera? It is also a case of seeking an explanation of a transcendental kind when a simple mechanical one is ready to hand. It sins against the 'law of parsimony' in ignoring the ceaseless action of gravity acting on the long heavy hair of these hairy animals, and notably in the case of the **Orang.** A second obvious cause which would contribute to the result on the extensor surface is also ignored. As an *Ape* or MONKEY sits on its haunches one can see how common it is for the extensor surface of the forearm to rest on the animal's own flexor surface of the thigh when it is not grasping the boughs of a tree. The pressure of the forearm against the thigh is exactly calculated to produce the reverse direction of hair, viz. to the elbow, which is found to exist here in all *Anthropoid Apes,* many higher MONKEYS and **Man** himself. This attitude with the supporting surface modified is very common in all these different **ANTHROPOIDEA,** and in **Man** we are familiar with his frequent habit of resting the under surface of his forearm against some object.

Here, then, are two simple and common forces at work, that of gravity and that of pressure against a supporting surface of some kind, which obviously do contribute towards the hair-slope found here. When one has pointed out these two forces, it may be freely admitted that among those **ANTHROPOIDEA** which inhabit moist tropical climates the *effects* of heavy long-continued rain among the branches of trees would confirm or contribute to the same result as the two forces mentioned. This is a very different position from that assumed by the exclusive selectionist, who can see nothing in nature which selection does not govern. The connection of tropical rain with the peculiar thatch-like slope on the extensor surface of the forearm would be that the rain tends to produce the slope, and not that the slope is produced or adapted *for* the purpose of running off the rain.

A comparative study of this area in **Man**, *Anthropoid Apes*, MONKEYS, and the two orders of **CARNIVORES** and **UNGULATES**, shows it to be very markedly a "critical" one. Without entering into the details of the arrangements found in these very different groups of animals, one may say broadly that *a reversed area of hair on the extensor surface of the ulna is only found in those members of these groups which have the habit of resting this surface against some supporting object.* This generalisation is easily shown to hold good, and is a very strong corroborative piece of evidence for the purely mechanical production of the hair-slope in question as distinguished from the selectionist's view of its origin.



Hand of Ape and Man showing the change of slope of hair on the Digits of Man.



Foot of Man and Ape, showing bare area usually found in Man about upper level of ankle-joint

FIG. 26.—FOOT AND HAND OF MAN AND APE.

The direction of the hair on the **Hand of Man** is so similar to that on the **Foot** that one description will suffice for the two parts. On the dorsal surface of the Hand and Foot the general trend of hair is towards the ulnar side in the case of the Hand, and to the fibular side in the case of the Foot. Along the centre of the first metacarpal and of the first metatarsal bones a more or less definite parting of the hair-stream is found, so that at this line the main stream passes almost at right angles to the long axis of the limb towards the ulnar or fibular border of the Foot or Hand, and the remaining narrow stream, in which the hair is always scanty, passes to the radial and tibial borders (Fig. 26.) On the digits of the Hand and Foot the hair, even when scanty, observes a curiously definite course which is worth a little attention. As in the case of the dorsal surface of the Hand and Foot the general tendency of the hair is to pass to the ulnar and fibular borders. But a narrow tract of hair can almost always be seen at the radial or tibial side of the digits, and this preserves its primitive longitudinal direction, inherited no doubt from ancestors whose hair passed straight along the digits, as is still the case in many of the lower MONKEYS. A little straw shows how the wind blows, and I submit that it is so with the prevailing trend of hair on the dorsal surfaces of the Hand and Foot, on the digits, and on the two small exceptions found on the metacarpal, metatarsal bones and phalanges. These arrangements are whimsical, irrational, and mysterious if they be not caused by the preponderating small and constant forces which act in the directions

indicated. A little observation of the parts will show that the primitive streams of hair on the phalanges pass under the cover of those phalanges which lie to the radial and tibial side of the others. To leave this obvious interpretation of the facts and to invoke selection to account for them is to drop the substance and clutch at its shadow.

On the **Thigh** one critical area of importance is found, and here the proximal third of the extensor surface shows two converging streams which coalesce very much, as we found in the case of the corresponding streams of the extensor surface of the forearm. The central tract passes in a proximal direction until it reaches the gluteal fold, and thus the general slope of hair of the part is reversed. Such an arrangement can only be due to that habit which **Man** shares with the *Anthropoid Apes* of sitting and leaning back slightly with the knees more or less raised above the level of the hip-joint. An adequate mechanical explanation of the arrangement of hair is thus furnished. It may be remarked that it is not only the habit but the hair-slope of this part which **Man** shares with numerous other **ANTHROPOIDEA**.

The **Leg** may be said to be devoid of any critical area, and, as a piece of negative evidence for the mechanical theory of the production of hair-direction, this is important. It is important also to observe that just the one limb-segment or area in Man's body which shows nothing peculiar in hair-slope is the one where no constant or even very frequent force is found to act, either that of any passive or active habit or the influence of any clothing.

One remaining fact as to the hair on the body of **Man** is to be noted carefully for what it is worth. If a very hairy subject be examined, the sudden termination of the hair just above the malleoli is very marked. Above this point the hair is thick and close all round the limb, below it, the larger hairs of the same kind are absent from every part of the foot and toes, except the dorsal surface and the phalanges, and here they are very scanty. It is held by some that this is part of the general phenomenon of decay of the ancestral hairy covering of **Man.** But it seems somewhat going out of one's way to demand that this *abrupt* termination of hair should be shown as part of a general phenomenon, when one reflects that this level is exactly that where the shoe of modern **Man** terminates. From this source an adequate force of constant friction and wearing down of the hair is forthcoming, and is provokingly inopportune for those who would interpret this small fact by some vague selectionist method.

The phenomena of hair-direction found on the body of **Man** may be summed up by saying that the variations from a primitive type, and from the corresponding arrangements of the hair of his nearest existing congeners are very numerous and incapable of explanation by any form of selection. **Man** has by some means acquired a very complicated hair-slope, and all the evidence available tends to show that he has acquired them by the action of mechanical forces alone. Of these forces nearly all are open to investigation and are in present operation.

CHAPTER V

DELIMITATION OF HAIR-TRACTS

THE foregoing study of the direction of hair in lower animals and **Man**, has shown that this is neither meaningless, inexplicable, nor unimportant from a scientific point of view. When all the available phenomena of any subject have been observed and described, there still remains for science the final duty of discovering, if it may be, the causes for them. No one will dissent from the remark of Jevons in the conclusion of his "Principles of Science," where he says:* "Now, among the most unquestionable rules of scientific methods is that first law that *whatever phenomenon is, is.* We must ignore no existence whatever; we may variously interpret or explain its meaning and origin, but if a phenomenon does exist it demands some kind of explanation." Professor Ray Lankester also says in "The Advancement of Science," with much more to the same effect:† "That only is entitled to the name of 'Science' which can be described as knowledge of causes, or knowledge of the order of Nature." It is unnecessary to go

* "The Principles of Science," 1900, p. 769.

† "The Advancement of Science," p. 7.

beyond two such statements, from such sources, to show that, until Natural History becomes Natural Science, it has not yet taken its place in the fabric of knowledge.

The present chapter is an attempt to arrange and co-ordinate most of the scattered facts of the case, and will deal with the principles already referred to, which put in their proper place the phenomena observed in individual species and larger groups of animals. The more precise discussion of causes will be left to another chapter.

References have already been made (chap. i.) to the principle of explaining, more or less accurately, all the divisions of the various hair-tracts on the bodies of animals. According to this scheme, the various tracts are divided into two main groups:

I. **Primitive.**

II. **Acquired** (*a*) by morphological change; (*b*) by use or habit.

In the consideration of such a subject we are reminded of the delimitation of the frontiers of newly opened countries, now becoming so important a feature of modern progress, where the Western nations are seeking to enlarge their borders and fulfil their natural tendency to expansion. We hear much of hinterlands in such countries as Africa, but in those parts of the world where modern Man has long established himself the frontier-lines are well known and accurately fixed. In such regions there are no hinterlands. Bearing in mind the analogy of these greater subjects, one obtains a little help in considering the varying territories which are to be placed under I., II. (*a*)

or (*b*) on the very numerous hairy MAMMALS of the world. In this peaceful delimitation of frontiers we may encounter no "frontier incidents" which shall imperil the relations of two great empires, but none the less ought we to pursue, as we may, in our humble way, the topography of the MAMMALIAN hair-tracts.

An illustration of the main division of the hair-streams which are to be studied may be taken from the geological history of parts of the earth's crust. We are told by the geologist that it is the rivers that make the valleys, not the valleys the rivers. This is true of the present configuration of the earth's surface, but it is none the less true that the primary configuration is due to "tectonic" causes, and thus *the general direction of rivers is primarily due to causes of a geological nature; the valleys themselves have been excavated by rivers.*

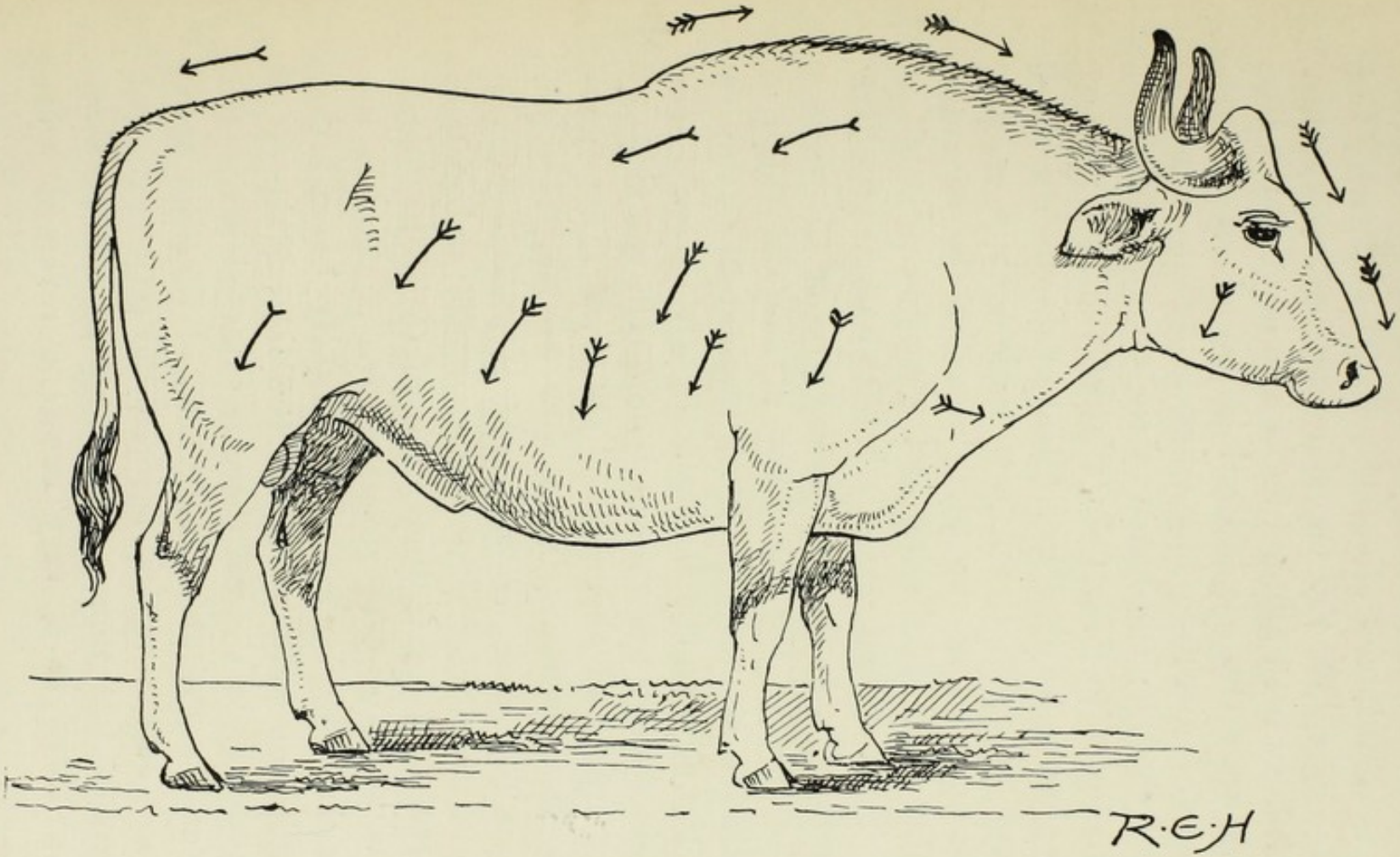
This illustration gives us, then, the results of primitive conditions on the one hand, and of secondary causes on the other. We have thus a parallel with the territories displayed on the animal skin: the primitive hair-tracts, as far as they remain, correspond to the early moulding of the earth's surface; those hair-tracts acquired by morphological changes, use or habit, to the excavation of valleys by rivers.

In such a study as this, which, if complete, would be co-extensive with the immense group of hairy MAMMALS, and even individuals of each species, it will not be profitable to do more than select types of the lower animals, giving more detailed attention to the hair-streams of the human body.

Among those animal forms which exhibit the primitive type alone there are many of the long-bodied, short-legged **CARNIVORES,** many **RODENTS, MARSUPIALS,** MARMOSETS and LEMURS. The features common to these widely divergent groups are a relatively long body and habits of a simple and primitive nature. An **Otter** may again be referred to as a familiar type, and all its hair-tracts may be claimed as primitive and untouched in any important particular, either by morphological change, use or habit.

When a more specialised **CARNIVORE,** such as one of the wild CANIDÆ, or one of the CERVIDÆ or of the BOVIDÆ, such as **Bos Gaurus,** is considered from the topographical point of view, some changes from the primitive type appear, chiefly those due to increased morphological change, with a few unimportant modifications due to use or habit. We tread here on more debatable ground than in the case of the **Otter** and **RODENTS,** for very few animals that present marked variations due to morphological causes do not also show here and there some due to use or habit. By way of illustration a large member of the BOVIDÆ is taken, and from the figure it is easy to see the places where the changes in the direction of hair follow morphological departures from the primitive type. (The hair-tracts which come under (*b*) are ignored for the sake of simplifying this instance.) Fig. 27.

Among the lower animals which present a combination of the **Primitive** and **Acquired** modifications, (*a*) and (*b*), more fully, three familiar forms may be treated—a **Domestic Pig, Ox** and **Horse.**



H

FIG. 27.—THE GAUR (*Bos Gaurus*).

Showing direction of hair on naso-frontal region of head and dorsal and cervical regions of spine. Morphological change on side of trunk.

In these three differing forms the Primitive direction is maintained along the dorsal surface of the neck and spine, the **Ox** showing two exceptions, which have been alluded to.* The head of the **Pig** shows, after the nasal whorl is passed, no common change of direction but what is due to morphological change; the heads of the **Ox** and **Horse**, so far removed in form from that of the **Pig**, present not only the very marked distal or downward slope of hair all over the frontal region, thus exactly reversing that of the **Pig**, but also the constant Frontal whorl, feathering and crest due to habit or use. The external ears of all three remain primitive in their type, as also the greater part of the surface of the limbs. On the limbs of the **Ox** there is practically no variation; on the extensor surface over the ulna of the **Horse** a slightly reversed area of hair due to pressure in lying. On the sides of the thorax and abdomen of all these three types there is definite variation due to morphological change (*a*), and on the ventral surface of the abdomen a similar condition. On the abdomen of the **Horse** there is very little of (*b*) to be found, only a small area of reversed area of hair in the supra-pubic region extending slightly beyond this towards the umbilicus. On the lateral aspect of the abdomen in the **Ox** there is reversed hair. On that of the **Pig** also a very marked reversed area, and also on the ventral surface, and on the ventral surface of the thorax extending to the pectoral region there is a very constant reversed area,

* Chapter III.

obviously related to their habit of resting with their fore-limbs outstretched before them (Fig. 3).

No detailed account is required here of the various reversed areas of hair, whorl featherings and crests, and tufts which are found extensively on the body of the **Ox**, and more so on that of the **Horse**. They have all been treated in earlier parts of this work,* and are indicated in the illustrations.

The net result of a study of the various types of hair-direction from the most primitive to most specialised forms, viz. from the **Otter** to the **Domestic Horse**, is to show that complexity of hair-slope increases *pari passu* with increasing complexity of form and habits of life of the ascending series.

On the body of **Man** the delimitation of the three groups of hair-tracts I., II., (*a*), (*b*), can be worked out more closely than in other animals, even though his vestigial hairy covering is so inconspicuous and mostly unimportant from the physiological point of view.

It is easier to map out the different areas for the reason that the habits, which apply to and effect the changes acquired by use or habit (*b*) are known much more thoroughly than in the cases of most of the lower animals.

It is unnecessary here to go over again in any detail the varied departures from a primitive type and from the type of his existing though distant relatives, the *Anthropoid Apes*. The subject has been considered separately and fully elsewhere.†

* Chapter III.

† A chart of the Human Hair-streams, showing their lineage and history. *Knowledge*, July 1902.

A reference to the illustration shows that Man retains but little of the Primitive Hair-slope.

I. The Primitive areas are, chiefly, the streams covering the occipital region, the central stream passing down the vertebral furrow to the coccyx, the pectoral region below the Sternal Angle, small portions of the flexor and extensor aspect of the upper arm, thigh, and, most notably, the leg. In many of these there is a very slight change from the purely primitive line of hair through morphological change. The hair-streams under group II. (*a*) are about as numerous as I., and are found on such regions as the face, abdomen, parts of the upper extremity, the thigh, except in the upper third of the extensor surface. A certain number of these necessarily merge into II. (*b*), the frontiers between the two being, of course, somewhat vague.

This last group is extensively represented on Man, much more so than on any other hairy MAMMAL, and covers all the Critical Areas described in Chapter IV. They require only to be enumerated here :

Frontal Region.—Edge of scalp. Level of eyebrows.

Occipito-cervical.

Pectoral.

Dorsal.

Lateral Aspect of the Abdomen — (inguino-axillary line).

Limbs.—Deltoid region. Extensor surface of forearm. Extensor surface of upper third of the thigh. Digits.

From the survey of these various hair-tracts of

FIG. 28.—TWO VIEWS (A AND B) OF THE ASSUMED PROTOTYPE OF MAN, SHOWING THE PRIMITIVE DIRECTION OF HAIR. SEVEN VIEWS (C, D, E, F, G, H, I) OF MAN'S BODY.

Copied by permission of the Proprietors of *Knowledge*.

Primitive tracts of hair shown by arrows with single heads; those acquired by morphological changes marked by arrows with two heads; those acquired by use and habit marked by arrows with three heads.

the human body, one is led to conclude that if the descent of Man be what it is claimed to be, he has acquired by some means or other, and transmitted, a very remarkable series of changes both from the primitive and Simian type. The contention maintained throughout this work is that these can only have arisen through habit, use, and the action of environments, and by disuse, and that any reference of them to Selection is estopped. There is no hair-tract on the human body diverging from the ancestral or Simian arrangement which has not an adequate and ascertainable mechanical force to which the facts may be attributed.

CHAPTER VI

ÆTIOLOGY

THE facts of the direction of hair in the lower animals and Man have been treated at sufficient length for the formation of a judgment, on the one hand, of their value as evidence for the mechanical view, and, on the other, of their bearing on the question of the inheritance of acquired characters. These two points must be once more referred to in some detail.

In any line of inquiry into natural processes a guiding principle is of great value even before it takes shape as an accredited scientific hypothesis. This is true of small not less than of the greatest subjects. The principle which Hutton first laid down, and by which Lyell once for all illuminated with the white light of science the history of the earth's crust, viz. that of *explaining changes in the surface of the earth by reference to causes now in action*, may profitably be applied to the humble topography of the hair of animals.

Once such a principle as that of Hutton and Lyell was grasped, the subsequent work of the geologist became natural science in the full sense of the word. From that time its business was to co-ordinate the

vast and varied phenomena of earth-building and earth-moulding, and to assign to each and all of them their places in the Order of Nature. One of the data of scientific thinking, which should even precede any hypothesis in our inquiries, has been well described by Professor Larmor * as "the fundamental postulate of physical science that mechanical phenomena are not parts of a scheme too involved for us to explore, but rather present themselves in definite and consistent correlations, which we are able to disentangle and apprehend with continually increasing precision." This he sums up in the conception, "The Rationality of Natural Processes."

The consideration of the subject is assisted, I think, by viewing the hair of an animal as a stream proceeding from the cephalic to the caudal extremity. This conception is so far familiar and useful that anatomists find it convenient to speak of "hair-streams" for the purpose of conveying clearly the facts of the case. There are several points about the hair of animals with which a stream presents analogies. Though the rate of growth of hair is slow, not more than half an inch to an inch a month, it is constant, and the points of the hairs are always being pushed away from the skin in the lines of growth, which are the lines of least resistance. We have, then, a living tissue, an appreciable rate of growth, lines of growth and marked plasticity of this tissue. On the other hand, a stream may be of all degrees of magnitude, rate of flow, and direction, from a rivulet to a brook, a torrent, a river, a stream

* "Address on Mathematics and Physics." British Association of Science. 1900.

of lava, or a glacier moving in the larger Alps at the rate of a foot a day. When the varied obstacles which may alter the course of a stream are borne in mind, some light is thrown on those mechanical causes which are found to present obstacles to the primitive flow of hair initiated by Natural Selection in the making of the hairy MAMMAL.

To some extent the questions of ætiology have been sketched in earlier chapters, especially in that dealing with the Delimitation of Hair-tracts. Once it is recognised that the variations of hair-slope are neither meaningless phenomena nor variations in the biological sense of the word, theories of their causation are implicit in the facts, and among these theories the choice is very limited. There is one theory which would, if accepted, cover all of our subject-matter to the minutest detail, and that is that the various groups and individual animals were created as we find them. I imagine that at the present time this theory will not find acceptance in scientific circles, but that natural causes must be sought for natural phenomena. If original creation be not allowed as a working hypothesis, its most formidable rival, Natural Selection, must be heard as to its power to produce such phenomena as the direction of hair in animals. We are permitted, then, to ask whether Natural Selection, operating in conjunction with the Struggle for life, Heredity and Variation, is competent to bring about these heterogeneous, numerous, and mostly unimportant changes in an animal's hairy coat. It is freely granted, as shown before, that the primitive arrangement of hair on hair-clad MAMMALS is a product of Natural

Selection, and that the general "set" of an animal's hair from cephalic to caudal extremity is a definite advantage to it either for comfort or survival in the struggle of life. But when this large province has been assigned to Natural Selection, no further light can be thrown on the questions of cause by any form of selection whatever—natural (or personal) selection of Darwin, sexual selection, histonal selection of Roux, or germinal selection of Weismann. It is sufficient to state a very small portion of the facts of the case to show that such phenomena as whorls, featherings and crests, tufts, and most of the areas of reversed hair are outside the province of selection. They are so numerous, varied, intrinsically unimportant and even whimsical, that the simplest study of the facts will show that causes must be sought elsewhere.

The exclusive selectionist undoubtedly has a very strong position. Apart from the acknowledged claims of selection over the great mass of adaptive modifications, he can take very much the line with his leading principle that the earlier advocates of the theory of Immediate Creation could always take. He points to the obvious and large territory over which selection is allowed to preside, and if other and fresh facts are brought forward, difficult to reconcile with any explanation from his point of view, he can ask you with a touch of indignant surprise if you are so intimately acquainted with the lives of wild plants and animals and their needs and environments that you are bold enough to say, "Selection cannot act here or there." He has the assured and commanding tone of his theological-

scientific predecessor, and is here relying largely on what is called the argument from ignorance. He may argue with some weight that among the lower animals we do not know enough of their essential nature, lives, habits and environments to enable us to say with assurance that this is not the case and that is the case in the delicate questions of animal life. And thus inquiry on simple mechanical principles into such a subject as the direction of hair may be officially closed. But I cannot admit, after a considerable investigation into the facts of the direction of hair, that even in the lower animals, apart from the province which has been allowed to Natural Selection, and apart from a probable influence of this factor in the case of those **ANTHROPOIDEA** which inhabit tropical forests and whose hair-slope on the extensor surface of the forearm agrees with the selection theory, that *any* of the changes noted are adaptive modifications. But the matter must be carried farther than this. If an element of uncertainty be claimed by the selectionist as to lower animals, the highest and most complex as to his hair-slope of all the series of animals must be questioned. **Man** has been shown to present so many changes from either the primitive type or from any known or conceivable Simian ancestor, that he furnishes the best of all testing-grounds for theories. He has not yet lost much of the extent of his hairy covering, though its length and thickness are sadly reduced. But it is still sufficient to stamp him with the records of his past and present history, and to portray many of his habits in the simplest of hieroglyphs. It is not less

convenient for such purposes as these than the decaying Coptic language was to Champollion in his study of the Rosetta stone, through which he was to open up the new study of the ancient monuments to other investigators. To those who have followed the description of the Critical Areas in **Man's** hairy covering it is sufficient to be reminded of the two types of occipito-cervical slope, the pectoral region, the dorsal region, to show conclusively that there are tracts of hair which the most pronounced selectionist will frankly acknowledge have nothing to do with selection. Any one of these, indeed, is sufficient to demonstrate this point.

The general principles or laws, then, under which alone theories of the production of our phenomena must be sought, are **Creation, Selection** and **Use or Habit.** The first states the facts without an attempt to explain them. The second attempts to explain them and fails. The third refers all but an inconsiderable remainder to simple intelligible forces in present action.

The theory of **Use or Habit** is equivalent to a mechanical view of the production of hair-direction, and must be resolved into certain component parts and diverse forces. These are **Pressure, Gravity,** and **Underlying Divergent Muscular Traction.**

The force of growth in certain primitive lines laid down long ages back by Natural Selection is not lightly departed from. Endless casual forces are acting on the surface of the animal body throughout its individual life, but these are found to produce no definite or transmissible change. Unless there be

one which predominates over the rest in a large series of individuals they become mutually destructive. The simplest illustration of this is on the head of **Man**, where the very different and inconstant methods of parting the hair found in all ages and nations have not produced the slightest change of the uniform slope of hair over the vault of the skull, established by morphological change. On the other hand, the converse of this is familiarly illustrated in the prevailing trend of trees in a situation where the winds from all quarters are free to blow upon them. Thus in an elevated portion of the western end of the Isle of Wight all the stunted trees show a most marked inclination to the North-East. We require no elaborate induction to demonstrate the fact that the prevailing winds are from the South-West. We do not argue that no winds from the North-West, the North and East and the South-East blow in that region, but by the simplest possible inference understand that such winds as are not from the South-West are overbalanced in their action on the slope of the trees by the predominating wind. If you should lose your way in a fog in such a region and knew the facts as to the inclination of the trees, you would have a tolerable substitute for a compass. Again, if you should know the character of those rows of plane-trees which border so many of the roads in the Pyrenees, you need have no doubt as to the South quarter of the compass after a glance at the bark of the stems, where patches are stripped off more markedly in all of them on the South side of the trunk. But you do not here either assume

that the sun does not reach the eastern, western, or northern surfaces of the trunks.

The forces of **Pressure, Gravity,** and **Divergent Muscular Traction** have been abundantly illustrated in previous chapters, and the present purpose will be best served by a short reference to each, with more or less striking instances.

Pressure.—In considering the action of pressure upon such a tissue as the hair of animals, it is legitimate to include with it such others as friction, *e.g.*, in cleaning of fur, contact with grass and undergrowth in woods, dripping of rain on an animal's coat and friction of parts of harness on horses, though all these are of less importance and frequency of application than simple pressure against an opposing surface. The instance chosen for illustration is the singular slope of hair on the fore-limb of the **Great Ant-eater** (*Myrmecophaga Jubata*), seen when the animal is standing. Superficially, this direction of hair seems abnormal and curious. The long hair, it would seem, ought to follow the action of gravity, but I venture to say that if we did not know how this sluggish creature spent a large proportion of its life, we could read it from the record of its hair-slope on its fore-limbs. This nocturnal animal is known to spend the day in sleep in a lair among long grass in the forests of Tropical America, and it lies curled round on its side with the legs folded together * in just such an attitude as is calculated to press the long, thick hair of the fore-limbs into a direction which forms almost a right angle with the limb. We do not infer from this singular fact

* "Royal Natural History." Lyddekker. Vol. iii. p. 212.

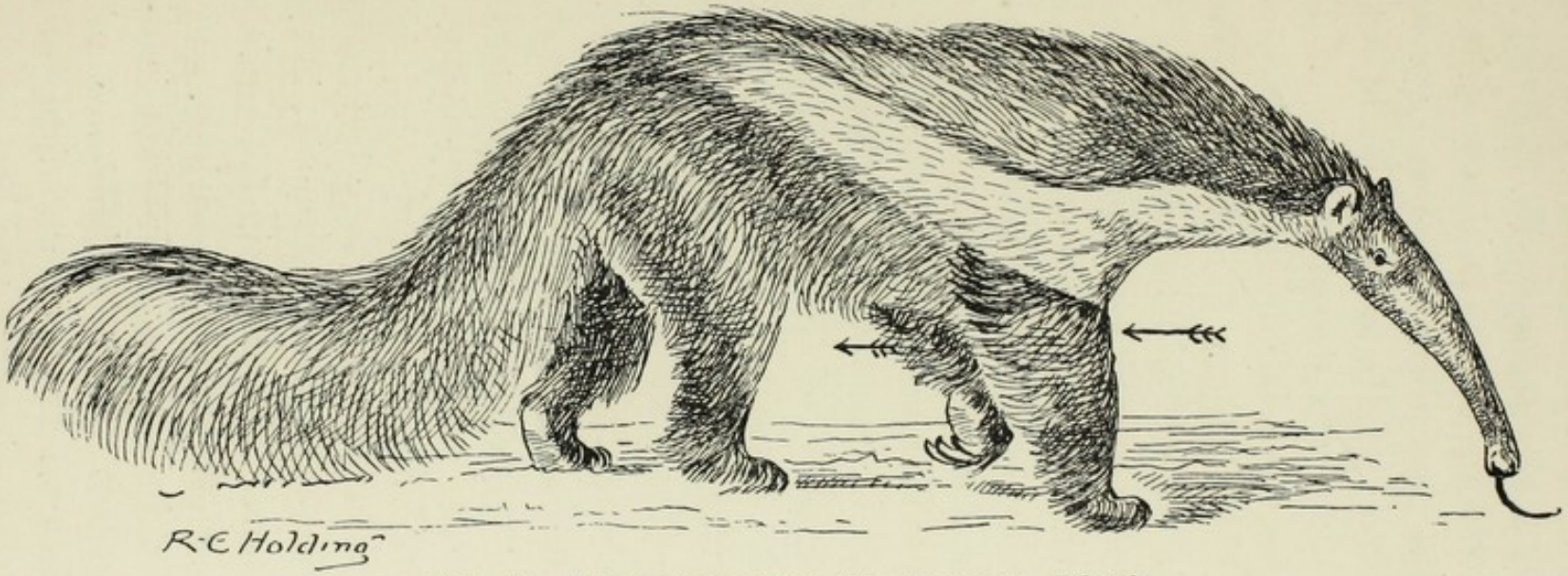


FIG. 29.—GREAT ANT-EATER (*Myrmecophaga Jubata*).

Showing abnormal direction of hair on fore-limbs.

anything more than it indicates. The animal walks and trots and works generally for its living, but it is impossible to doubt, on the evidence of its hair-slope alone, that its prevailing habit is that of rest, as described. Incidentally one may point out how the theory of Wallace and Romanes as to rain-tracks in the hair of the forearms of MONKEYS, which has been applied by others to other regions, wholly breaks down in this instance. Such creatures are not less exposed to torrential rain than other denizens of the tropical forests, and yet here is a region where the hair-slope ought on that theory to be very different from what it is, if Natural Selection and adaptive modifications are to be invoked! An equally simple example of the effect of pressure is that of a member of the SUIDÆ given before, p. 15, Fig. 3, where the primitive slope of hair prevails over the greater part of the animal's body and is reversed only where the flexor surface of the fore-limbs rests against the pectoral region, and the hind-limbs against the ventral surface of the abdomen. Here, again, the prevailing attitude of these rest-loving animals is graphically depicted in their scanty hair.

Gravity.—Three instances may be briefly referred to in illustration of the action of gravity in influencing the slope of hair. The **Orang** is distinguished above all its congeners for its very long hair, and over the greater part of its body the direction is only what one might expect from the influence of Natural Selection. But on the arm and forearm the long reddish hair slopes towards and beyond the point of the elbow, where it shows longer hair in this part

than any other *Anthropoid Ape*. This would seem to be an opportunity for the selectionist to claim an instance of adaptation to needs and to consider this arrangement as a thatch for running off the rain. It is impossible to prove that this has no bearing on the matter, but it is a further sin against the "law of parsimony" to stake all on this view, and to ignore the obvious alternative that the very frequent draining of rain along this surface, admitted to take place, is calculated to *produce* in its measure this arrangement. The selectionist would say it is produced *for* the rain to flow over easily. I would suggest that it is produced *by* the rain flowing over it. But still more simply may one attribute the singular slope of hair to the action of gravity influencing the prevailing direction of this exceedingly long hair. This is in accord with the fact that the proximal slope of hair in the **Orang** is more marked all over the forearm than is the case in any other *Anthropoid Ape*, though no evidence is forthcoming that this genus more than any other has the prevailing habit of resting on the boughs of trees with its hands grasping other boughs.

The **Chacma Baboon** exhibits an arrangement of hair on the gluteal region and outer surface of the thigh which is very striking when the animal is seen standing on its four legs. The hairs here point in a line nearly parallel with the long axis of the trunk, and indicate very clearly the prevailing habit of the animal, which we know to be that of sitting on its haunches. One has only to examine the general "set" of the hair of this **Baboon** when sitting and when standing to see at once that the

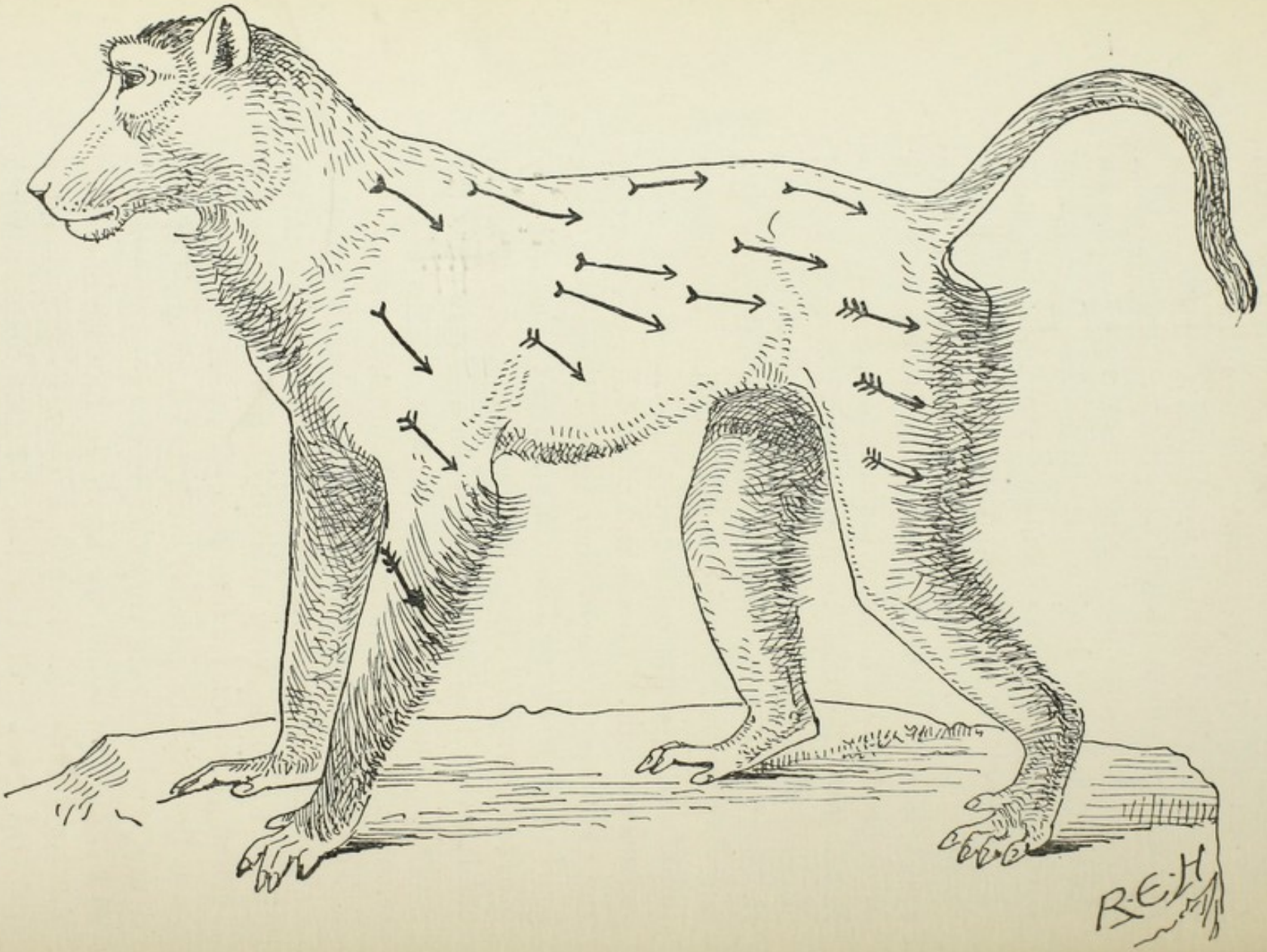


FIG. 30.—CHACMA BABOON (*Cynocephalus porcarius*).

Showing streams of hair on fore-limbs and femoral region of hind-limbs altered by action of gravity.

former is its habitual or normal attitude. The long thick hair undoubtedly takes the direction described from the effects of gravity and perhaps the dripping of rain, and it is impossible in this instance to

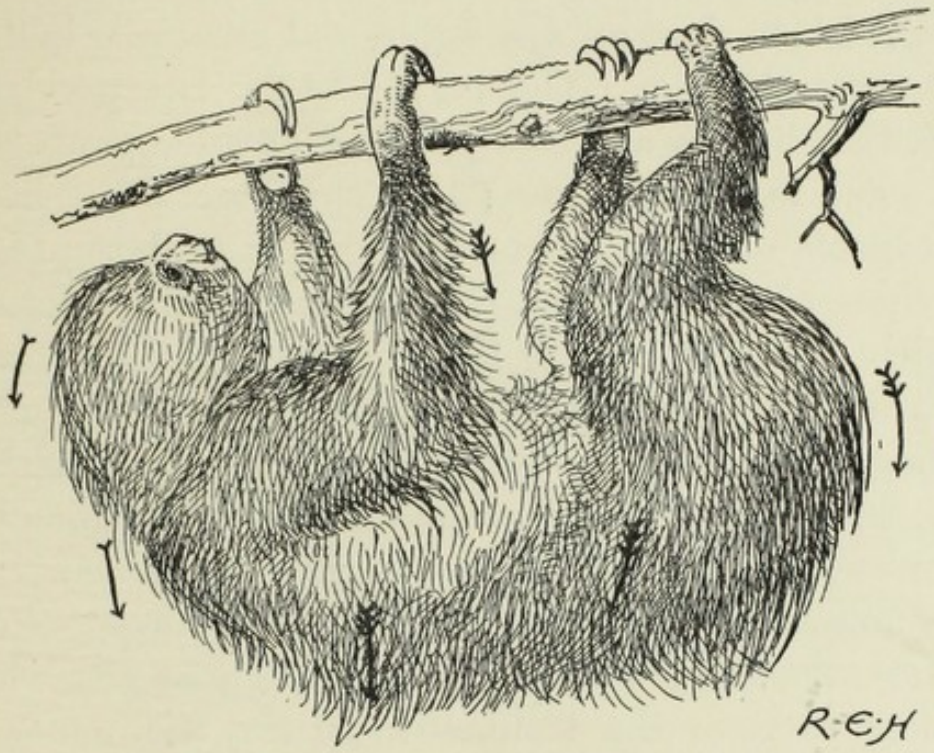


FIG. 31.—TWO-TOED SLOTH (*Cholopus didactylus*).

Showing action of gravity upon hair-streams.

invoke the providing and presiding influence of selection.

Still more strikingly is the effect of gravity shown in the arrangement of the hair in the **Two-toed Sloth** (*Bradypus didactylus*). This arboreal denizen of the darkest tropical forests of South America bears the ineffaceable marks of its sluggish habits on its hairy coat. It is about the only animal that spends the greater portion of its existence upside down, suspended from the boughs of trees, only at night-time descending to the ground to wander

slowly in search of food. It is unnecessary to do more than refer to the figure of this animal to understand the remarkable instance of the action of gravity upon its long and abundant hair.

Divergent Muscular Traction has been fully treated in various animal forms, and especially in the **Domestic Horse.** The materials for the problem are, that hair is a tissue growing at an appreciable rate and in definite lines; that the direction of hair is capable of modification during life; that the seat of these effects is over a triangular area, the sides of which are represented by very frequently acting and divergent groups of muscles; that the phenomena claimed to be due to this force, viz. whorls, featherings and crests, are in direct ratio both as to number, constancy and size to the muscularity of the animal presenting them. These are matters of observation, and capable of verification by any who choose to take the trouble to study the matter. The mechanics of the problem involved are necessarily somewhat obscure, because we are dealing with the delicate matter of animal dynamics, and with several different but related regions of the body. But it is impossible to survey at all fully the animals which exhibit whorls, featherings and crests, and to analyse the facts of their superficial anatomy, without acknowledging that the connection between them, and divergent muscular traction in muscles underlying them, is intimate and essential.

The method of inductive inquiry must be followed here, as elsewhere in science, if any validity is to be claimed for the chief position maintained. This is, broadly, the production, by mechanical forces alone,

of the large group of hereditary phenomena of hair-direction other than those allotted to natural selection. In other words, whorls, featherings and crests, reversed areas of hair and tufts, are produced by mechanical causes alone.

Hitherto the stages of Preliminary Observation, Hypothesis and Deduction have been followed sufficiently for the purpose in hand. But the concluding stage of any such inquiry, that of Verification, is required. From the nature of the case it is impossible to handle and vary these phenomena by exact experiment. The length of time needed for their production precludes this. We are compelled to rely upon such *undesigned experiments* as Nature has carried out for us during a long series of generations of animals, and such as **Man** has unconsciously performed upon the lower animals and himself.

At the present time **Man** is unconsciously carrying out a series of experiments on the lower animals which are continuous with others that have been in progress from immemorial times. He has obtained control over that useful **UNGULATE** stock, which he has moulded into the varieties of the **Domestic Horse,** and has so employed for his own purposes of draught this locomotive animal as to have left indelible marks on its hairy coat in the shape of whorls, featherings and crests.

These have been shown to be so closely related to the degree and character of the **Horse's** locomotive life as to be fitly called "pedometers." From a stock which exhibited in primeval times no whorls, featherings or crests, except that universal Frontal whorl, he has cultivated a species on which unmistakable

registers of the ancestral habits are stamped with these plastic stamps. Though no geological record nor historical document can ever be called upon to prove this statement, it is a perfectly legitimate inference from the facts of the case and the universal teachings of comparative anatomy. **Man** has, then, unconsciously exercised his domesticating power for purposes whose definiteness has been growing with his developing mental power, till in the case of the **Horse**, as with other species, the unconscious selecting power has become conscious. So much has this been the case that, among the domesticated animals developed thus out of wild stocks, the large industry of breeding has grown up and flourished. In the great majority of species, varieties, and their various specific characters, selection has ruled with increasing purposefulness. There is no question as to how the fleetness of one **Horse**, the strength of another, the qualities of the wool of the **Sheep**, the qualities of the milk of one breed of **Oxen**, of the flesh of another, and the draught-power of a third, or how the different physical and mental qualities of the numerous breeds of **Domestic Dogs** have been produced. These have been cases of long-drawn experimentation as to the power of selection when guided by intelligence, and all contribute their tale of bricks to the building of the Darwinian edifice.

But the value of the evidence for the selectionist case thus adduced is in direct ratio to that of another branch of evidence which these extensive experiments have produced. These have been by-products of a rough nature but undeniable value, from the

theoretical point of view, which have come out of this manipulation of the wild stock. They are the whorls, featherings and crests so often referred to and most fully developed in the **Domestic Horse.** Thus, while Man has been slowly and laboriously contributing one line of evidence to Darwinism, he has all unconsciously carried out experiments which establish conclusively the operation of Lamarckian factors in animal development, and the occurrence of instances sufficient to show that inheritance of acquired characters can and does occur. This conclusion does not suit the rigid system of the Neo-Darwinian, but it suits the evidence of a large series of phenomena as no other can do.

It may be worth noting here two instances in which the Inguinal whorl, feathering and crest is affected by interbreeding of species. The **Ass** normally shows none, but the **Mule** exhibits the normal equine type in the Inguinal region, reduced to half the size of that of the **Horse,** or somewhat less. Thus the product of the **Horse** and **Ass** furnishes this specific equine character, modified, as would be expected, from the union of an animal possessing the full degree of this character and another destitute of it. The fact does not bear directly on the question of Use-inheritance, but is interesting more particularly as showing that the Inguinal whorl, feathering and crest is a dominant specific character.

A similar single instance has been seen recently at the Zoological Society's Gardens, London, in the case of a hybrid brought from South Africa. This was a cross between a **Zebra** and a pony and showed

the Inguinal whorl, as in the case of the **Mule**, of just half the size of that in the **Horse**.

In addition to the changes produced in the hairy coat of the **Horse** by oft-repeated special muscular action, there have been other interferences with the direction of its hair from the pressure and friction of harness of various kinds used by **Man**. These have been referred to previously and shown to differ in their action on the hair-slope from those more vital forces connected with the passive and active habits of animals. Of all the complicated portions of **Horse's** harness there is only one which shows fairly often any result in changing the direction of hair. This is the kicking-strap, which passes across the great extensor muscles of the hind leg, and it does in a small percentage of **Horses** produce a tuft of hair exactly where it rubs against the rounded surface of this part. The three parts of the harness, reins, traces, and kicking-strap, are more free than others to move with every step of the **Horse**, and it has been pointed out these movements occur at the rate of about six thousand an hour in trotting and about four thousand an hour in walking. The reins and traces are not less free to move than the kicking-strap, but in their friction against the coat they do not nearly so closely oppose the direction of hair-slope, and lie almost parallel to the hair on the neck and flank respectively, whereas the kicking-strap at every step is jerked upwards *against* the stream of hair. It is hardly possible to doubt that this much-repeated reversed friction against the "set" of the hair is the cause of the curious tuft found in this exact spot. Nothing like it is found on all the rest

of the body except the corresponding tuft on the flank, which has been shown to be due to muscular action and "jolt." What the pressure of harness has not done, and what it has done in a large series of generations, is equally significant from the present point of view.

Man has performed certain undesigned experiments on his own body, which bear upon the question of the direction of hair.

It has been shown how on the occipito-cervical region there are two types of slope. In one, which is termed Normal, as being ancestral and Simian, the hair slopes gently away from the middle line; and in the other, termed Abnormal, it slopes to the middle line more or less sharply. The view maintained here and elsewhere is that these two types represent, on the one hand, the effects of dressing the hair, which consists in tying up the hair in some form of knot and drawing thus the two lateral streams together; and on the other hand, the result of the simple dressing of the hair which consists in brushing or combing it downwards and not tying it up at all. It may again be stated that out of a very large series of Europeans examined these two types are found in a nearly equal ratio, and this has been held to correspond with the fact that the general rule in the two sexes is that women dress their hair in this region by drawing it together and thus tending to produce the Abnormal, whereas men leave it more to nature, combing and brushing it downward and so encouraging the Normal type. These habits have prevailed so extensively for many generations of men in various countries, and operate for nearly the whole

life of each individual man or woman, that some effects on the plastic growth of hair might have been reasonably looked for, and if it were to be found at all it would be such as it is found to be. I would further point out in this connection that there is no other type of slope represented here beyond those cases where the Normal and Abnormal are somewhat mixed, and this negative fact is important from the present point of view, for no other than these two influences referred to can be found operating here.

Man has also left on the frontal border of his scalp, as on the occipito-cervical region, marks of his habits of dressing the hair in different ways. Illustrations have been given of the different positions and methods of arrangement of the partings on the edge of the scalp found in infants, and three main arrangements have been shown to prevail over all the others, viz. the right lateral, left lateral, and central, and of these the left lateral to be much the more frequent. This fact agrees with the observation that the large majority of men part their hair on the left side, the figures being: 13 right lateral, 9 central, 78 left lateral, in 100 cases.

In the case of women, the position chosen is too variable to allow of any statistics. This instance again gives a preponderating force, viz. the parting in the left lateral position, which has left an hereditary effect on infants and young children.

Clothing has also been adopted by **Man** for an unknown number of generations in most countries of the world, and this fact has constituted one of the undesigned experiments of **Man**. It has shown the

effect of constant friction of movable and more or less rough substance against the hairy covering, which was becoming reduced in length and thickness when the experiment was being initiated. Over the greater part of the surface the friction of clothing does not tend to interfere with the primitive slope of hair on **Man's** body. But at the upper portion of it, up to where in general the dress of all nations terminates, viz. the middle of the neck, the clothing comes into relation with one of the Critical Areas referred to in Chapter IV. It has been pointed out how on the pectoral region of **Man** and the front of the neck up to the level of the larynx, where the dress terminates, the mechanical effects of clothing would be to produce a reversed area of hair. At the level of the Sternal Angle the upper part of the thorax heaves upwards in respiration at the same moment as the part below is expanding slightly downwards. This has been lately demonstrated by Dr. Keith in a simple experiment. Thus some idea of the importance of the sterno-manubrial joint or Sternal Angle in man is obtained. If man wore no clothing his hair would, as in all other **ANTHROPOIDEA**, retain its normal primitive slope on the front of the neck and chest. The introduction of clothing at this very critical spot has served the purpose of an undesigned experiment and produced this remarkable and even unique reversed area of hair. The view of its causation put forward has been and will be challenged for direct proof, and investigation has been made for me into the question as to whether in uncivilised races of men who have never clothed their bodies in this

part with any form of clothing this same curious upward stream of hair is found. Hitherto the results have been mostly negative, for many of the races of men who have not worn clothing, such as the Baganda, have short curly hair, and this type of hair does not produce definite lines of growth, as in Europeans. Dr. Howard Cook, who has carefully examined a large number of these natives of Uganda, has found that, though the bulk of them showed no disposition to any fixed type, a certain proportion presented a remarkable difference from the others. They showed a slope of the hairs from the level of the manubrium *upwards and to the right*, while below this level the hair retained its primitive and downward arrangement. This fact he attributes to the wearing of a garment called the "Suka," which they wear knotted over the right shoulder, the arms being free. If this interesting observation be further sustained, it will be a valuable *experimentum crucis* in connection with the effect of clothing on the hair.

The only remaining point connected with the influence of Man's clothing on his hair is that one previously considered as to the remarkable cessation of hair just above the ankle, where the shoes terminate. This is in accordance with the theory supported here as to the effect of mechanical forces on the hair, and as to the occurrence of use-inheritance, which, in this case, would be called more correctly *disuse*, and mutilation by friction.

It may not be out of place to notice two more instances in which Man has made undesigned experiments on a domestic animal and on himself.

The reason for alluding to these two instances is that they show what mechanical forces have *not* done; the conditions, we may presume, not being suitable for the production of modifications.

In the case of **Domestic Horses**, it has been the custom to groom their manes from the near side, so that in about 95 per cent. of **Horses** in this country the mane falls on the off side. Thus a group of 1634 **Horses** in London showed only 70 in which the mane fell on the near side. This would seem to furnish a case in which the mechanical force of growing the mane always in one direction and of gravity acting upon the long hair would produce a tendency for the hair to fall to the off side in young **Horses.** After much inquiry from breeders and others possessing large knowledge of **Horses**, I find that in the young there is no tendency for the mane to fall more to one side than the other, and that the hair of the mane is scattered along both sides of the neck.

The second instance is one in which Man has performed an unconscious experiment upon his own hair without result. Among Mohammedans, since about the tenth century, there have been two sects opposed strongly to one another in many ways, but in one particular way which seems very trivial. These are the Shiahs, found mostly in Persia, and the Sunnis, and among both there prevails the ritual custom of "wuzu," or washing before prayer five times a day. The difference that divides the Shiahs from the Sunnis in this matter is that one sect washes the forearms in one direction and the other in the reverse direction, the details of which

need not be here described. In many cases, however, the washing is only performed once a day, the number of washings depending much on the religious strictness of the individuals. Now, this instance of a definite reverse friction of the hairy skin in a certain direction every day of the lifetime of a **Man**, from about the age of eighteen upwards, might have been expected to produce some modification in the hair-slope of the offspring. But, as far as inquiries in India, Kashmir and Persia have gone, no difference in the two sects is to be found in this respect.

Here, again, one may suppose that the interference is too transient in its action to produce any fixed effects.

In an inquiry of this kind it is much to be desired that exact experiments could be carried out for the purpose of more fully meeting the requirements of an induction; but, for various reasons which have been given, no such experiments with individual animals or men are possible in the lifetime of one person. It is evident that very frequent repetition of the forces and stimuli involved in a large series of generations is required for the production of these, and, perhaps, of any modifications of the animal body. But in such a matter the weight and extent of evidence has to be considered, and the absence of any ascertained contrary evidence. When we know that the process of proof upon which the theory of gravitation, the nebular theory, and the theory of evolution are sustained is not a perfect one, and never can be perfect, but an induction ever increasing in validity, and that these great theories

have no more than a very high degree of probability to support them, we recognise that any other small theory such as we are considering cannot be expected to vindicate itself to the uttermost. It deals with a variable and uncertain factor, the animal organism; it includes a vast number of individuals and groups of animals; and, *ex hypothesi*, a great stretch of time. But the problems press for investigation. They are not meaningless and so obscure as to baffle inquiry, but so suggestive and related to the lives of men and a great group of MAMMALS as to command attention and to promise solution. A well-established induction should include in its verification the results of prediction; and, in the light of this principle that the active locomotive habits of an animal are depicted on its hair in the form of whorls, featherings and crests, there are several instances in which prediction as to the habits of species and individuals of species may be supplied by the examination of the hairy covering alone, and apart from direct knowledge of their lives. In some measure, also, this is true in other species as to their passive habits of sitting and lying.

Thus, in the case of the **Domestic Horse**, if one were to examine the skin alone, at the Critical Areas here considered, *e.g.*, Inguinal, Axillary, and Pectoral regions, one could pronounce correctly as to the muscularity of the individual **Horse** as distinguished from its mere size and fatness. Before Przewalsky's **Horses** were known to Science, it might have been calculated that, being wild animals, they would show poorly-developed Inguinal and

Pectoral whorls, as is found to be the case on examination. The rare **Bongo** from West Africa, a

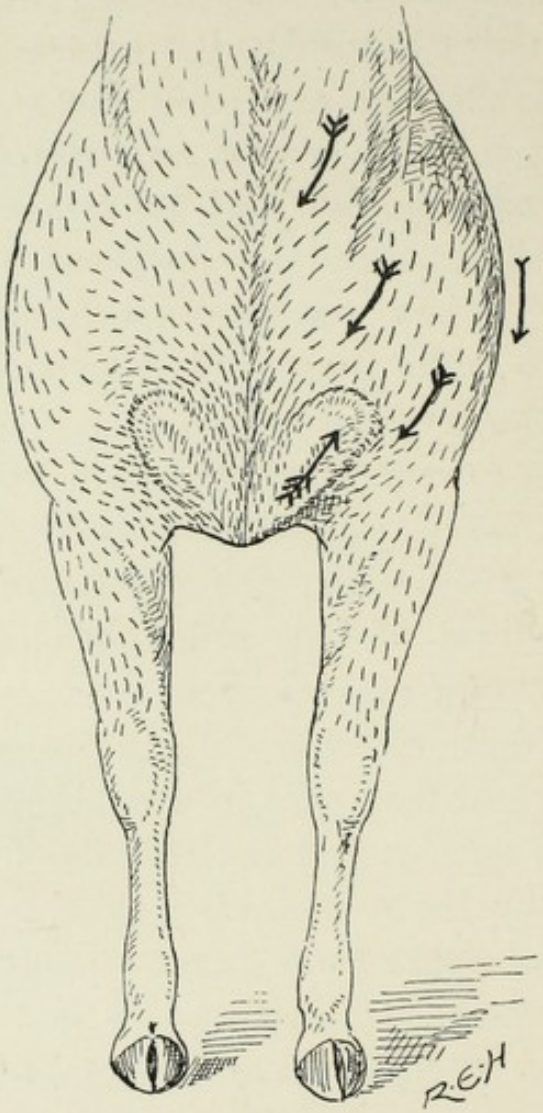


FIG. 32.—CHEST OF BONGO (*Tragelaphus eurycerus*).

Showing pectoral whorl, feathering and crest fully as much developed as that of the Domestic Horse.

large ANTELOPE, well developed in its chest and fore-limbs, has a most marked Pectoral whorl, feathering and crest nearly equal to that of a Horse, and though little is known of its habits, it is safe to calculate beforehand that its locomotive habits are very active. Two of the three varieties of Asiatic

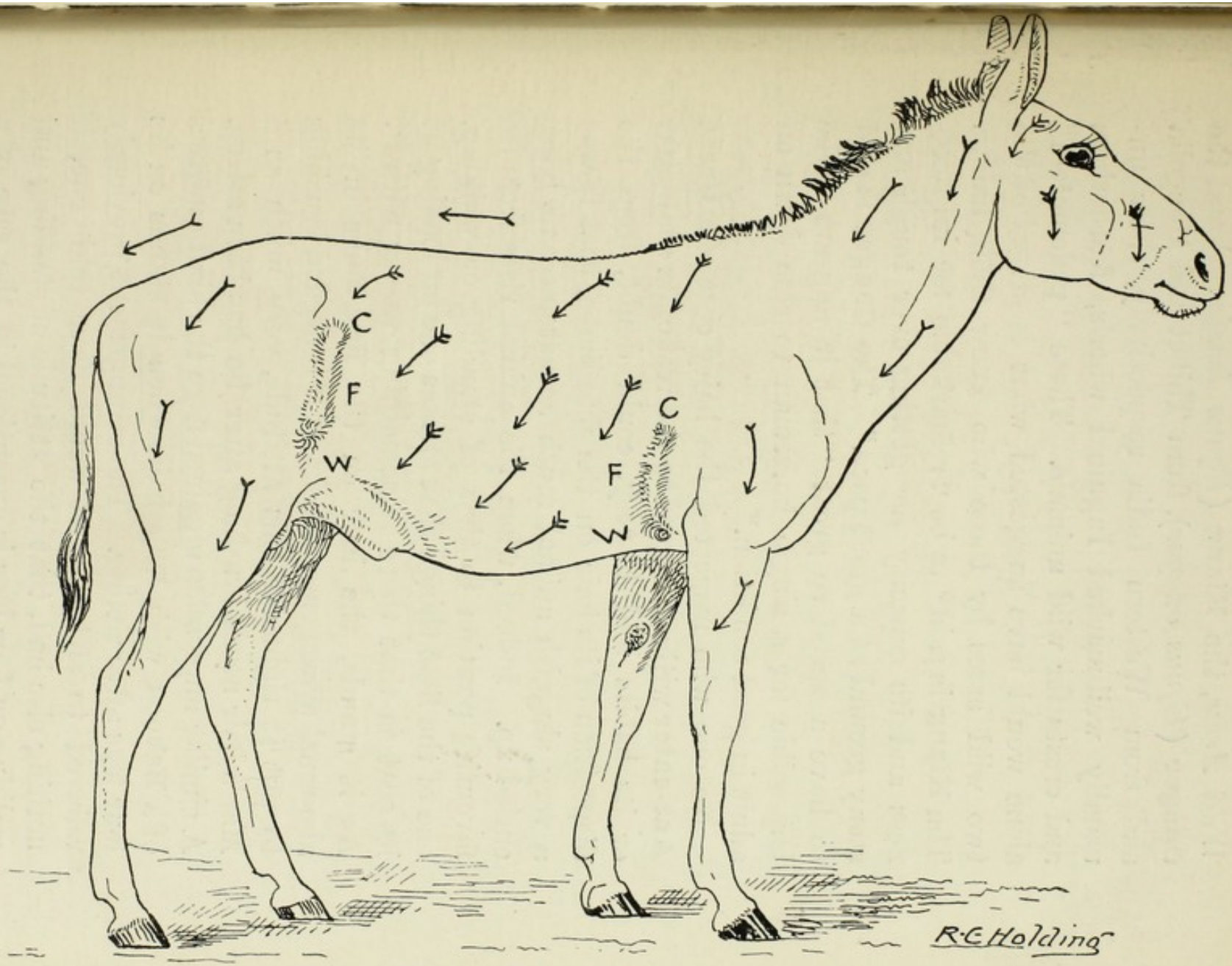


FIG. 33.—KIANG. THIBETAN WILD ASS (*Equus hemionus*).

Showing morphological change on direction of side of head and flank, and Inguinal and Axillary whorl, feathering and crest, W, F, C.

Wild Asses, the **Kiang** (*Equus hemionus*) and the **Onager** (*Equus onager*), from Thibet and Mongolia and from Western India respectively, show unusually well-marked Inguinal whorls, featherings and crests for wild animals. These "pedometers" alone would have suggested what is stated of the two wild asses by those who know their habits. The **Kiang** is said* to be "remarkable for its fleetness and its capacity for getting over rough and stony ground at a great pace." The **Onager** is said to have a speed so great "that it appears to be impossible for a single horseman to ride down an adult in good condition."

No one who inspected the hairy coat of a **Great Ant-eater** without regard to the rest of its character, or its habits and history, could doubt, from the disposition of its hair on the fore-limbs, that it was a very sluggish animal much accustomed to lying curled up. Indeed, when the animal rises from its favourite position to that of standing or walking, one of the first things that strikes one on looking at its coat is that there is something wrong with it. As it stands, the hair on the fore-limbs in its abnormal arrangement looks as if it needed brushing to put it right for this attitude, very much as a Man's hair needs brushing after he has been asleep. A similar impression is gained from the hind-quarters of a **Baboon** with long hair, when it stands on its four legs after sitting. The arrangement previously referred to and figured would have told one, if nothing else had, that the attitude of standing and walking on four legs is exceptional in the case of a

* "Royal Natural History." Lydekker. Vol. ii. p. 509.

Baboon, and that the sitting posture largely prevails. Without information of any kind as to the habits of a **Two-toed Sloth,** one could be sure, from the examination of its skin and hair, that the almost unique habit of living upside down was its prevailing one.

In reference to these few isolated instances of prediction, a sentence from Professor Karl Pearson's "Grammar of Science" may be alluded to*: "We may note that when, from a sufficient if partial classification of facts, a simple principle has been discovered which describes the relationship and sequences of the group, then this principle or law itself generally leads to the discovery of a still wider range of hitherto unregarded phenomena in the same or associated fields."

It cannot be doubted that a wider survey of the large group of facts as to direction of hair in animals will supply numerous instances of prediction according to the principle here formulated.

In concluding this subject it may be well to restate what is claimed, and what is not claimed, as the contribution of the facts of hair-direction to larger issues of heredity and organic evolution. No antinomy between Darwinism and Lamarckism is proposed, but rather something of a fusion of two great principles, as far as the facts bear upon them. Hardly anywhere is the great province of selection now denied. We have not, indeed, to ask, "Does Nature *or* Nurture rule as absolute lord in this place?" But we may fairly claim that if our line of argument be valid, the old position held by

* "Grammar of Science." London, 1892. P. 17.

Darwin himself, Nature *and* Nurture, or Darwin *and* Lamarck, is definitely reinforced.

So much for what is not claimed.

But it is claimed that Use-inheritance is a factor in organic evolution the importance of which has yet to be ascertained. And seeing, that the non-inheritance of acquired characters is an integral part of the system of Heredity-according-to-Weismann, it would seem that some very great modification of that system is called for.

The evidence, then, bears primarily upon Weismannism, and only on evolution in a subordinate manner. If these observations and arguments be accepted as conclusive in their own sphere, the matter does not end there. Weismannism, with all its wealth of biological knowledge and the *prestige* which it derives from the reputation of its distinguished author, is shown to have some fundamental defect as a coherent system of theories. The strength of a chain being no greater than that of its weakest link, Weismannism, then, fails to assert its supreme authority. It resembles a well-known and fated man-of-war, the *Captain*, of some thirty years ago. That splendid vessel seemed at the time to stand for the acme of the shipbuilder's art and science. Money, skill, and scientific construction could no farther go. And yet, from some radical error in her marginal stability, which was not adequate to the needs of a sea-going ship, she brought disaster upon many and blame upon a few. The highest experts of the day—with certain exceptions—could not calculate that she would react so disastrously to the impact of wind and

waves until experience once for all demonstrated the fault that was in her.

If the conclusions here advanced be not accepted, the alternative views are beset with difficulties. The only alternatives worth noting are as follows :

(1) It may be held that **Man** and the various animals dealt with were created as we find them, and the direction of their hair is thus left unexplained.

(2) Some will shelter themselves under the statement that we do not know enough of the lives of animals in a state of nature, and we must reserve judgment It has been pointed out that this evasion of the question at issue does not avail at all widely, and can only be maintained for the sake of deferring the consideration of the matter, if one may say so, putting it into Chancery.

(3) Many will endeavour to bring these facts under the jurisdiction of natural selection, but cannot in any serious degree press such a view.

(4) Others will say that as Weismann's doctrine is contravened by the conclusions put forward, and as a large amount of evidence and current biological opinion is in favour of Weismann's views, any contrary facts, such as we have here, are probably due to other causes yet to be discovered. Such is Weismann's own attitude towards them. This may be magnificent, but it is not science. At the present time, various thoughtful biologists suspend judgment as to the debated doctrine concerning "acquired characters," and invite those who hold the unorthodox opinion to bring forward

evidence in its favour. Surely the scientific attitude is that of judging a large series of facts on their own merits, and according to the weight of evidence, even if it tend against a widely accepted hypothesis!

(5) Some will urge that changes in the direction of hair in animals are to be looked upon as characters borne along various lines of evolution in the wake of other characters, notably of muscle-arrangement, whose changes are of major importance. But if this view could be sustained in a few cases, it is inadequate to meet the bulk of the cases of change of direction in the lower animals, *and all of those in Man.*

Each of these five alternatives to Use-inheritance is unsatisfactory when brought face to face with the facts in question. Indeed, the supreme difficulty of the opponent's position is encountered when the hair of **Man** is under consideration. In the lower animals some remainder of doubt can be suggested as to the ætiology of the facts. But the divergences in the hair-slope of **Man** from that of any conceivable ancestor are so pronounced that the opponent has to choose between accepting here the doctrine of Use-inheritance and rejecting the Simian ancestry of **Man**.

Against Use-inheritance there lies no essential improbability. It does not contravene the Descent of **Man** as generally accepted. It does not sin against "the law of parsimony." It asks only to "live and let live." It appeals to simple and ascertainable mechanical forces now in action. It affords a reasonable hope of the solution of some

outstanding problems of science, without committing a trespass on the lawful sphere of selection, whereas the burdensome rule of the exclusive selectionist grows more oppressive with a widening knowledge of Nature's handiwork.

APPENDIX

PART I.

Cervical whorl, feathering and crest present in Felis leo, F. pardus, F. tigris, among Carnivores; and among Ungulates: Bos sondaicus, B. gaurus, Tragelaphus euryceros, Dorcelaphus bezoarticus, Damaliscus pygargus, D. jumela, D. albifrons, Addax nasomaculatus, Budonas taxicolor, Connochætes albojubatus, Cobus defassa, Oreas canna, Nemorhœdus bubalinus, Equus burchelli.

Spinal whorl, feathering and crest present in Felis leo, in Bos gaurus, B. frontalis, B. mindorensis, B. caffer, B. bubalus, Boselaphus tragocamelus, Tragelaphus angasi, Nemorhœdus bubalinus, Hemitragus jenlaicus, Cobus vardoni, C. Senegamus, C. thomasi, C. leche, C. defassa, C. ellipsiprymnus, Cervicapra arundinum, Bubalis lichtensteini, B. cokei, Oryx beisa, O. gazella.

The *Pectoral* whorl, feathering and crest is present in so large a number of Mammals that it is simpler to enumerate those in which it has been found to be absent; these are chiefly Ungulates. It is also absent in many long-haired animals. Absent in Bos gaurus, B. mindorensis, B. caffer, Bubalis cokei, B. swaynei, Boselaphus, Domestic Ox, Oreas canna (present in a female specimen), Giraffa camelopardis (one specimen), Œpycerosmelampus and petersi, Gazella subgutturosa, G. clarkei, G. gerenuk, G. cuvieri, G. granti, G. Sömmering, G. muscatensis, G. leptoceros, G. thompsoni, G. mohr, G. Spekei, Antidorcas euchore, Genus madogna, Oryx gazella, Muntjacs, Cephalophus sylvicultor and jen-

tinkei, Damaliscus pygargus. Among Equidæ—E. zebra, E. onager, E. hemionus. All Rodents examined. Among Marsupials—Macropus irma, M. nalabatus, M. ruficollis, and many smaller forms of Macropus.

Post-Humeral or Axillary whorl, feathering and crest present in Strepsiceros kudu, Rangifer tarandus, Cobus leche, Equus hemionus, E. burchelli (one young specimen), Bos sondaicus, B. depressicornis, Ovis ophion, O. ammon, O. sairensis, O. poli, Antilocapra americana, Dorcelaphus americanus, D. dichotomus, Elaphurus davidianus, Lama huanacus.

Inguinal whorl, feathering and crest present in Bubalis caama, Rangifer tarandus, Cervicapra fulvorufola, C. arundinum, Cobus thomasi, C. buffoni, C. vardoni, C. leche, Equus hemionus, Bos sondaicus, B. indicus, Ovis ophion, O. ammon, O. sairensis, O. poli, Capra pyrenaica, Saiga tartarica (present in a male specimen, absent in a female), Gazella granti, G. mohr, Antilocapra americana, Cephalophus dorsalis, Cervus kuhli, C. elaphus, Camelus bactrianus, Lama huanacus.

PART II.

Exceptions found among Ungulates to the ordinary slope of hair over the Extensor surface of the ulna are as follows:

Oryx gazella, O. beisa, Strepsiceros kudu, Oreas canna, Alces machlis, Raphicerus campestris, R. melanotis, Ourebia nigricaudata, O. hastata, Tetraceros quadricornis, Nesotragus moschatus, Cephalophus grimmi, C. rufilatus, C. leucogastris, C. abyssinicus, C. doriæ, Pudua humilis, Moschus moschiferus, Xenelaphus antisiensis, Hydropotes inermis, Dorcelaphus bezoarticus, D. americanus, D. hemionus, Cervulus muntjac, C. reevesi, C. lachrymans, Capreolus caprea, Elaphodus michianus, Cervus alfredi, C. porcinus, C. axis, C. duvauceli, C. elephus, C. dama, C. cashmirianus. Also certain Chevrotains and Suidæ were noted.

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