Use-inheritance illustrated by the direction of hair on the bodies of animals / by Walter Kidd.

USE-INHERITANCE

ILLUSTRATED BY THE DIRECTION OF HAIR ON THE BODIES OF ANIMALS

BY

WALTER KIDD, M.D., F.Z.S.

LONDON
ADAM AND CHARLES BLACK
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TWO SHILLINGS AND SIXPENCE NET

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PREFACE

THE facts dealt with in the following pages are intended to show that the doctrine of the non-inheritance of acquired characters does not always hold good. They are neither numerous nor exhaustive, but typical of a large group of phenomena, and indicate what *may* occur in regard to use-inheritance rather than what generally occurs.

Though the title may be open to objection because the cases adduced are not strictly those of use or function, but the results of habit, the idea of the contents is sufficiently conveyed, and the title thereby justified.

The names given to certain muscles, and referred to in the text bearing on them, are those employed in veterinary anatomy.

USE-INHERITANCE

INTRODUCTION

It is proposed in the following pages to attempt to show that certain inherited characters of animals can only be interpreted by considering them to have arisen in ancestors of those animals by use or habit. This proposition amounts to a denial of the universal validity of Weismannism, as an articulated system of heredity, which is nothing if not universal. The larger question, now more than a century old, as to the value of Lamarckian factors in organic evolution, is not touched upon here. Lamarck is not without his able champions, even in these days when Selection has established for itself in the minds of biologists an astonishing ascendency. It must indeed be admitted that a remarkable difficulty has been found hitherto in showing that the effects of habit, use, and disuse in certain individuals are inherited by their descendants. All the various forms of mutilation of animals and man practised from time immemorial have failed hitherto to furnish cases of such mutilations being transmitted by descent. All the facts of use and disuse of parts or organs, and their effects on individuals, have hitherto been open to selectionist interpretations, and even the inheritance of certain diseases in man has been stoutly challenged. The cases hitherto recorded seem to be summed up, by authority, as a "handful of anecdotes." That Lamarckism

can only be true to a minor extent in the development of organic forms is generally admitted, but that the effects of use and disuse or habit *cannot* be transmitted is maintained only because a certain theory requires its maintenance. This is no real blot on the undoubted merits of Weismann's great theory, or catena of theories, which he, as readily as any, acknowledges to be provisional, and which has laid the scientific world under great obligation on account of the clear definition of principles which has emerged from his teachings.

Under these circumstances it seems at first hopeless to attempt, after many years of investigation, to show any exceptions to Weismann's great rule, which undoubtedly holds good very largely. The excuse for the present attempt rests upon the following statements on this question, from the works of two of our foremost zoologists, one British and the other American. "I believe that the conclusion of the whole matter should be an emphatic 'not proven' on either side, while the practical corollary is that we should cease to talk so much about possibilities (in regard to which one opinion is often as logically reasonable as another), and betake ourselves with energy to a study of the facts."[1] . . . "Would they not do well to rest on their oars, and to look about them? For that which they are in search of may prove to be plainly in the sight of those who have the eyes to see,"[2] speaking of the "inheritance of acquired characters."

It is surely then worth while to test this fundamental canon of Weismannism by a study of very simple facts, such as are presented in the disposition of hair on the bodies of mammals, man included. In such a study it is clearly safer to exclude the large group of facts bearing upon the general

[1] *The Study of Animal Life*, p. 336, J. Arthur Thomson. 3rd edition, 1896.

[2] *The Foundations of Zoology*, W. K. Brooks, p. 78.

direction of the hair on the animal body, for such an important matter as the question whether the hair should slope from the cephalic to caudal end of the trunk of an animal, or the reverse, and whether on the limbs from proximal to distal end, or the reverse, is of extreme importance to the well-being and perhaps the safety of the animal. Such a question as this must then come at once, and without doubt, under the province of adaptation to needs, and so be open to selectionist interpretations. But it is otherwise in many of the details of hereditary dispositions of hair in hairy mammals, found in certain critical areas of the body. These dispositions constitute a mass of exceptions to the general rule of slope from cephalic to caudal end of trunk, and from proximal to distal end of limbs, which demand an entirely different interpretation. The exceptions are numerous, varied, intrinsically trifling, and some even characteristic of species. I would go so far as to say that the whorl, feathering, and crest, found on the flank of a Domestic Horse, must take rank as a specific character, and there are others of which the same may be alleged. The trifling intrinsic importance of these characters will come out in the course of the following study of the facts, and produces the impression on one's mind that, except for maintaining the credit of a great theory, such as that of Weismann, there is only one way of interpreting them, and that is according to Lamarck.

I would submit that the value of these facts, taken as a test of Weismannism, rests upon their want of importance to the animals in which they are found. Further evidential value attaches to them from the fact that certain of them are stereotyped upon species; others very similar are in process of development at the present time, and the factors that may be at work in producing them are open to investigation. This is a form of evidence too much wanting in most of the great problems of organic development.

Two classes of facts are dealt with—first, the formation of whorls in the hairy coats of mammals; secondly, the slope of hair in certain selected regions of the bodies of animals and man. These have all been gathered from domesticated animals, from specimens in the Zoological Gardens of London and from dead specimens in the Natural History Museum, South Kensington, and from a variety of living human subjects. I hope indulgence will be shown to the imperfect character of these observations, for the reason that they are not intended to be an exhaustive study of the disposition of the hair of all mammals, but rather as a test, in a variety of living forms, of the effects of use and habit in the production of certain hereditary characters.

CHAPTER I

THE FORMATION OF WHORLS IN THE HAIRY COATS OF MAMMALS

It is a matter of some interest, and perhaps of importance from the present point of view, to ascertain the origin of those radiating whorls which are seen very generally in the hairy coats of Mammals. They occur with great frequency and variety in this group of animals, and in certain regions of the human body, and appear only to be entirely absent in a few aquatic animals, such as beavers and seals, and in certain rodents.

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 very usually 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 conditions—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, on the two sides of which the hair-slope is in opposite directions.

FIG. I.

Whorl. Whorl and Feathering.

A. Whorl.
B. Feathering.
C. Crest.

For the study of this matter of whorls the Domestic Horse is, of all animals, the most useful, being short-haired, very well known, exceedingly widely distributed, of varying breeds, and an animal whose affinities are clear. It is also an animal so much adapted to and given up to locomotion, more than any animal, that it affords an excellent opportunity of testing the dynamical view of the formation of these whorls here put forward. The Domestic Horse, as seen in this country, presents five separate regions where whorls are found, as follows: *Frontal, Inguinal, Pectoral,* uniformly;

the *Post-Humeral* or Axillary, and *Cervical*, occasionally. With this special animal may be contrasted another nearly as common, the Domestic Ox, which presents no whorl except the Frontal, Spinal, and a small Axillary, and rarely the Cervical, and which, it may be noted, is not, in this country at least, and in no country in a degree at all approaching the Horse, a locomotive animal. Two Zebras, a Burchell's and Grevy's Zebra at South Kensington, are the only two animals (except aquatic mammals and a few rodents) in which no whorl has been found by me on any part of the body, except a very small frontal whorl.

Besides the five regions so generally presenting whorls in the Horse, there are three others where they are more or less commonly found in other animals—the *Vertex*, *Nasal*, and *Spinal* regions. So there are eight in all in which I have been able to discover these arrangements of hair in all degrees of development, from the rudimentary star-like whorl to the complete whorl, feathering, and crest before referred to.

Among the various orders of Mammals the Ungulate furnishes by far the greatest number and variety of whorls: the terrestrial Carnivores have very generally only two—the *Pectoral* and *Frontal* or *Nasal*, not usually both the latter.

Among aquatic Carnivores, Rodents, Insectivores, and Marsupials, whorls are seldom found, except in the pre-maxillary or nasal regions. A few marsupials have a pectoral whorl.

The more exact distribution of whorls among animals will be dealt with in detail in an appendix.

1. On the *Vertex* in Man, Anthropoid Apes, and many Monkeys, a constant and marked whorl is present, situated chiefly towards the occipital rather than the frontal region of the head. It is usually single, but in Man especially is often bilateral. It appears to be situated just at that

point of the head where the long hair of this part is obliged by its weight to find a point of divergence in order that it may be distributed over the surrounding convex surfaces.

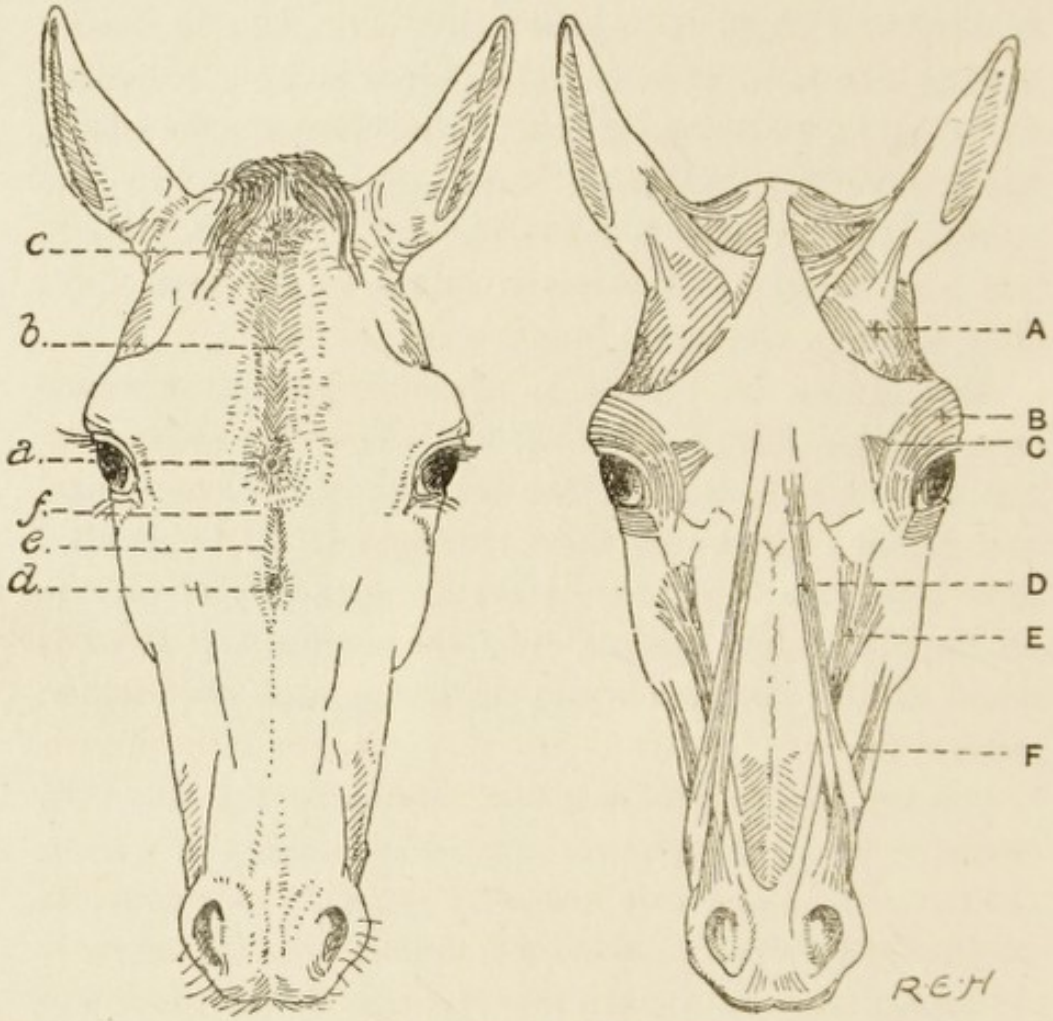


FIG. II.—FRONTAL REGION OF HORSE.

On left side—

a, b, c. Universal whorl, feathering, and crest.

d, e, f. Occasional supplementary whorl, feathering, and crest.

On right side—

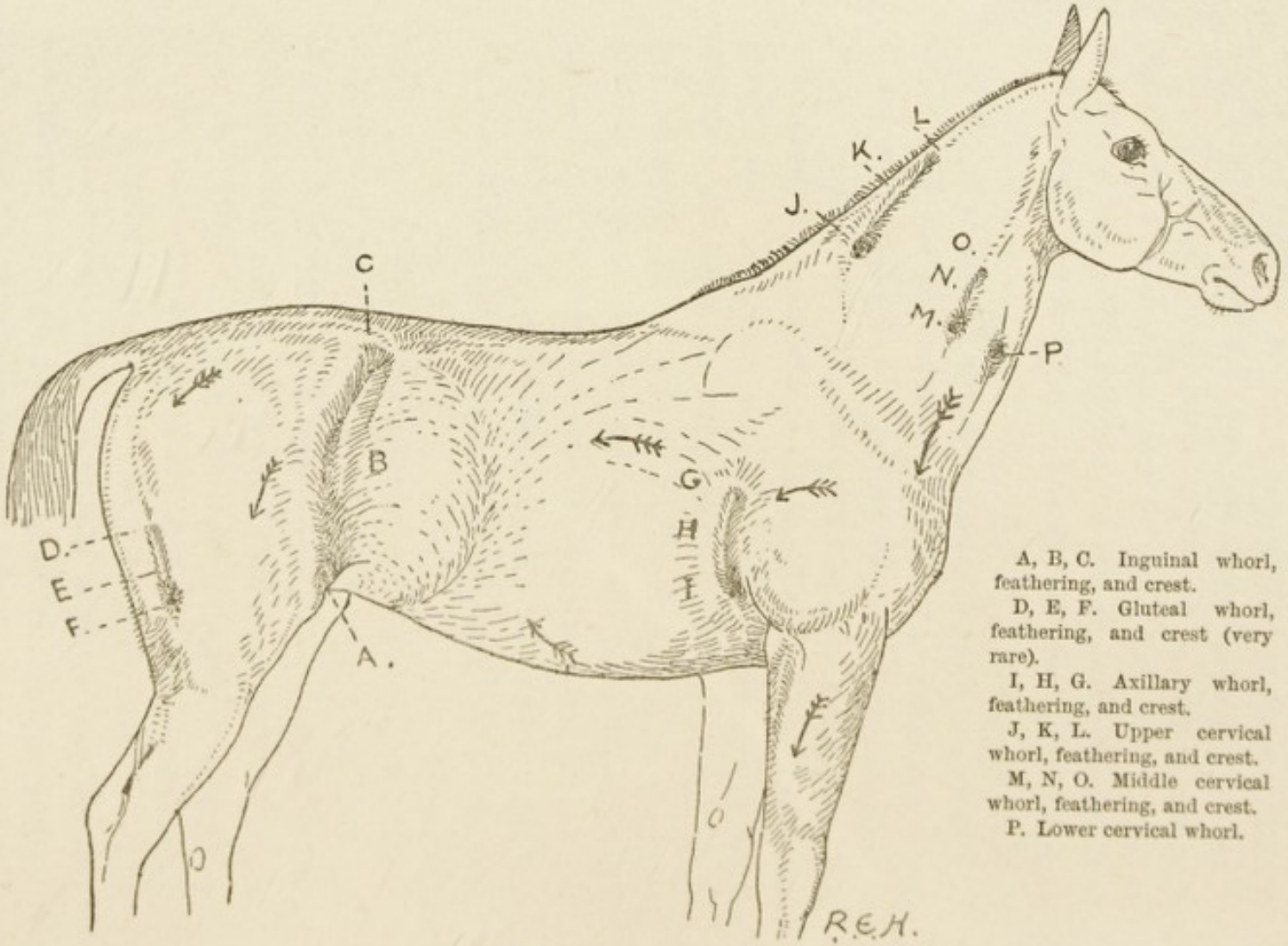
A. Temporal muscle.
B. Orbicularis.
C. Corrugator supercilii.
D. Maxillaris.
E. Nasalis.
F. Caninus.

2. 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. 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 crests below it, also in the middle line. Fig. II. *d*, *e*, *f*.

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, 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 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.

3. *Nasal* region.—This 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. This whorl is seldom associated with a feathering and crest.



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.

FIG. III.—SIDE VIEW OF HORSE.

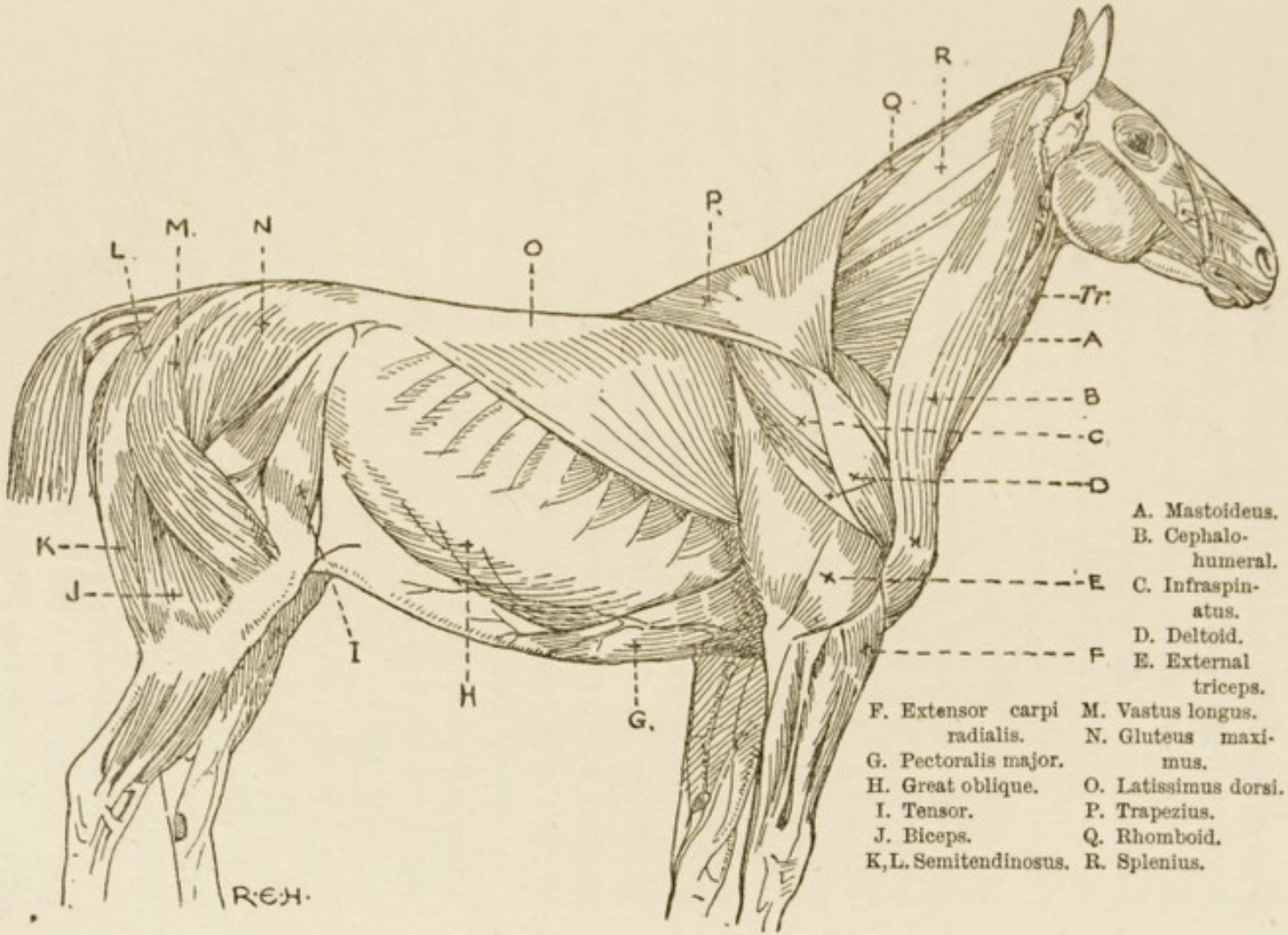


FIG. IV.—SIDE VIEW OF HORSE, SHOWING CHIEF SUPERFICIAL MUSCLES.

4. *Cervical.*—In the Horse, on several regions of the neck, whorls are found, though much less common in other animals than any whorl except the *Nasal.* In the Horse they are found in three chief regions of the neck—at the line of crossing of the direction of the trapezius, splenius, and cephalo-humeral muscles—and often more anteriorly along the edge of the splenius; also where the cephalo-humeral and mastoideus adjoin one another, and where the mastoidei muscles of the two sides separate. On the neural aspect of the neck the whorls frequently pass into a feathering which passes forward towards the head in a well-defined way (see Fig. III.). On the ventral surface of the neck the whorls have a very expanded kind of feathering, less exact than in other parts. In certain Carnivores with very muscular necks, such as Lion, Tiger, Leopard, these are found. The two positions of this region of the Horse, in which whorls are most commonly found, also lie immediately over large groups of muscles which pull against one another, viz. where the anterior portion of the trapezius, the splenius, and rhomboid muscles cross one another as to the direction of their fibres, and here a feathering and crest are very common; and even two whorls, one more towards the head than the other, are often found (see Fig. III.). The second region where they are chiefly found is the ventral surface, and they lie over the junction of the cephalo-humeral and mastoideus, or between the mastoidei of either side, and in the middle line. Here the divergence of the lines of action of the muscles referred to is not so marked in many other regions (see Fig. VI.).

5. *Pectoral.*—This whorl is practically universal in Horses, and expands into a feathering, and very often this ends in a crest. It varies very little, is always bilateral, and the feathering has an oval outline, starting from a whorl which lies at the edge of the mass of the pectoral muscles, where it adjoins the also strong mass of muscle on the flexor aspect of the ulna.

The pectoral whorl is often rudimentary in Ungulates and some Carnivores, and is in some forms found situated on the flexor surface of the forelimb instead of the pectoral region, and from this whorl a feathering may pass for a short distance on to the pectoral region. In a few Horses one finds a third whorl and feathering, which lies in the median line between the bulging masses of the pectoral muscles of the opposite sides. In the Horse this whorl lies over the spot where the lines of the extensor carpi radialis and extensor communis digitorum diverge sharply from those of the lower portion of the pectoralis major, and the feathering continues from here upwards to the point where the directions of the pectoralis major and cephalo-humeral cross, and a crest is usually present.

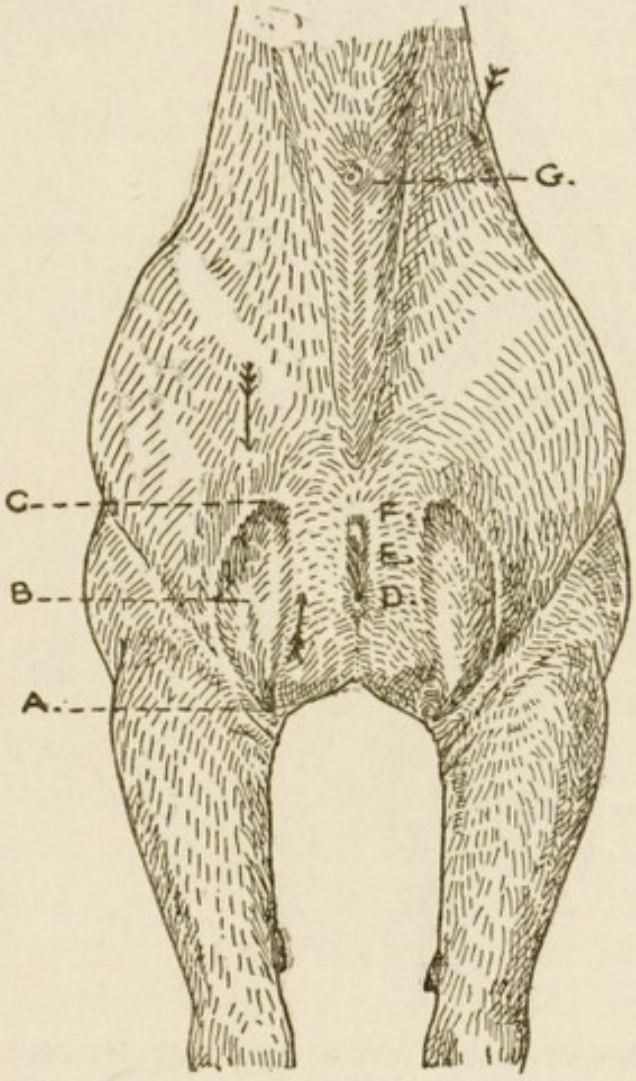


FIG. V.—FRONT VIEW OF HORSE'S CHEST, SHOWING HAIR-TRACTS, WHORLS, FEATHERING, AND CREST.

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

6. *Spinal.*—Along the whole line of the vertebral spines whorls may be found, and these are greatly more common in Ungulates, though a few very marked instances occur in

the Felidæ. Usually these are central, and of course on that account single ; and of this arrangement very good examples, with whorls passing into a long feathering and ending in a crest, may be seen on two Lions in the Natural History Museum, South Kensington (Fig. VII.). There are other cases where a bilateral whorl and long feathering is found on either side of the vertebral spines, and one of the Bovidæ (*B. Mindorensis*) shows the feathering from one side passing over the median line to the opposite side. This region also shows in the central line similar muscular conditions to those of other regions, the trapezii of the two sides pulling in lines very much opposed to one another. It is over the line between these two muscles that most of the whorls and featherings are found. Those found to the side of the median line present no such arrangement of muscles, but may be associated with the very strong action of the

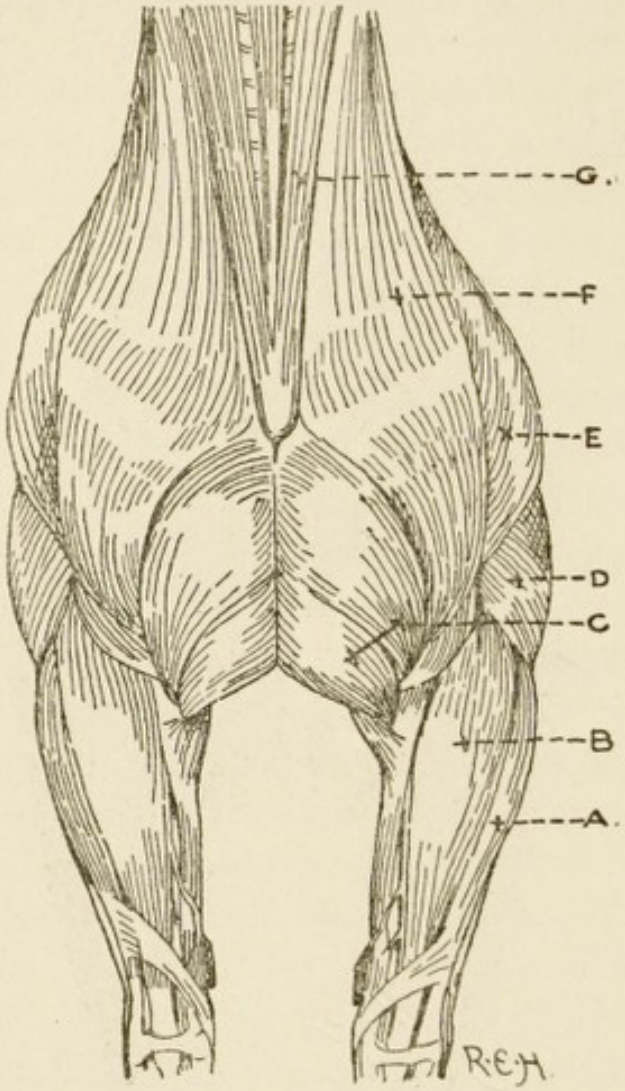


FIG. VI.—FRONT VIEW OF SUPERFICIAL MUSCLES OF HORSE'S CHEST.

A. Extensor communis digitorum.
B. Extensor carpi radialis.
C. Upper and lower portions of pectoralis major.
D. External triceps.
E. Supraspinatus and infraspinatus.
F. Cephalo-humeral.
G. Mastoideus.

panniculus carnosus, as they are most common in such Ungulates as have very strongly-acting dorsal portions of this muscular sheet.

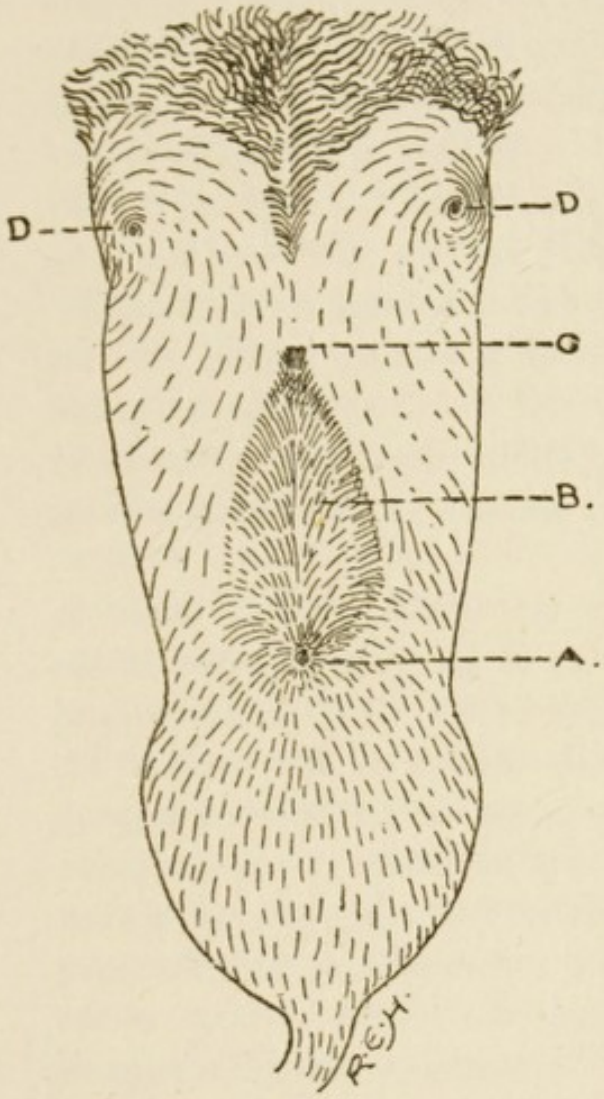


FIG. VII.—VIEW OF LION'S BACK, SEEN FROM ABOVE.

A, B, C. Dorsal whorl, feathering, and crest.
D. Bilateral whorl on shoulder, with occasional feathering.

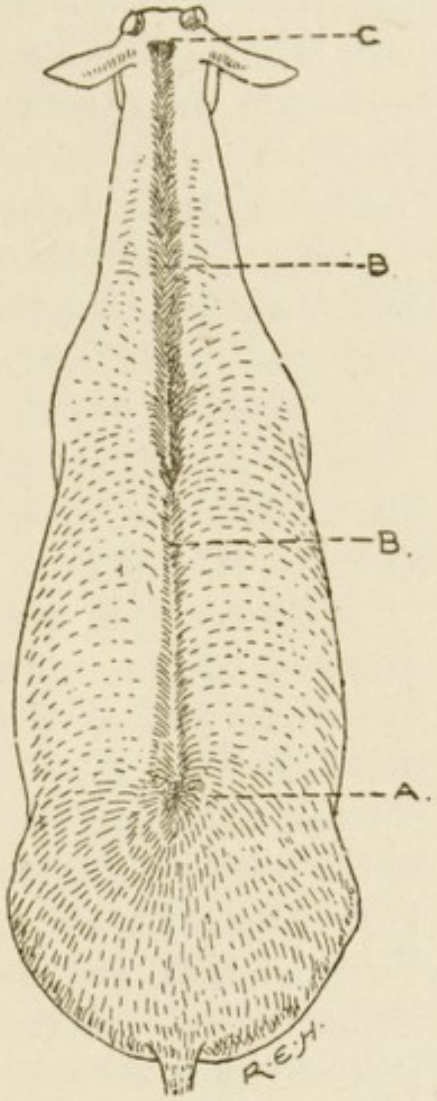


FIG. VIII.—VIEW OF BACK OF ORYX BEISA (BEISA ANTELOPE), SEEN FROM ABOVE.

A. Whorl over sacrum.
B, B. Long central feathering.
C. Crest.

7. *Post-humeral* or Axillary.—The whorl here is very variable in the Horse, being found in about the proportion of one in fifty of the cases examined.

It also varies much in individuals of the same species, and

is, generally speaking, more variable than any others of the eight whorls here described. It may exist in the three stages of whorl, feathering, and crest. It is so rare in Carnivores that, after an extensive search for it among them, I have been able only 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 Post-humeral or Axillary region, with 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 (see Figs. III. and IV.).

8. *Inguinal.*—In Horses this whorl may be taken as universal, being most striking in its persistence and in the uniformity with which it presents a whorl, feathering, and crest. The whorl lies nearly always at the edge of the inguinal fold of skin, though occasionally it is found as much as half-way towards the crest of the ilium. From this point, at the edge of the fold, a marked feathering proceeds against the great dorsal and lumbar stream of hair, and lies in a slightly curved position along the hollow in front of the great flexors of the thigh. It continues without change as far as the level of the crest of the ilium, where it terminates sharply in a crest or ridge, which is very noticeable when the coat of the Horse is long enough. I may mention here a particular case which I examined, of a small pony which had just been clipped, and at the exact spot where the crest would have been normally, and no doubt was at other times, there was a definite dimpling of the surface. The branches of stream formed by the anterior and posterior portions of the feathering blend gently with the adjoining stream, the

former taking a wide sweep on to the abdominal wall, and passing to the ventral surface in a line of junction which is often very clearly seen, and which may form a tuft at about the level of the "knee" of the animal. The posterior portion of the feathering joins less definitely with the stream of hair covering the gluteal region (see Fig. III.).

The Inguinal is another region equally marked in its muscular arrangements as affording very much opposed traction of muscles. The rectus femoris and vastus externus, with the rectus abdominis and great oblique muscle, need only be referred to in support of this. In addition to these, the point at which the feathering sharply ceases in a crest, at the level of the crest of the ilium, is indicated by the striking arrest which appears to be put to the action of the muscles just mentioned by the strong fibres of the latissimus dorsi, which at this level pass across the lines of action of the other muscles (see Fig. IV.).

The view which I would submit of the formation of these arrangements of hair is that they are due, with the single exception of the whorl on the vertex of man, apes, and monkeys, to the traction of the underlying muscles of the part in question. In all the eight regions except that of the *vertex* there are muscles so situated, and pulling, when in action, so that their line of traction is more or less opposed. On the vertex it may be that there is a special reason for the whorl found, viz. that with the long hair found there, falling downwards from a convex surface, it would be impossible for the hair to fall as it does without some such starting-point as the vertex or whorl found, and that this case has no bearing on the remaining seven instances.

It is difficult to see any explanation of the formation of whorls, featherings, and crests in the hairy coats of Mammals than a dynamical one. Any anatomical explanation fails when a great variety of animals and whorls in several

regions are examined, animals of almost identical anatomical structure presenting very different appearances as regards whorls. Again, it cannot be maintained that they are mere peculiarities, or variations in the biological sense, on account of the exceeding uniformity with which certain, such as the Frontal, Pectoral, and Inguinal in the Horse, are found. Sexual selection can have no influence in producing them, for they have no colouring or any markedly attractive properties attached to them.

The reasons I would suggest for the dynamical view are:—

1. They all occur, except that on the vertex, in regions where opposing traction of underlying muscles is found.

2. They never occur over the middle of a large muscle, and seldom in any place where there is not a hollow or groove in the superficial anatomy.

3. They are most uniform and most marked in animals with very strong muscles, and those that are actively locomotive.

4. Their constancy appears to depend upon range of action and activity of function of the muscles in the part and individual animal affected. This is especially shown in the three regions of the Domestic Horse—Pectoral, Post-humeral, and Inguinal. In the Pectoral and Inguinal, where flexion of the anterior and posterior limbs at the elbow and knee has a very great range, whorls, featherings, and crests are uniformly present, and nearly constant in character. In the Post-humeral, where extension of the elbow occurs, a movement with greatly less range than the two former, the whorls are present in the proportion of one to fifty of Horses examined, and feathering and crests are often absent or rudimentary. In the rapid action of a horse, especially when it is thin and the outline of the deeper parts can be better traced, marked jolting, limited most accurately in the case of the Inguinal region

by the crest of the ilium, can be observed in the Pectoral and Inguinal, and very much less in the Post-humeral. A small series of observations, referred to in a paper read at the Zoological Society in June 1900, upon Domestic Horses, showed the Post-humeral whorl present in eighty-seven horses altogether, of which fifty-seven were cart-horses, which have a much greater range and strength of action of the parts underlying this whorl than the commoner hackneys and nondescript varieties.

As to the view that whorls are formed through the action of underlying muscles which pull in opposing directions, there is a small group of anatomical facts which seem to support it by analogy. Thus, on the human skin, dimples are found in situations where either opposing muscular action occurs beneath them, or where portions of superficial fascia, attached to the deeper layer of the corium more closely than is usual, are dragged upon in different directions by muscular action. The chief spots where dimples are found are:— First the chin, where the levator menti and depressor labii inferioris muscles of each side pull in opposing directions on the skin and fat of the part. Secondly, the cheek, where the zygomaticus and risorius muscles are attached to the tissues of the corner of the mouth, and pull in somewhat different directions, and especially in a direction different from that of the masseter. Thirdly, over the external condyle of the humerus, where the superficial and deep fascia are adherent more closely than in the surrounding parts, and where the extensor carpi radialis longior, extensor carpi ulnaris, anconeus and triceps, pull in very much opposed directions. Fourthly, over the metacarpo-phalangeal and metatarso-phalangeal joints of all the digits, where the deep fascia merges into the sheaths of the underlying tendons on the one hand, and the superficial fascia on the other. These dimples on the hands and feet are

only seen, as a rule, in young children as they become fat, and disappear later in life, except in the cases of adults with very fat hands and feet.

In all these instances the requisite mechanical conditions for producing a dimple or pit in the skin are found, and may throw light on the formation of whorls in the hair of mammals.

The distribution of the whorls referred to is given in detail in an Appendix, pp. 46 and 47.

CHAPTER II

SLOPE OF HAIR ON THE BODIES OF ANIMALS

THE direction taken by the hair of animals in general is undoubtedly subject to a law given by Mr. E. E. Thompson,[1] by which he says the backward direction is given to the hair, viz. the need for minimising resistance to opposing forces. It is adapted to their habits and environments, so that they move with the greatest possible ease through brushwood, swampy ground, and water. By this arrangement also they present the least possible obstacle to the wind, and certain special forms of pressure encountered by them in their wild life, *e.g.* in the case of burrowing animals, are diminished. Over such broad adaptive modifications selection may well be assumed to preside. A second law given by the same writer, and supported by many others, that the downward direction of the hair on the trunk and limbs is produced by the need for running off the rain when the animals are at rest, is demonstrably of limited application to the varied arrangements of hair found in animals. The writer admits as much as this on p. 5: "But these rules are much broken by local requirements of more force." It will be sufficient to take the instance of three Antelopes—Eland, Sable Antelope, and Roan Antelope—to show that this law can apply with

[1] *Art Anatomy of Animals*, p. 5, E. E. Thompson.

little certainty to this class of character, and to study the hair-slope on the extensor surface of the ulna in these three similar forms, to show that this law applies with little force, if at all, to this class of character. Indeed, the statement would hold good more generally if it were rendered: "But these rules are much broken by the effects of certain habits."

On the bodies of Mammals certain areas present exceptions or peculiarities of hair-slope, and of these, two in the lower animals, and three in Man, will be considered.

A. *Extensor Surface of Forearm.*—This small region of the body has been chosen because of its being open to very different influences in different animals, and of its presenting a great variety of dispositions of the hair in different 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.[1]

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 life. 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,

[1] *Nature*, vol. 55, p. 236.

for convenience, the Exceptional type. The reason for provisionally calling this type Exceptional is that a marked *reverse* of 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.

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.

This and all other features of the bodies of animals are open to one of three interpretations:—

1st. That by original creation of large groups of animals, these were so produced as being suited to their lives and habits.

2nd. That they are adaptive modifications governed by natural selection.

3rd. That they are inherited modifications, produced by use or habit.

Certain of such characters have been claimed to be vestigial; but if they can be shown not to be open to selectionist interpretations at the present time, *a fortiori* they cannot be vestigial, and in any case the number of these must be extremely small.

It remains to ask which of these three is the most scientific and probable. The first must be left out of account in a purely scientific discussion of such points as the ætiology

of characters like those in question, though certain uncompromising Neo-Darwinians may have to reckon with the first if they reject the third of these interpretations. To hold the second is to surrender all fair inference from facts for the sake of the consistency of a great theory. It can hardly be held that survival-value of the most remote kind, or even comfort, can be conferred on one of the domesticated animals, such as a Fox-terrier, or one of the wild Ungulates, such as an Eland, whether the hair on the under surface of its ulna slopes to or from its body; or to a Domestic Horse, whether the hair slopes for a fourth of the length of this surface towards the radial border and inclining in a proximal direction, and for the remaining three-fourths wholly towards the carpus; or to Man, that his short hairs along the axial and preaxial borders of his forearm should coalesce over the posterior border of his ulna, and there form a narrow straight stream of hair which passes in a straight line to his elbow. The third view

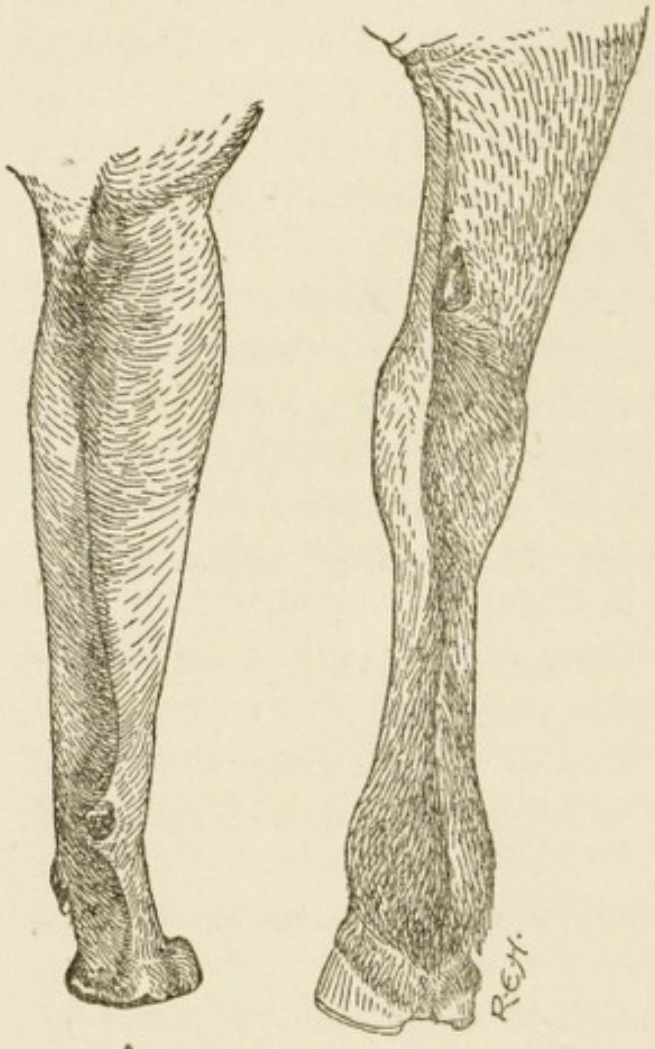


FIG. IX.

A. View of hair-streams on extensor surface of ulna of short-haired Dog.
B. View of hair-streams on extensor surface of ulna of Horse.

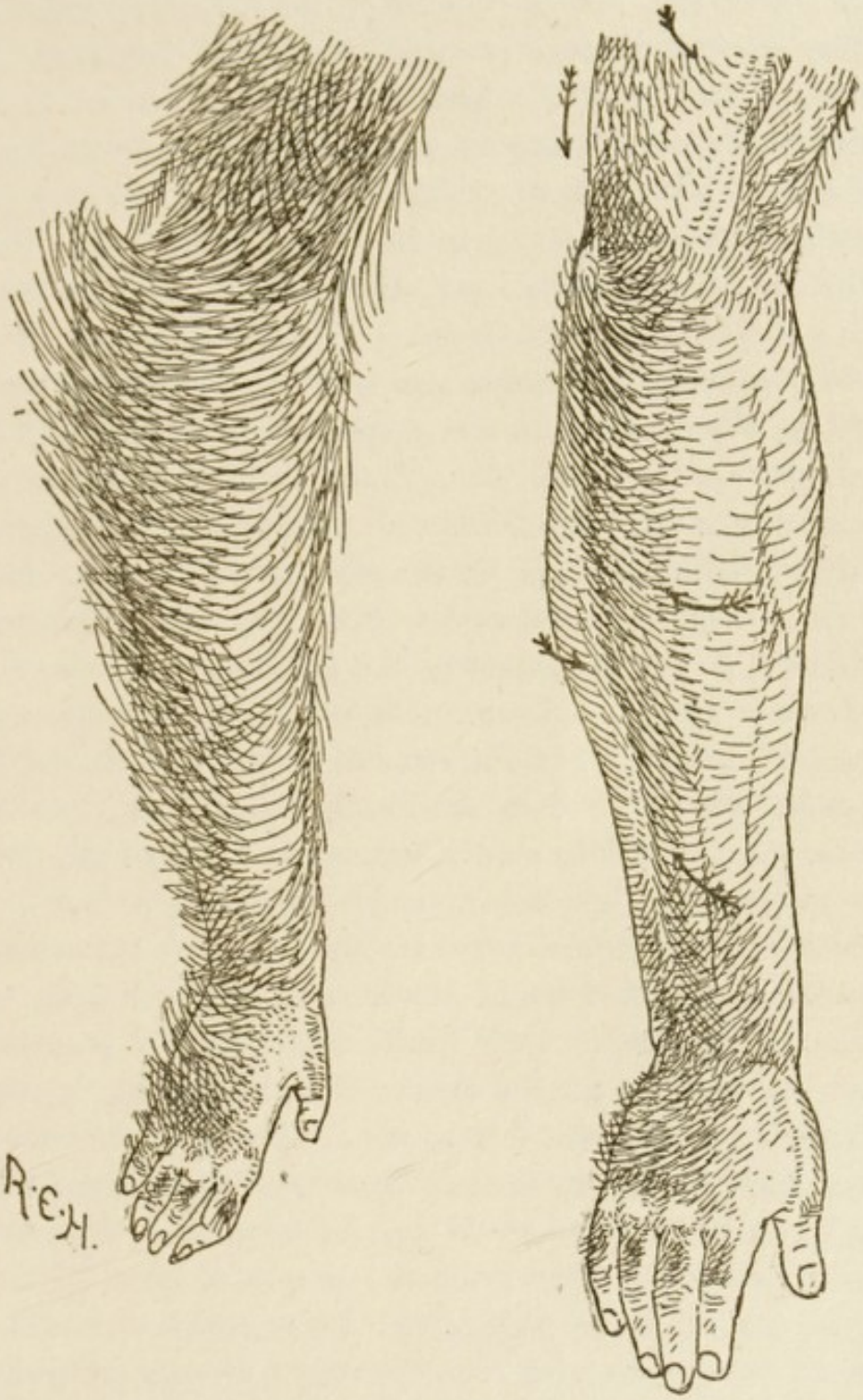


FIG. X.—HAIR-STREAMS ON EXTENSOR SURFACE OF FOREARM OF ORANG AND MAN.

agrees with fact, if not with Weismannism. Thus 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 forelimbs, 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 forelimbs 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, Equidæ, and most Antilopidæ. In this case the contact of the opposed surfaces makes no change from 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 attitude both of adults and young, arranged so beautifully 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.

B. *Naso-Frontal Region.*—This is a surface equally subject in animals to influence from habit or environment, and, as a matter of fact, it is equally variable in respect of the slope

which the hair is found to take. Accordingly it furnishes another useful test-area.

The direction of hair may be from nasal to frontal, or from frontal to nasal region, with certain varieties in different forms, but here again one can easily distinguish what may be called a Normal from an Exceptional type. In the former, mostly found in animals with elongated snouts, the hair slopes from the edge of the muzzle, beginning there in a

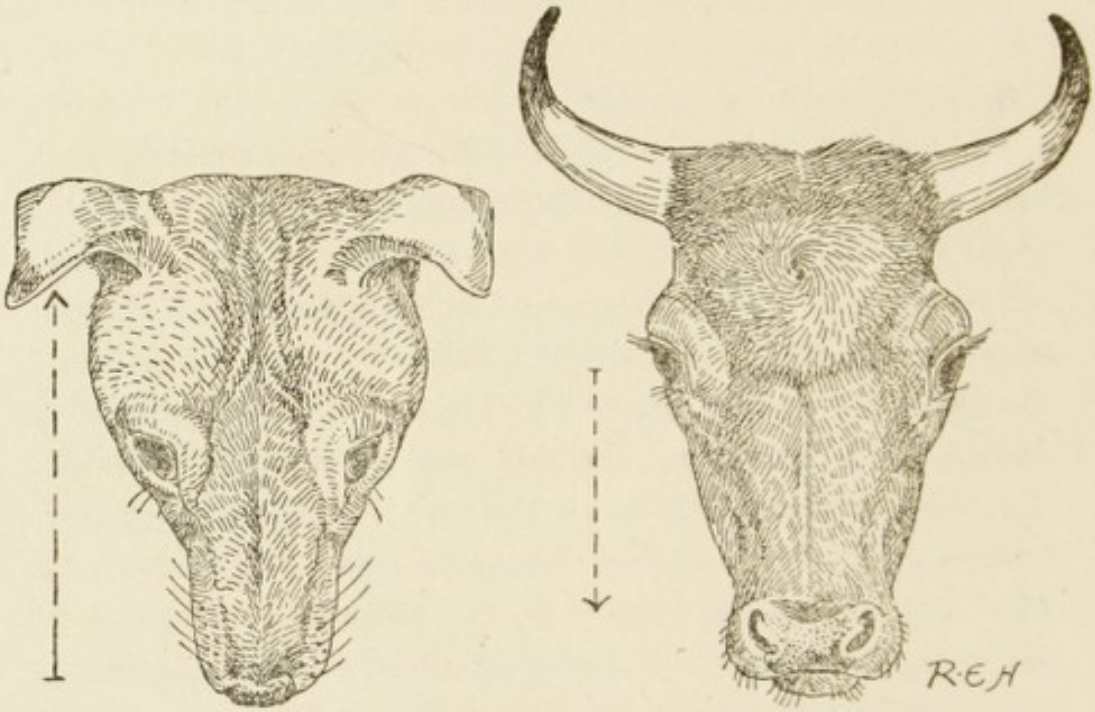


Fig. XI.—Hair-streams on Nasal and Frontal Regions of Dog and Cape Buffalo (Arrows indicate direction of Hair).

whorl, and passes up the central portion of the nasal and frontal regions to join the streams of the neck, sending off branch-streams laterally on the nasal region and at the level of the orbits. This type is seen in a Carnivore, such as a Wolf, Fox, Dog, Bear (Fig. XI.). In the Exceptional type the slope is from the frontal to the nasal region, starting either, as in a Cape Buffalo (Fig. XI.), from the level of the horns, and passing without interruption to the edge of the muzzle, or, as in a Domestic Horse (Fig. II.), from a whorl which usually lies

at or near the level of the orbits, and passing straight to the edge of the muzzle. It will be noted that here the Normal and Exceptional types differ very markedly, and it is sufficient to state that among those showing the Normal type are all Marsupials, Rodents, Insectivores, Ungulates (except for 7 Antelopes, 13 Bovidæ examined, Tapirs, and Equidæ), Carnivores (except about a dozen forms, chiefly the Felidæ), and

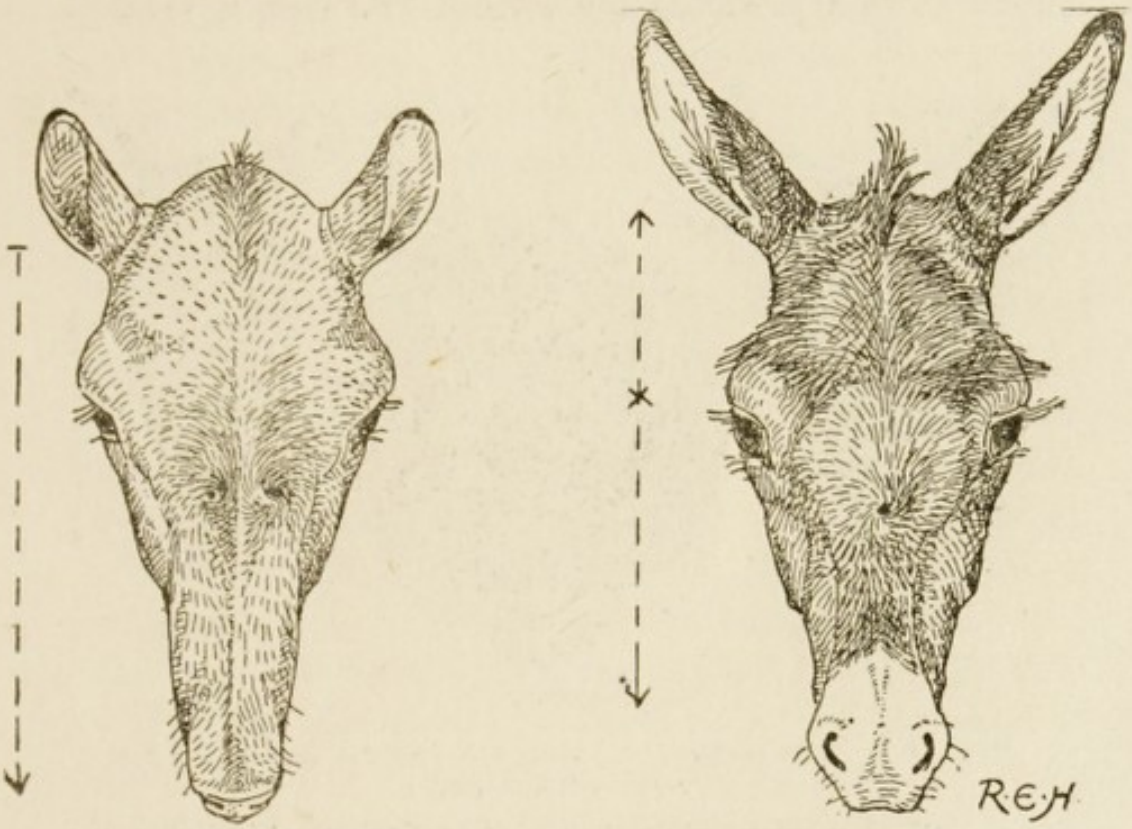


FIG. XII.—HAIR-STREAMS ON NASAL AND FRONTAL REGIONS OF TAPIR AND DOMESTIC ASS.

Lemuridæ. From this brief list it will be seen that comparatively few animals present the Exceptional type, and the terms Normal and Exceptional acquire sufficient justification.

The hair-slope in this naso-frontal region is then open to the three previously mentioned interpretations, and again the question must be asked as to which is the more scientific reading of these simple and trifling facts. I would submit that to lay upon Natural Selection, with adaptation to needs,

the burden of accounting for such small divergences as these, in a biological character hardly worth the name, is to put upon it a breaking strain.

I have shown elsewhere[1] that the Exceptional type is only found in Carnivores, such as the Lion and other Felidæ, with broad snouts, and in Ungulates, such as a few Antelopes, Oxen, and Equidæ, which have the habit of holding their heads more approaching the vertical line than is usual in

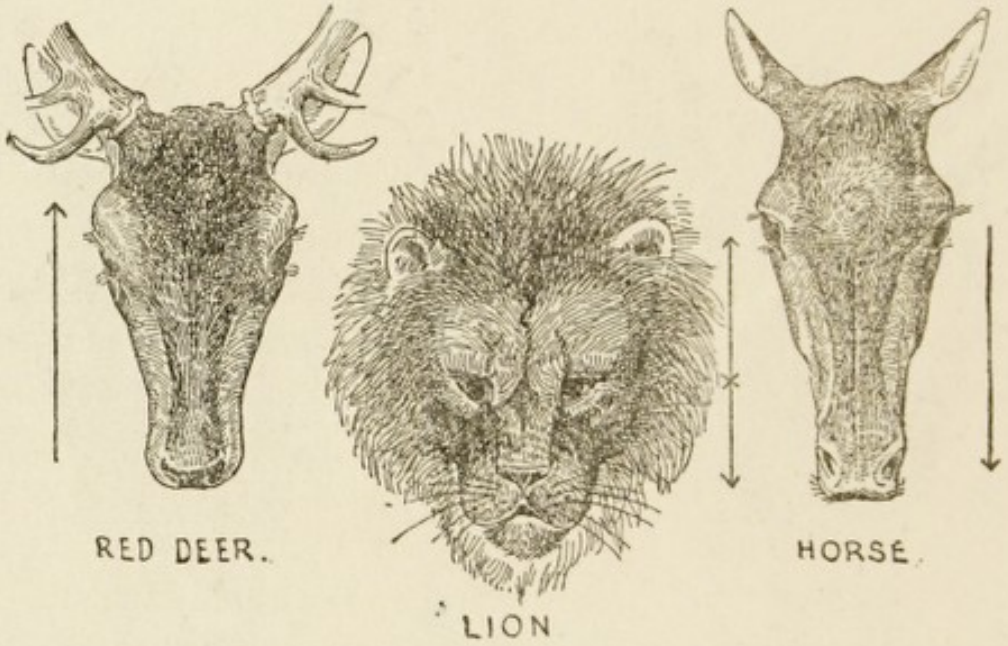


FIG. XIII.—HAIR-STREAMS ON NASAL AND FRONTAL REGIONS OF RED DEER, LION, HORSE.

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

other Ungulates. But it is difficult to see how a mere correlation of breadth of snout in a Lion and the downward 'pose' of a Horse's head can of itself account for a direct reversal of what is found in the long-pointed snout of a Dog, Wolf, or Fox, on the one hand, or the erect level snout of a Deer on the other. The only correlation of the one fact with the other that appears is that the anatomical shape of the part leads to certain *habits*, differing in different forms. This

[1] *Proc. Zoological Society*, London, June 19, 1900.

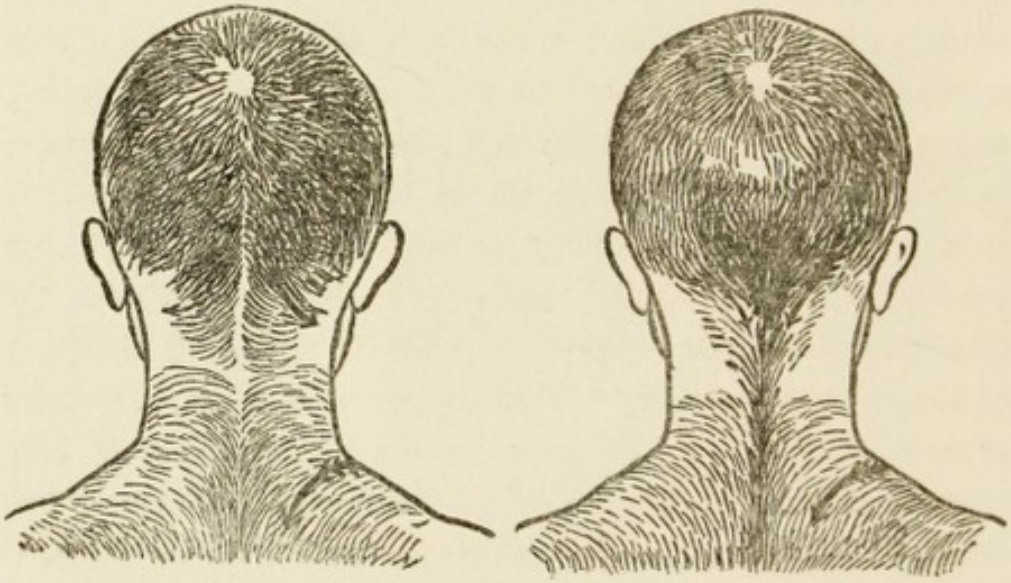
portion of the animal's head is subject to a variety of influences from its environment, and it is difficult to see how a plastic growth like that of the hair could escape being modified in its 'set' by the factors which go to make up such environments, which themselves lead to certain habits. Among these one may mention such as the angle of incidence of wind, tropical rain, the pressure of undergrowth, swampy or marshy ground, water, and such habits as rooting, burrowing, and cleaning of fur. The last appears to me to be a very efficient cause of the variations in slope of hair found on the snout, as it is exceedingly common in animals, and on this region would be calculated to influence the slope according as the snout was pressed against other objects such as grass, or was cleaned by the action of the fore-paws of the animal. It is a matter of observation that the broad-nosed Carnivores are more disposed to clean their fur on the nasal region by an action of their paws which agrees with the distal direction of the slope of hair which they exhibit. It is probable that in most other regions of the body the general slope of hair referred to is much emphasised by the habit of cleaning fur, which can only be in one direction on the trunk and limbs.

It makes the selectionist interpretation of this group of facts no easier to maintain that, the animals referred to being descended from more primitive stock, some factors, not now to be discovered, may have operated in producing, under selection, these changes of slope. This is to leave fact and fair inference for unverifiable hypothesis.

C. *Certain Points in the Hair-slope in Man.*—The distribution of hair on the body of man is sufficiently marked, in any hairy young adult, to be easily traced without a lens, and when so traced it is found to correspond very closely with the arrangement of hair in the fœtus. This has been elaborately figured and described in 1837 by Eschricht,[1]

[1] *Archiv für Anat. und Phys.*, 1837.

and in 1857 by C. A. Voigt.[1] To a considerable extent this arrangement of hair in Man corresponds with that of the Anthropoid Apes, and to that extent is an argument for the theory of Man's descent from a Simian stock. But when the whole surface is taken into account, there emerge certain facts which present to the followers of Weismann's theory of heredity a dilemma which it seems impossible for them to escape. The irreconcilable supporter of that theory has to choose between considering that the hair-slope in Man



Normal. Exceptional.

FIG. XIV.—HAIR-STREAMS ON OCCIPITO-CERVICAL REGION OF MAN.
(Copied by permission from *The Journal of Anatomy and Physiology*.)

is a strong argument against the theory of the Simian descent of Man (as far as present evidence goes), or that it furnishes a body of evidence against his cardinal rule that acquired characters are never inherited. To illustrate this point three regions of the surface of the human body will be considered—*Occipito-Cervical*, *Dorsal*, and *Thoracic* (lateral). These and several other critical areas of hair-slope on the human body have been elsewhere more fully investigated.[2]

[1] *Denkschriften der K. K. Akad. zu Wien*, Bd. 13, 1857.
[2] *The Journal of Anatomy and Physiology*, vol. xxxv. pp. 305-322.

On the *occipito-cervical* region the hair descends in a stream from a whorl found on the vertex of the skull, the median portion of which passes along the whole length of the vertebral furrow to the coccyx, being joined by streams of hair from the trunk. But the lateral portions of this stream in the occipital and upper cervical regions are found to pass in two almost opposite directions in different individuals. In a large number of men, with sufficiently short hair, it is easy to see that about half present one type of slope and the other half a different type. This applies equally to female subjects, but is less easy to distinguish. In the first, which I will call Normal, the central stream passes away *from* the middle line in varying levels to coalesce with the streams from the side of the head and face and the ventral surface of the neck. In the second or Exceptional type the streams from the side of the head, face, and neck pass *to* the middle line, and with the occipito-cervical central stream form a united one which curves more or less sharply towards the middle line (Fig. XIV.).

These terms "Normal" and "Exceptional" are used so that one may distinguish the Normal type, or that one which, on the theory of Man's Simian descent, should be inherited, from the Exceptional type, which requires some other interpretation than that of descent. In all Monkeys and Apes examined the so-called Normal type has been found by me, and no approach to the Exceptional. This, then, is characteristic of a certain number of the human species, and is absent from his supposed nearest congeners. A difference of type so marked as this, even in those of British blood, which it is impossible to bring under Natural Selection, requires an interpretation which can only be Lamarckian. I have suggested[1] that the Normal type is the one inherited from the male, and the Excep-

[1] *Journal of Anatomy and Physiology*, vol. xxxv. p. 313.

tional from the female line. In the first place, this would agree with the nearly equal numbers which present the two types in this country. It would also agree with the fact that every form of dressing this portion of hair—the 'back-hair'—would involve a certain constant traction of the lateral hair-streams towards the median line. In the early history of Man's development a time must have been when a growing desire for self-adornment brought with it some form of dressing the hair; and from what one knows from modern parallels, the female would both precede and distance the male in such practices. The male would then be, and has to a great extent ever since been, disposed to allow the hair to take its natural course, by either not dressing it at all, or combing it downwards. No doubt in Mongolian peoples the *queue* has existed for thousands of years—in China for a much longer period than in Japan; and among such peoples this point of ætiology would need to be tested in a way which cannot be done in Western peoples. If the interpretation here suggested be not the correct one, it is difficult to see any other for a difference so singular, and, if one may so say, so whimsical.

In the *Dorsal* region Man's hair-slope shows another remarkable divergence from that found in every member of the Simian stock that I have been able to examine. In Apes and Monkeys the general trend of hair follows the usual rule, and they invariably, as far as I can ascertain, show a marked slope of hair in the long axis of the trunk, which accords very closely with their frequent assumption of the erect position. Man's dorsal region shows a slope of hair which is not far removed from a direct reversal of that on the corresponding region of an Ape. The streams of hair which curl round the thorax and lumbar region from the ventral surfaces, to form those of the dorsal region

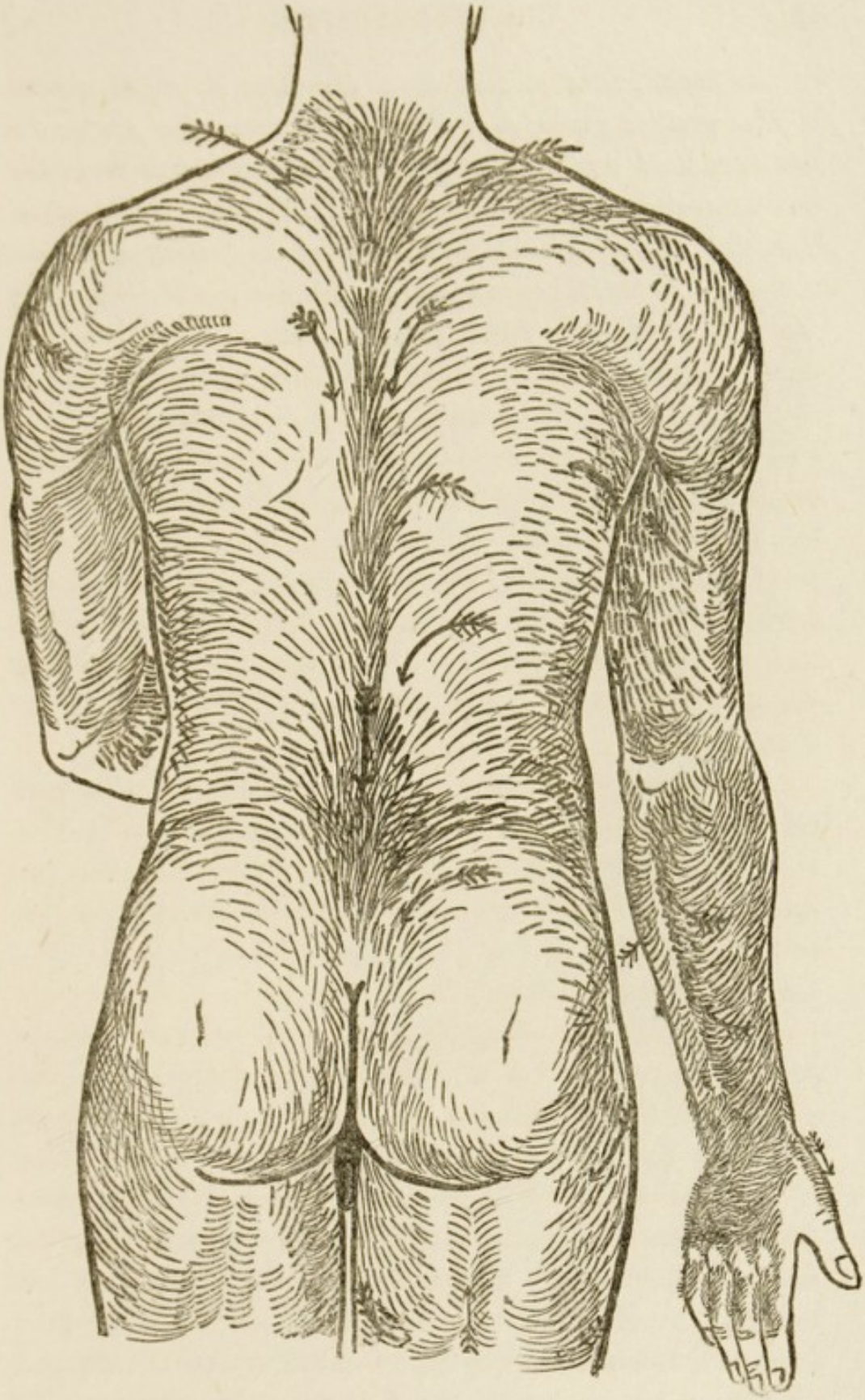


FIG. XV.—DORSAL VIEW OF TRUNK OF MAN, SHOWING HAIR-STREAMS (DIRECTION INDICATED BY ARROWS).

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of the trunk, pass at first in a direction at right angles to the median plane, and then, when 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 direction of the corresponding hair-streams on a Dog or a Horse.

This aberration of hair-slope I have suggested to be produced by the habit which Man has of spending about a third of his life, during sleep, in lying mostly on his side, and, for some millenniums at least, with some sort of rest for his head, of which a pillow is the modern development. A very little reflection shows that this attitude on the part of Man in sleep, whether on his back or on his side—the latter being by far the predominant attitude—supplies just the necessary mechanical conditions for producing the hair-slope in question. It must also be remembered that the only other force acting

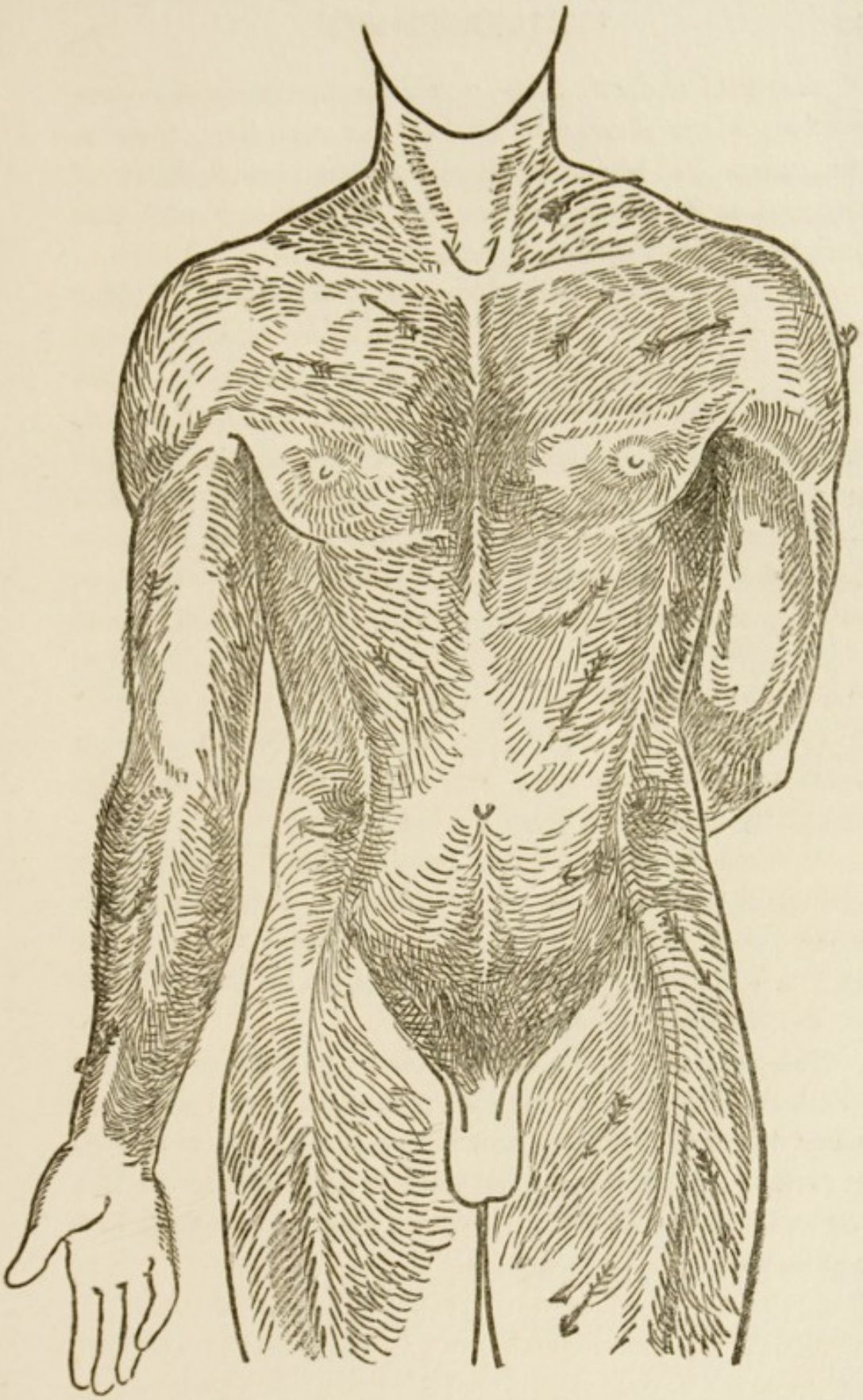

FIG. XVI.—ANTERIOR VIEW OF TRUNK OF MAN, SHOWING HAIR-STREAMS (DIRECTION INDICATED BY ARROWS).

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on this part of man's body, worth mentioning in this connection, is one similar to that in the recumbent position, viz. when he leans backward against some object of support, as in sitting, so that this attitude and habit also tend to confirm the described slope.

On the *Thoracic* (lateral) region a peculiarity of hair-slope is found in Man which is also different from any found in the Simian family. The streams of hair passing to the ventral surface of the thorax and abdomen, and that passing to the neural aspect of the trunk, divide in a remarkable manner at a line which passes from the centre of the axilla in a slightly sinuous direction to the centre of Poupart's ligament, being interrupted a little before it reaches the level of the umbilicus by a radiating whorl. There is thus formed a parting of the streams, as they pass to the two surfaces of the trunk, which lies exactly where the arm of that side rests in sleep if the person is lying on his side, and the whorl is found just where the point of the elbow lies, when this joint is slightly flexed, as it generally is in sleep.

I would suggest that this purely human character of a parting of the streams is due to the slight pressure which is being constantly exercised in sleep, according to the degree in which the person lies on his side or more towards his back, by the weight of the upper arm.

The *Extensor surface of the forearm* in Man (see Fig. X.) has been referred to under the description of this surface in Carnivores and Primates, and it is not necessary to refer to it further, though it is a strong case, when considered in Man alone, in favour of the Lamarckian view of hair-slope here put forward.

SUMMARY

1. To understand the disposition of hair on living animals, it is necessary to look upon it as a stream, and this is very plastic.

2. In Man, and various groups of animals, the great majority of the peculiarities here noted are congenital.

3. Certain peculiarities of hair-slope are at present in process of development.

4. The hair-streams are disposed in the lines of least resistance.

5. The mechanical conditions required for the production both of the general and special hair-slopes are in present operation.

6. The hair-slope can be modified during the life of an individual.

7. Selection (whether natural, sexual, or germinal) is incompetent to produce these peculiarities of hair-slope.

8. If these were not originally created with the forms of life which present them, they must have been produced in ancestors by use or habit.

APPENDIX

(2) The *Frontal* whorl is present only in the *Ungulate* order and in the following species:—Bos indicus, B. frontalis, B. sondaicus, B. depressicornis, B. taurus (Congo Buffalo) (Chillingham Wild Cattle), B. bubalis, B. mindorensis, B. caffer, B. grunniens, B. bonasus, B. americanus; Ovibos moschatus—Oryx beisa. Bubalis swaynei, B. tora, B. tragocamelus. Connochœtes gnu, C. taurina. Saiga tartarica. Cervus tarandus. Zebra. Quagga. Equus asinus, E. hemionus, E. caballus.

(3) *Nasal* whorl is present in *Lemuridæ*, *Œluroidea* (except Felidæ), *Cynoidea*, *Arctoidea*, and in the following *Ungulates*: Bos indicus, B. frontalis, B. sondaicus, B. depressicornis, B. taurus (Congo Buffalo), B. grunniens, B. caffer, B. bonasus, B. americanus, Ovibos moschatus—Oryx beisa, Bubalis swaynei, B. tora, B. tragocamelus, Connochœtes gnu, C. taurina, Saiga tartarica, Cervus tarandus, and in *Cervidæ*.

(4) *Cervical* whorl 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, Connochœtes albojubatus, Cobus defassa, Oreas canna, Nemorhœdus bubalinus, Zebra (Grevy's).

(5) *Spinal* whorl present in Felis leo, F. pardus among *Carnivores*, and among *Ungulates* 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.

(6) *Pectoral* whorl present in so large a number of Mammals that it is sufficient to enumerate the chief forms in which it is absent, which are chiefly *Ungulates*. It is, however, absent also in many long-haired animals. Absent in Bos gaurus, B. mindorensis, B. caffer. Bubalis cokei, 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. speki. Antidorcas euchore, Genus madogna, Oryx gazella, Muntjacs, Cephalophus sylvicultor and jentinkeii, Damaliscus pygargus. Among *Equidæ*, Equus asinus, Zebra. Among *Rodents*, in all examined. Among *Marsupials*, Macropus irma, M. ualabatus, M. ruficollis, and many smaller forms of Macropus.

(7) *Post-humeral* present in Strepsiceros kudu. Rangifer tarandus. Cobus leche. Equus hemionus. Equus burchelli (young). Bos sondaicus, B. depressicornis. Ovis ophion, O. ammon, O. sairensis, O. Poli. Antilocapra americana. Dorcelaphus americanus, D. dichotomus. Elaphurus davidianus. Lama huanacus.

(8) *Inguinal* present in Bubalis caama. Rangifer tarandus. Cervicapra fulvorufola. Cervicapra 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 male, absent in female). Gazella granti, G. mohr. Antilocapra americana. Cephalophus dorsalis. Cervus kuhli, C. elaphus. Camelus bactrianus. Lama huanacus.

THE END

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PART IV.

THE PLATYHELMIA, MESOZOA, AND NEMERTINI

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