THE R. M. JOHNSTON MEMORIAL LECTURE, 1925. THE MAMMALIAN TOILET AND SOME CONSIDERATIONS ARISING FROM IT.

By

FREDERIC WOOD JONES, D.Sc., F.R.S.,

Elder Professor of Anatomy in the University of Adelaide.

With 23 Text Figures.

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Few ways of honouring a departed pioneer in science could be conceived as more appropriate than the establishment of a memorial lecture. Among the memorial lectures that have been founded the world over to commemorate the life and work of outstanding men in the realm of Science, the R. M. Johnston Memorial Lecture may be considered as a younger member. For this very reason the delivery of the lecture becomes a matter for careful deliberation. Should the lecturer attempt to interpret some phase of the work of the pioneer in whose honour the lecture is delivered? Should he take some episode from the career of the leader and elaborate that into a theme into which his own work may be woven? Or should he merely give his own and, as far as his ability lies, the best of his own, as a tribute to the memory of the man whose life work the lecture honours?

I am tempted to adopt this last course, and this for two reasons; the one that certain memorial lectureships have an accepted standard, to which successive lecturers, over the interval of centuries, have attempted to attain, of expounding the doctrines of some great teacher.

It has often seemed to me that in these lectures there was a possibility that the lecturer might have had a message to deliver, but that in paying tribute to the master and attempting some familiarity with his writings and his work the message has become so subordinated as to be well nigh undecipherable.

The second reason for departing from the tradition that clings to certain memorial lectureships and, thereby, in establishing a precedent in this one, is that my predecessor

in this office, Professor Sir Edgeworth David, delivered what might be termed *the* R. M. Johnston Memorial Lecture.

There is no man who might be better trusted to place an appropriate verbal wreath upon the tomb of a scientific pioneer; no man who could better strew the pathway of memory with the petals of well merited praise than Sir Edgeworth David. It might be said that, as a memorial lecture, he has left this office a barren one by virtue of his own tribute.

I feel, therefore, that I am absolved from attempting a task such as Sir Edgeworth David accomplished. But I feel also that Sir Edgeworth's tribute is only one aspect of a memorial lecture; the other is to offer up, in memory of a great man, that which in one's present occupation seems most fitted to constitute a subject for philosophical reflection and for possible suggestion as to future lines of research. I shall, therefore, elect, as the R. M. Johnston Memorial Lecturer for 1925, to pay my homage rather in the form of a lecture which introduces certain matters for homely consideration than in attempting to elucidate any phase of work, or in dwelling upon any special researches, of the man whom we are met to honour.

Who first invented proverbs I do not know. There is a suggestion of the East about many of them, but probably they are common to all humanity. Most proverbs are retained in common usage since they may be employed as maxims wherewith age and experience may advise or admonish youth and inexperience. But some are double-edged. The child who is reproved for adopting the natural method of eating with his fingers has always in the background, even if it comes no further into usage as a very present help in time of trouble, the saying that "Fingers "were made before forks." The child is in the right. It is true, fingers *were* made before forks, and herein lies the charm that captivated Samuel Butler.

Butler's was the mind that placed forks and fingers in their proper perspective. What is a fork but a finger made, as we say, artificially? What is a fork but an extended organ —an external organ? Did we not make both? As Butler himself said (1): "The organs external to the body, and "those internal to it are, the second as much as the first, "things which we have made for our own convenience, and

(1) *Evolution, Old and New*, Reprint, Fifield, 1911, p. 39.

"with a prevision that we shall have need of them; the main "difference between the manufacture of these two classes of "organs being that we have made the one kind so often that "we can no longer follow the processes whereby we make "them, while the others are new things which we must make "introspectively or not at all, and which are not yet so incor- "porate with our vitality as that we should think they grow "instead of being manufactured. The manufacture of the tool "and the manufacture of the living organ prove, therefore, to "be but two species of the same genus; which, though widely "differentiated, have descended, as it were, from one common "filament of desire and inventive faculty."

Tools and limbs—there is not much between them. The limbs are part of us, and made in our own making; the tools are only temporarily part of us, and made independently of our structural unfolding. Forks and fingers; if we regard them as Butler did, there is not a great difference between them. Fingers grow on us, forks are part of us only during meal times; but we shall see that there is a very pretty sequence in the development of these things.

Fingers were made before forks, that is true. But think of how many things were made before fingers were invented, and, in order to limit the discussion, think of how many other things were made in order to assist and extend the office of the fingers in some very humble processes—functions which we are usually prepared to forget or to pass over.

Most people have a proper respect for the scientific worker whose daily occupation leads him to contemplate the ordering of the movements of the heavenly bodies, and even the man who spends laborious days in unravelling the story of atoms is recognised as one living in an elevated sphere of mentality. But what can be said for the man who has a mind of such a homely type that he is willing to be perplexed by the problem of how animals keep their ears clean? The process of keeping the ears clean is one that is generally considered to be hardly worth studying, and certainly one of which the importance does not excuse the nastiness. The business of keeping the ears clean is, however, only a detail in a great scheme of processes, some of the other details of which are far less suitable for polite discussion.

The whole great assemblage of processes we may group together under the title of Toilet Operations. These little operations are homely enough things, and yet if we are prepared to forget their lowliness, and what might even be termed their unpleasantness, there are several lessons to be learned from them. Just as fingers were made before forks, so were fingers made before tooth brushes and tooth picks. But what preceded fingers in those animals in which the digits are so altered as to be useless for these functions? We shall see that, in almost all toilet operations, nature has invented some peculiar device for the performance of the function; that this device is rudimentary or absent when the animal possesses fingers, which can perform the operation better; and that, as a final stage, man has invented other artificial members to replace the use of the fingers. The sequence is in three stages. First there is the local mechanism, then there is the digit, and last the external instrument. Ears must be kept clean—every schoolboy knows it. In many animals there are structural specialisations developed for this purpose. There are processes of the external ear developed for shutting up the passage. There are, in many marsupials, for instance, mechanisms for folding the whole ear and protecting the inner parts; and then there are all sorts of specialised glands and specially directed hairs for keeping the passsage free from foreign bodies. In us some of these things persist. We have a complete system of wax glands, and secretor-motor nerves supplying them; we have rather variably developed specialised bristle hairs (vibrissæ) in the external auditory meatus. The wax that is secreted from the wax glands is a peculiar substance, its function seems obviously to be that of snaring particles of foreign matter gaining access to the external auditory meatus. It is a substance that does not decompose; but it slowly shrinks and dries after it is excreted. It seems as though in our ears wax were secreted at the bottom of the external auditory meatus, that it was destined to dry up, but that there was no normal mechanism for expelling it from the external auditory meatus. Indeed, we know that aural surgeons who are specially gifted in curing deafness are commonly especially skilled in the simple business of removing wax from the ear. But many years ago I was told by an aural surgeon that there was a mechanism provided for ridding the human ear of the wax that has been secreted and has accomplished its purpose. The wax, as it is secreted, enmeshes the vibrissæ, the axis of which is oblique. As it contracts it pulls these bristles down; but the turning point comes, the inspissated wax parts company with the surface of the

passage, the hairs straighten themselves suddenly, and the mass is loosened and freed. How true this dictum is I do not know, but that wax may be suddenly loosened from the ear, with a quite recognisable "click," is probably within the experience of all. I imagine that the explanation is a reasonable one, and I think that an inquiry along these lines might solve the problem of why some people are for ever becoming deaf, owing to the accumulation of wax, and others never suffer from this condition.

Whatever may be the mechanism of freeing the wax from the depths of the ear, there is no doubt that its ultimate removal is, in man, effected by the nail of the little finger. So obvious is the office of the little finger in this connection that for centuries the fifth digit of the manus was known to the learned by the name *Auricularis*. To-day we term it *Minimus*, but to my mind, though this name may be considered more polite, it lacks the distinction of assigning a definite function, however humble, to this digit.

In this matter of digital nomenclature we may take Diemerbroeck as our guide. Of the digits he says:—"The "first, which is the thickest, and equals all the rest for "strength, is call'd *Pollex* or the Thumb. The second is the "Forefinger from the use, call'd the *Index*, or *Demonstrator*, "the Pointer, because it is us'd in the demonstration of things. "The Third or *Middle*-finger is call'd *Impudicus*, *Famosus*, "and *Obscoenus*, the Obscene and Infamous, because it is "usually held forth at men pointed at for Infamy, and in "derision. The Fourth, the *Ring-finger*, or *Annularis* and "*Medicus*, the Physitian's-finger; because that Persons for-"merly admitted Doctors of Physic were wont to wear a "Gold Ring upon that Finger. The Fifth, call'd the Little-"finger, in Latin *Auricularis*, or the Ear-finger, for that "men generally pick their Ears with it." (2)

It may perhaps be doubted if this explanation of the name "obscoenus" for the third digit is correct. We all know of the degradation that results from being pointed at with the Finger of Scorn; but I have a fancy that this is not the origin of that very peculiar name for the middle, or longest, digit of the manus. As for Auricularis, he is clear and direct. There is no gainsaying Diemerbroeck's explanation of the name.

(2) Isbrand de Diemerbroeck, *The Anatomy of Human Bodies*. Translated by William Salmon, London, 1694. Book III., Chapter II., p. 494.

After all, those of our race should be the last to be squeamish concerning the toilet functions of the fifth digit. With us it is not a case of fingers were made before forks, for we have not yet invented the successful fork unless the rolled up edge of the towel so much and so rightly dreaded by the child can be accounted as such. The fork, or its equivalent, has, however, been invented by others. Few, if any, of the Asiatic races are without a definite instrument for cleaning the external auditory meatus. In the splendid coils of her black hair the Malay woman wears a little silver pin some six inches long; one end of this ornament is pointed, the other, which is crooked, is fashioned like a tiny spoon. This is the Korek Kuping, and, though it is an ornament worn becomingly in the hair, it is also a functional instrument, the use of which is the toilet of the external ear. (See Figure 1.) Fingers were made before Korek Kupings, and

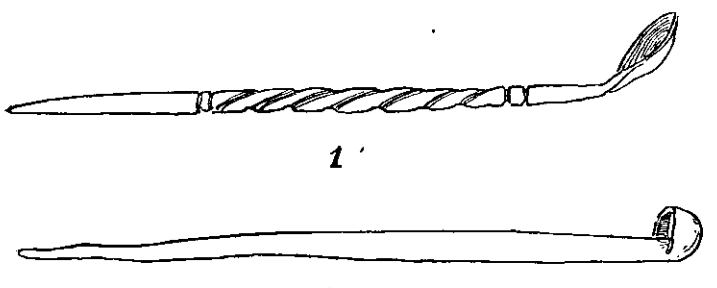

Figure 1.—Two examples of the Korek Kuping—the toilet implement of the ear. (1) A Malayan and (2) a Chinese specimen.

we—though it may be on the sly—still employ the fifth digit of the manus for the office the Korek Kuping was designed to discharge. Although we have ceased to name it Auricularis, we still, behind closed doors, demonstrate the appropriateness of that name. It may even be suggested that the adoption of an instrumental Auricularis, such as is employed by Asiatic races, would be a movement in the direction of toilet refinement. It is true that such an instrument has been invented, and has been made available in chemists' shops. This invention, however, which was known as an "aurilave," was branded by the contemporary aural surgeon (C. H. Burnett, *The Ear*, 1884) as "that most pernicious "and reprehensible instrument," and, so far as I know, aurilaves enjoy no present-day popularity.

If we open the mouth of a dog and look at the margin of his lips we see that the condition differs very widely from that which we see when we look inside our own lips. The margins of the lips of a dog, or indeed of the lips of most mammals, are beset with curious little tags and frills. (See Figure 2.) These little tags are processes of the substance

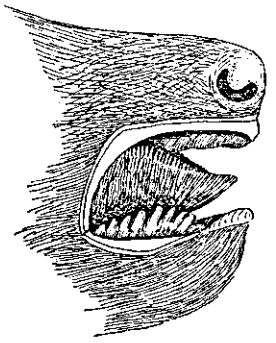

Figure 2.—The mouth of a Wolf Cub with the cheek removed, to show the papillæ growing from the lip and from the side of the tongue.

of the lips, bluntly pointed at the ends, and clothed with a surface epithelium, which is almost horny in its nature. If this frilled fringe of the lip is left in apposition with the teeth it will be noticed that the little processes lie against the teeth and that, when the lip is moved, the tags work up and down along the interspaces between the teeth and on the surfaces of the teeth themselves. If we look further into the mouth we shall notice that, on the inner side of the tooth row, there are other tags developed from the side of the tongue, or from a fold below the tongue. The outer row of tags, or labial processes, are variable in form in different mammals, but are constant in site, inasmuch as they arise from the margin of the lips. The inner row of tags may arise either from the sides of the tongue itself or from certain folds, the *plica sub-lingualis* or the *plica fimbriata*, below it. (See Figure 3.) All of us have admired the clean white teeth which most animals possess; and those who have regarded rats as being unclean, because their teeth are yellow, forget that the yellow colour is natural to the enamel of their incisors. The beautifully clean white teeth of the carnivora know no artificial tooth brush; they are innocent of tooth powder, tooth paste, or tooth pick. They are cleaned in the

common mammalian fashion by the play of the little rubber fingers of the lips and tongue.

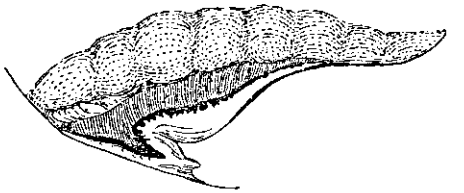

Figure 3.—The tongue of the Flying Opossum (*Petaurus breviceps*), to show the fringe of papillæ (plica fimbriata and plica sublingualis) along its side.

In the Primates these little tags are lacking, but it is not to be forgotten that the human child at birth shows a condition in which the lips are beset with little papillæ which seem obviously to be remnants of those which are present as a common mammalian heritage. (See Figure 4.) In the

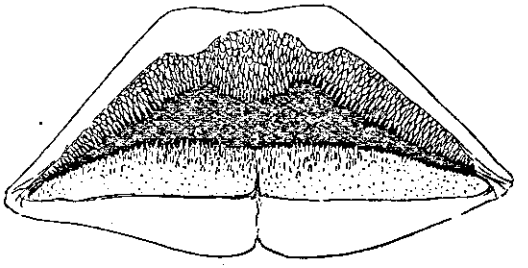

Figure 4.—The lips of a new-born baby, to show the little papillæ with which they are clothed (after Ramm).

Primates the intimate tooth cleansers seem to have been subordinated to the activities of the digits.

We have our tooth brushes and our innumerable dentifrices, but we must remember that our tooth brushes, by working along the line of our teeth and not up and down, as do the labial and lingual processes, are not so effective in cleansing inter-dental spaces as are Nature's methods. Nor must we forget that European tooth brushes are not the only kind invented by man, for many races use a brush which is applied up and down as are the lost intimate tooth cleansers. Such tooth brushes, which are very like the frayed-out ends of wooden meat skewers, are widely used, but though put on the European market have, I believe, never proved acceptable to European taste.

Even the up and down tooth brush does not exhaust the aids to dental cleanliness employed by some races, and for a complete armamentarium for the dental toilet probably the Chinese is as well equipped as any man. Perhaps it may here be said without shame that, for what may be termed the general toilet of the mouth, the European lags far behind the Asiatic. We Europeans have our tooth picks, which enjoy a curiously anomalous acceptance midway between covert usage and open display upon restaurant tables. These articles may be purchased expensively, wrought of gold and silver, or cheaply when made of wood or quill; but their recognition is only partial. They are not employed overtly as the tooth brush, the neglect of which is shame, they are not unknown as is the Korek Kuping; they are in a stage of recognition as implements but of disfavour as to public employment. We do not know if their usage is of the right hand or the left.

Fingers were made before tooth brushes and tooth picks; but before fingers there came a whole series of beautiful adaptations to the local mechanism of cleansing the teeth.

As with the ears and with the teeth, so with every other external part which may need toilet attentions.

No more delicate external organ than the eye can well be imagined; and although we must not fall into the popular error of supposing that eyelids are developed purely for the purpose of protecting or cleansing the eye, we must not overlook their office in this matter.

There is a very attractive Gecko, which is widely distributed in Australia, but does not extend its range to Tasmania, named *Gymnodactylus miliusi*, which in Australia has almost become legendary as the "Wagga," which stands on its hind legs, barks like a dog, and bites severely and venomously. It is a charming and harmless creature, which is certainly vocal and certainly stands erect on the tips of the toes of all four feet; but beyond that does nothing outrageous. Like all Geckos, it lacks moveable eyelids; but lacking one instrument, it uses another, and its tongue replaces the absent eyelids in the office of removing particles from the surface of the eye. *Gymnodactylus miliusi* has an attractive habit of solemnly sweeping its tongue over the surface of its eyes, and probably other Geckos can do the same. But though Geckos and other animals may employ expedients of this sort, the real mechanism for conducting

the toilet of the eye is the third eyelid, or nictitating membrane, acting in conjunction with the upper and lower lids. Though the upper and lower lids have other functions to perform—the third eyelid is a toilet implement pure and simple—its function is to sweep across the eye and remove particles and draw them across to the inner corner of the eye. It works like the Gecko's tongue. In all the monkeys this third eyelid is a mere rudiment, just as it is in man, but in some mammals it is of considerable size. As Robert Knox observed, "The third eyelid, perceptible enough in man, "though clearly a vestige; more developed in the ox, horse, "dog; still more in the elephant; most of all in the bird—"ever the same elements nearly are found in all; it is merely "a question of size and function, but not of kind or "organisation." (3)

We are so used to being able to remove foreign bodies from the inner corners of our eyes by the use of our finger tips that it is difficult to picture the condition in those animals in which no instrument save the innate toilet mechanism of the eye exists.

It would seem that the mobile, inquisitive, and resourceful finger had usurped the functions of many very beautiful mechanisms, and let it be remembered that in the three simple examples of the ear, the teeth, and the eye, which have been instanced by way of introduction, we have only invaded the marches of this great realm of the special digital toilet.

Would you hand the sweetmeats to a son of Islam you must elect the right hand for that office; for there is a specialisation in the usage of the hands for offices polite or impolite. I have, in the examples I have cited, chosen somewhat from the right handed offices of our digits. Not only have we limited ourselves to the more or less honourable use of the digits, we have also limited ourselves to certain special portions of the body, which may be defined as the orifices of certain sense organs—though from choice we have left the nose out of account. In all this we have not considered the great question of the toilet of the general surface of the body, the toilet of the coat, the business of keeping the whole of the skin and hair orderly and clean. In this business many mechanisms play, or have played, their parts, and we should look to see wide differences in the toilet appliances, for there are wide differences in type of

(3) Robert Knox, *Great Artists and Great Anatomists*, 1852, p. 196.

the toilet to be performed. A hairy coat is the birth-right and the hall-mark of the mammal, but the nature of the hairy coat varies widely, since a mammal may be clothed with spines or bristles, with harsh, coarse hair, with fine silky, velvety, or woolly fur, or it may be relatively or absolutely naked.

For all sorts and conditions of spines, hairs, and furs there must be a special and definite toilet and a definite toilet mechanism. There is also another consideration; there may be parasites of very varying types that find lodgment in the coats or upon the skin of the animal. The presence and the nature of parasites are important factors, and they have probably played a conspicuous part in the begetting and moulding of toilet implements.

We brush our hair when we rise in the morning, we may do it again in between times and before we retire at night. Animals perform the toilet of the coat at very varied intervals; some do it only when the call is imperative, some perform it almost without ceasing during their waking hours. As a homely example, the cat is for ever at its toilet when not otherwise employed; the dog devotes its energies to a good scratch only when the insistent attentions of a flea, or something of the sort, have evoked an imperative desire to scratch. In this very homely illustration there lies a deep physiological truth. The dog possesses the well-known "scratch reflex"; tickle his front ribs, and his hind legs will start scratching movements in response. The cat has no such generalised reflex, save for a slight local manifestation around the ears. You may tickle a cat's ribs as long as you care to do it, but you will never produce a sympathetic twitch in its hind leg, such as may be evoked on an instant in a dog. The coat toilet of the cat is a deliberate operation, the occupation of a well-employed leisure. The coat toilet of the dog is a reflex and unconsidered affair, imperative, utilitarian, and unæsthetic in its manifestation.

There are many ways in which the toilet of the surface of the body may be conducted, and in order to introduce some system into their study it is best to take the different methods and examine them separately.

(1) BY RUBBING AGAINST EXTERNAL OBJECTS.

This may be termed the method of the itching post, and it is a favourite method with certain animals that lack toilet implements of their own.

It is because of the general lack of toilet implements among the *Ungulata* that this rubbing against posts and trees has become so characteristic of them. The hoof prohibits scratching. As the animal cannot scratch itself, it must find something which will do the scratching for it. It invents a toilet implement; though it has not made a fork it has found an itching post.

(2) BY BRUSHING OR FLICKING WITH THE TAIL.

These methods play no great part in the toilet of the coat as we are here considering it, nevertheless they are important enough from the point of view of the animal. It is again in the *Ungulata*, cursed with the hoof instead of the hand, that the tail functions so predominantly as a toilet organ. In the study of structure and function, it would perhaps be difficult to find an organ of such outstanding interest as the tail. This dead end of the vertebrate body, left over after the body and its organs are fashioned, is ever available for some office. The various uses that have been made of it afford material for a bulky thesis.

Could John Hunter, the Very Revd. William Paley, and Samuel Butler have entered into partnership and produced a joint work upon the uses of the tail we would have had a regard for the tail almost as great as we have at present for monkey glands or pituitary bodies. The mammalian uses of the tail are legion; in comparatively few animals does it function as an instrument of the toilet, and then its office is called upon only because some other, and more customary, instruments are at fault. The horse, for instance, relies on its tail to perform the office that would be fulfilled by the teeth or the claws of a dog.

(3) BY SCRATCHING WITH HORNS OR ANTLERS.

This method of conducting the toilet of the coat is again a limited one, and one that does not lead us far. As with the itching post and the tail, it is mainly a toilet substitute of the *Ungulata*. Scratching with horns and antlers is necessarily limited in its manifestations in the mammalia; it is limited also, even in the horn-bearing animals, to the parts of the body to which it can be applied. A stag, an antelope, or a cow can scratch only a limited part of its body with its antler or its horn. Although these things play a definite rôle in the toilet of the coat, their rôle is limited in area and limited in its display among the mammals.

(4) BY TWITCHING WITH MUSCLES.

Everyone has seen this simple toilet operation performed by a horse; the little flicker that runs beneath and shakes the skin is familiar to everyone. The special subcutaneous muscle sheet which produces this twitching is very variably developed, and is put to many uses in different animals; as a toilet muscle its great function is to dislodge from the skin flies, parasites, and foreign particles which lodge upon portions of the body difficult to reach with any other toilet instrument. For our present purpose the panniculus carnosus sheet, which is a toilet muscle in so far as it is a twitching muscle, is of only minor importance, although twitching as a fine art is seen at its best among the marsupials.

(5) BY LICKING WITH THE TONGUE.

The tongue is in very different case from the other toilet instruments we have reviewed. The tongue—the member most unjustly named unruly—is one of the most perfectly adjusted neuro-muscular mechanisms in the body. A marvel for precise action, a revelation for obedience to cortical control, the tongue seems ever ready to take on new offices. Among these offices a conspicuous one is that of conducting the toilet of the coat by the process of licking. Although it is a simple thing to watch animals and to appreciate the enormous importance of the tongue as a toilet instrument, it is by no means easy to determine what modifications of the tongue itself are due to its toilet offices. In writing of the Lion's tongue, Flower and Lydekker (4) say:—

"The tongue, like that of every other species of the "genus, is long and flat, and remarkable for the development "of the papillæ of the dorsal surface, which (except near the "edge) are modified so as to resemble long, compressed, re- "curved, horny spines or claws; those near the middle line "attaining the length of one-fifth of an inch. They give the "part of the tongue on which they occur the appearance and "feel of a coarse rasp, and serve the purpose of such an "instrument in cleaning the flesh from the bones of the "animals on which the Lions feed." This rasping flesh from bone is a business of which we have all been told, and I would not dispute that it indeed may be an important matter. That the curious roughness of the tongue of the cats is in reality begot for flesh-rasping is to my mind a

(4) *An Introduction to the Study of Mammals, living and extinct*, 1891, p. 507.

very doubtful supposition. I think it may be contended that among the functions for which this peculiar roughness would be required, the business of coat toilet far outweighs that of flesh-rasping when we come to observe the habits of, even, a domestic cat. Although the flesh-rasping function has become the accepted and traditional explanation of the peculiar rasp-like nature of the tongues of the *Felidæ*, I feel certain that the brush-and-comb tongue is essentially a toilet implement, and that the flesh-rasping habit is rather a minor one, magnified in order to explain a very peculiar structure. In such a study as this we must not forget that apparent triviality may be compensated for by frequency; a condition that is often not duly considered. The toilet of the Feline's coat is a never-ending business, for every once that a cat's tongue is called upon to rasp flesh from bone it is employed a hundred times as brush and comb and sponge in one.

The toilet of the cats is a remarkable affair, and one well worth watching. It will be noted that the animal licks all parts of its body that are within direct reach of its tongue, and the tongue can reach almost all its body save the sides of the face, the top of the head, and the back of the neck. In order to conduct the toilet of these parts the cats have perfected a toilet process, which, so far as I know, is confined to them; they lick the side of the paw and cleanse the head and face with that. This use of the furry manus as a sponge is, I believe, unique with the *Felidæ*, but I by no means feel prepared to uphold the thesis that, when the operation is carried to the backs of the ears, rain is likely to follow.

It is not only cats and the other members of the *Felidæ* that lick their fur for the purposes of the toilet. Many marsupials lick wide areas of the body; but here only a certain element of this extensive operation may rightly be claimed as a toilet process. I do not know that it has been sufficiently appreciated that this extensive licking of the marsupials is merely a substitute for perspiration. In very hot weather, dogs, which cannot sweat, loll out their tongues and evaporate moisture from the wet surface. This is a substitute for sweating. Many marsupials, such as opossums and kangaroos, when distressed by the heat, lick the whole of the forelimbs, and with increasing need for heat radiation moisten large areas of the body by means of licking with

the tongue. This operation must not be mistaken for a procedure for conducting the toilet. It is merely a means of providing an evaporating surface, in the absence of sweat glands. There is, however, in almost all marsupials a residual licking, which is purely a toilet operation, and this is the business common to all mammals that, to use the recognised expression, lick their chaps. Apart from the elaborate feline tongue-toilet, and apart from the common mammalian process of the licking of the chaps, many animals have a limited toilet of the coat which is conducted by the tongue. Most *Ungulata* lick these portions of the body (and they are limited) which can be reached with the tongue. Everybody has seen a cow turn its head and lick the very small area available to the exploration of its tongue. There is an interesting sequel to this business of licking the coat. Should the condition of the coat be below normal, the tongue toilet becomes increasingly necessary. The accumulated hairs licked from the coat must be got rid of, just as we must remove the hairs from hair brushes and hair combs. Under normal conditions it is to be presumed these hairs are either ejected from the mouth or swallowed. In any case the amount of hair to be disposed of as the result of any individual toilet operation would be inconsiderable. But if the animal happened to be shedding its coat, it is possible that after each overhauling of the coat by the tongue a relatively large mass of hair is taken into the mouth, and the bulk of this will be swallowed. In this way result those homely products, elevated by age-long legend into the realms of the mysterious and occult; the simple or calcified hair balls of the pathologist, the fabulous, the priceless, the incomparably potent antidotes of the alchemist. Of these things Gaspar Schottus (5) wrote:—"Quam notus est lapis, quem Bezoar alii, alii "Bezaar, et alii Belzaar, hoc est (ut ajunt) veneni dominum, "seu veneno dominantem appellant"; and then the author tells much of mysteries and goats from the Indies which do not appropriately come under the heading of the Mammalian Toilet. Taking it all round, from the rasps of the Lion's tongue to the Bezoar stone of the *Capra bezoardica*, the business of the coat toilet conducted by the tongue is a large one, and it must be remembered that here we have only mentioned self-licking; there is a wide extension of the subject when we also take into consideration mother-conducted and mutual licking.

(5) *Physica curiosa*, 1667, Liber VIII., p. 858.

(6) BY COMBING WITH THE TEETH.

In the business of combing the fur with the teeth lies, from an historical point of view, perhaps the greatest interest attached to any of the toilet implements. It was Cuvier who, in 1829, called attention to the function of the curious procumbent lower incisors and canines in the Lemurs. When describing *Lemur catta*, Cuvier mentioned a curious habit, and he recorded that:—"Ces animaux sont portés, par "leur instinct, à se gratter mutuellement avec ces dents, qui "semblent ne leur avoir été donnés que pour nettoyer leur "pelage; car ils ne s'en servent jamais ni pour mordre, ni "pour couper; ce sont de véritables peignes." (6) This simple observation, made nearly a century ago, has often been overlooked by succeeding generations of zoologists; but of its accuracy there can be no doubt whatever. The four lower incisors of the Lemurs have become altered in form and in position, and, moreover, the lower canines have also participated in the change, and have become so thoroughly modified in the same direction as the incisors (see Figure 5) that they have frequently been mistaken

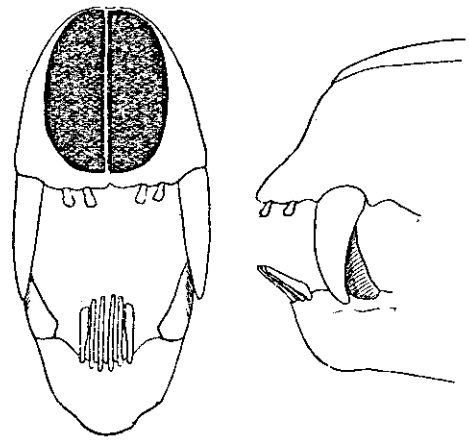

Figure 5.—The front teeth of a Lemur (*Lemur catta*), to show the adaptation of the six lower anterior teeth to the purpose of a hair comb.

as being incisors themselves. These six lower teeth have become elongated and compressed from side to side; in form they can only be likened to the teeth of a comb. They have also become altered in position, so that, instead of being

(6) Geoffroy Saint-Hilaire et F. Cuvier, *Histoire naturelle des Mammiferes*, 1829, p. 218.

directed towards their fellows in the upper jaw, they project almost straight forward. In consequence of this alteration in their axis the upper incisors are left without anything to bite against, and they have become reduced and probably almost functionless structures. There is no doubting the anatomical fitness of these lower front teeth for the office of a hair comb; there is no doubting the frequency with which they are put to that use by the Lemur. One has only to watch a waking Lemur for a short while in order to witness the use of the dental hair comb. Carefully, with downward strokes, the hair comb is passed through the hair. An efficient instrument, there is no denying it, and one well adapted to the peculiar woolly fur of the Lemur. When we realise that the peculiar form of the lower front teeth of the Lemur is the result of specialisation effected for the elaboration of a hair comb, we obtain the clue to the functions of another remarkable feature of lemurine anatomy.

We have previously mentioned the little tags found within the mouth of some animals; and these little tags we have postulated as being functional tooth cleansers. The lower front teeth of the Lemur, being no ordinary teeth, but hair combs, need an extraordinary tooth brush. This tooth brush is present in the form of the remarkable development of the lemurine sublingua. Although the real use of the sublingua was probably known to many observers of animals, to science it remained a mysterious structure.

In 1918, as the result of watching Lemurs at their toilet, I published an account of the functional rôle of the sublingua. (7) When a Lemur has conducted the toilet of those parts of its body that it can reach with its dental hair comb, it rapidly moves the sublingua backwards and forwards over the comb, and with its little horny processes removes the débris from its teeth. (See Figure 6.) The woolly-

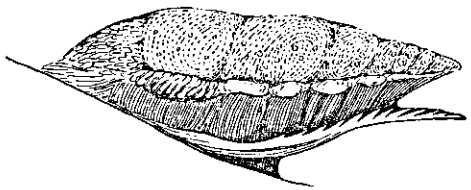

Figure 6.—The tongue of a Lemur, to show the so-called sublingua (plica fimbriata) adapted to the cleansing of the dental hair comb.

(7) *Journal of Anatomy and Physiology*, Vol. LII., p. 345-353.

coated Lemurs, which have nails instead of claws on all their fingers, and only one claw on their toes, are provided, nevertheless, with a complete hair comb and a most efficient brush for cleansing the comb.

A curious parallel structure in the nature of a dental hair comb is seen in the so-called Flying Lemur (*Galeopithecus volans*). The Flying Lemur is not a real Lemur, but it has a real dental hair comb, and this hair comb, though having the same function, is made in an altogether different way. In the true Lemurs six teeth are raked forwards so that each individual tooth constitutes a tooth of the comb; in the Flying Lemur the front teeth themselves are pectinated at their free edges, so that each individual incisor tooth furnishes many teeth for the comb. (See Figure 7.)

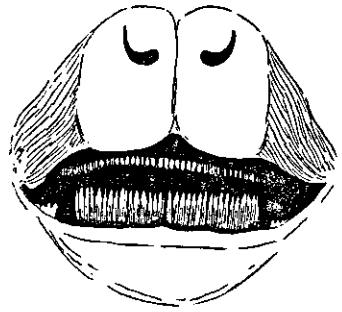

Figure 7.—The mouth of the Flying Lemur (*Galeopithecus volans*), to show the pectinated lower incisor teeth and the anterior, pectinated, edge of the tongue.

In this way there is an economy in the sacrificing of individual teeth for the composition of the comb, and in *Galeopithecus* there is no need for the canines to come forward and assume the form of incisors, but, on the other hand, they become modified in the direction of the molar series.

Just as the true Lemurs have developed their tooth brushes from the sublingua, so has *Galeopithecus* produced a harmonious structure, but it is made, not from the sublingua, but from the tongue itself. The anterior edge of the tongue of *Galeopithecus* is finely serrated, the serrations being used, so one imagines, for working in the interstices of the dental serrations, as the sublingua of the Lemurs works in the intervals between the individual teeth. I think that none would be likely to doubt this interpretation of the

Lemur's procumbent lower teeth and of its specialised sublingua. Certainly no one would doubt it had they watched a Lemur at its toilet. With *Galeopithecus*, so far as I know, no observations have been made on the living animal, and it may be that some would shrink from assigning a toilet function to the curious lower incisors, to which no other function, demanding the special development of the pectinated edge, has been assigned.

When discussing this matter seven years ago I suggested that the reason for the development of the dental hair comb and lingual tooth brush in *Galeopithecus* was to be found in the fact that its manus was hampered from performing toilet operations by reason of its incorporation in the flying membrane. At that time, not being concerned with the question of dental modifications for toilet purposes, I carried the matter no further; but it is difficult to know, to-day, just how far the matter can be carried. Take a further extension of the argument applied at that time to *Galeopithecus*. If the incorporation of the manus in a flying membrane might beget dental hair combs by reason of the manus being thrown out of toilet employment, then the Bats, one would imagine, might show some such specialisation. It may be that many mammalogists would not agree that the curious lower incisors of the *Microchiroptera*, or Insectivorous Bats, were highly specialised teeth, modified for the requirements of the toilet. We have seen that, with the development of a dental hair comb from the lower front teeth of the Lemur, the upper front teeth tend to become functionless and to undergo reduction. In the *Microchiroptera* this reduction of the upper front teeth, with the accompanying serration of the edges of the lower front teeth, is carried to extremes.

Opportunities for watching the *Microchiroptera* at their toilet are not easily come by, and it has not fallen to my lot to observe an Insectivorous Bat carry out the toilet of its coat since the peculiarities of its lower front teeth have attracted my attention. In the absence of direct observation upon this point it is, therefore, only possible to suggest—it is not possible to assert—that the curious serrated lower incisors of the *Microchiroptera* are modifications that are associated with the toilet requirements of animals deprived of the toilet uses of the manus. (See Figure 8.)

Observations on the life histories and habits of our native Bats are sadly wanting, and I would recommend to

our field naturalists the study of living Bats. If this study be carried out, I feel sure that it will be observed that some portion of the Bat's body, probably the ventral surface and the shoulders, is subjected to a combing by the curious serrated lower incisor teeth.

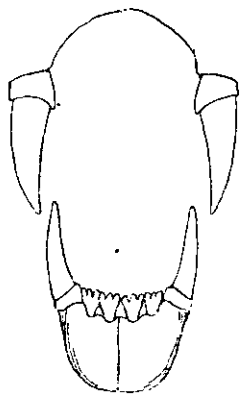

Figure 8.—The anterior teeth of an Australian Bat (*Taphozous flaviventris*), to show the pectinated lower incisors and the absence of upper incisors.

It is impossible, within the compass of this review, to deal with the innumerable possible toilet modifications of the front teeth of mammals. Only this may be asserted, that as observations on living animals are accurately recorded so will our appreciation of the front teeth as toilet implements grow.

Here we may confine ourselves to native animals upon which observations are easy to make, and concerning which assertions as to habits and structure are easy to check. The marsupial animals are traditionally divided into two sections—the *Polyprotodontia* and the *Diprotodontia*. The one section has many small front teeth, the other has few and large front teeth. There is, however, another possible division of the marsupialia into two other divisions—the *Didactyla* and the *Syndactyla*, the one section having normal pedal digits, the other having the second and third digits conjoined. With the exception of one family (*Peramelidæ*), the *Polyprotodontia* are *Didactyla*, and the *Diprotodontia* are *Syndactyla*. Put into ordinary language, this means that (with the exception of one family) all the marsupials having small front teeth have normal, simple, digits, whilst all the marsupials

having few and large front teeth possess the specialised syndactylous pedal digits. Surely there must be some underlying correlation in this. The syndactylous pedal digits seem to be begot when the front teeth become few. As we shall see later, the syndactylous pedal digits constitute an undoubted toilet implement. Do they then replace the many small front teeth which are themselves toilet implements? From observations on living polyprotodont didactylous marsupials I certainly think this is so. I have come to regard the specialised incisors of the *Didactyla* as being toilet modifications, and this as a consequence of repeated observations of their use for the purposes of the toilet. To this subject I have already called attention (8), and here it is only necessary to recapitulate, in a brief manner, the results previously recorded.

I have had examples of Krefft's Pouched Mouse (*Dasycercus cristicauda*) under close observation for upwards of four years, and the detailed toilet of the coat has been repeatedly witnessed in these animals. (See Figure 9.)

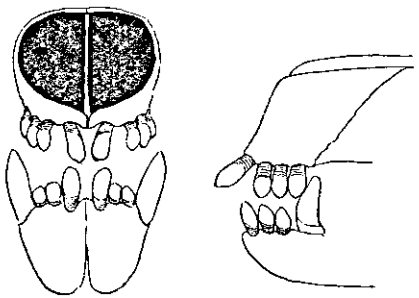

Figure 9.—The front teeth of Krefft's Pouched Mouse (*Dasycercus cristicauda*), showing the specialised central incisors.

These attractive little marsupials scratch themselves vigorously with the digits of the pes; but if any part of their body demands special attention they turn their heads and nibble and comb their hair in a very characteristic fashion. From these observations I have been for some time convinced that the front teeth and the syndactylous digits were complementary structures, vicariously discharging the same functions; and have already suggested that the little sharp front teeth of certain other animals are probably of more importance as toilet implements than as organs connected

(8) *Mammals of South Australia*, 1924, Part II., p. 135, and *Trans. Roy. Soc. South Aust.*, Vol. XLVIII., p. 187, 1924.

with alimentation. It is only of late, however, that, in watching *Dasycercus* at its toilet, I have come to realise that there is a remarkable specialisation of its front teeth, which is, as far as I can determine, related solely to the function of hair combing. Of the eight incisors carried in the upper jaw, two, the central members, are in every way abnormal. These two teeth are remarkable, not only in their form, but in the axis in which they are carried in the jaw, for they rake forward at an agle which carries them out of alignment with all the rest of the teeth. So marked is this projection of the upper central incisors that, in the normal position of the jaws, they do not articulate with the corresponding members of the mandibular series. The upper central incisors are large teeth, larger and longer than their fellows, from which they are separated by an interval which exceeds their own diameter. They are also separated from each other by a slightly smaller interval in the mid line, and at their tips they somewhat tend to approach each other. The corresponding lower central incisors are also specialised, being considerably longer and larger than their fellows, and separated from each other in the mid line by an interval similar to that which separates the incisors of the upper jaw. When the jaws are opened and shut it will be seen that these specialised front teeth do not bite together as the other incisors do, but the lower centrals close behind the upper centrals, their "occlusal" surfaces failing to articulate. It is impossible, after having watched the animal at its toilet, to avoid the conclusion that these specialised, projecting incisors, separated by a median gap, are the functional counterpart of the little parallel claws of the syndactylous pedal digits. Indeed, it is difficult to postulate any other function from them.

Dasycercus is not the only didactylous didelphian exhibiting this specialisation of the anterior teeth, for, with the exception of *Sarcophilus*, all the species that I have been able to examine show the peculiarity in some degree. The various members of the genus *Phascogale* display the long, projecting, upper central incisors in a still higher degree of specialisation, and the condition is well seen in *Phascogale penicillata*. (See Figure 10.)

In the Native Cats the differentiation of the front teeth is not so pronounced, but, nevertheless, the peculiarity is quite obvious, for the upper central incisors cant forwards and are separated from each other and from their fellows.

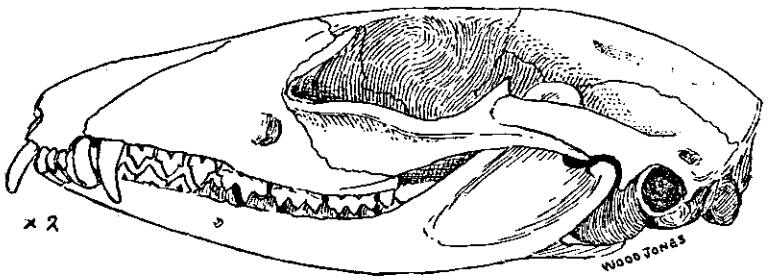

Figure 10.—Skull of the Brush-tailed Pouched Mouse (*Phascogale penicillata*), to show the projecting upper central incisors.

The lower central incisors are also large, distinct in form, and separated in the mid line.

Perhaps the most interesting modification of the anterior teeth is that seen in *Myrmecobius*, for here it is the lower incisors that are the most highly specialised, the upper central incisors being very small, but sharply pointed. In *Myrmecobius* the teeth are more widely separated in the mid line than they are in the Pouched Mouse, and it is to be hazarded if this modification is associated with the coarse, hispid hairs which constitute the animal's coat. The lower central incisors of *Myrmecobius* are relatively very large teeth, and are peculiar in their form. The special interest attached to these teeth of the Numbat lies in the fact that the dentition of the creature is obviously in a state of degeneration. In the midst of this degeneration the two lower central incisors stand out in marked contrast, and it might almost be said that they are practically the only undegenerate teeth that the animal possesses. (See Figure 11.)

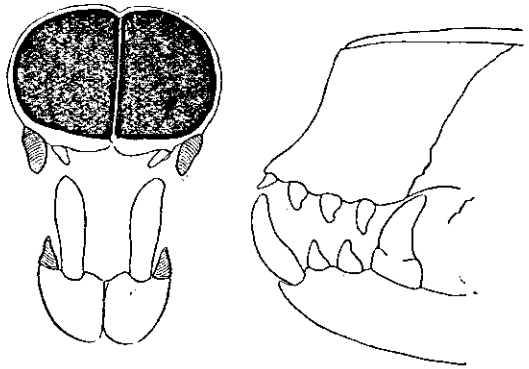

Figure 11.—The front teeth of the Banded Ant-Eater (*Myrmecobius fasciatus*), to show the specialised lower central incisors.

From the refined toilet of the coat by the dental hair comb of the Lemur to the casual nibbling at the site of the operations of an importunate flea, as witnessed in the dog, there is evidently a gradation in the toilet usage of the front teeth in the mammals. There still remains the question of the correlation of the two divisions of the Australian marsupials into the *Polyprotodontia* and *Diprotodontia* and the *Didactyla* and the *Syndactyla*.

We have seen that all the Australian marsupial animals, with the exception of the family *Peramelidæ*, which possess many small front teeth, have no specialisation of toilet digits on the pes, and that all the Australian marsupial animals possessing few and large front teeth have, without exception, the specialised syndactylous toilet digits.

The *Peramelidæ* (Bandicoots) are, therefore, in an anomalous position, for they have many front teeth and also possess the specialised pedal toilet digits. It is true that the Bandicoots possess the many front teeth, they have five upper and three lower incisors upon each side of the jaw, but the incisors are no longer of the type seen in the rest of the Polyprotodonts; they have lost their pointed, prong-like character, and have become chisel-shaped. It is not, therefore, the quantity of front teeth, but the quality of them which determines their use as toilet implements. The *Peramelidæ* have many front teeth, but these front teeth, being useless for the toilet of the coat, have been supplanted by the syndactylous toilet digits of the pes.

(7) BY BRUSHING WITH A SPECIALISED HAIR BRUSH.

How common mammalian hair brushes are, and upon what parts they may be developed, I do not know, but when we take into consideration the perfection of one of these organs it seems not unlikely that others, possibly less perfect, exist.

An excellent account of the toilet of a Free-tailed Bat—*Nyctinomus brasiliensis*—was published in 1865. The description was written by Mr. W. Osborn in Jamaica. Referring to the toilet of the Bats, he says: "The luxury King "James thought too great for subjects, and ought to be "reserved for kings, is largely indulged in by Bats. First "one and then another wakes up, and, withdrawing one leg "and leaving himself suspended by the other alone, ac- "uses the foot at liberty as a comb, with a rapid eff

"movement dressing the fur of the underpart and head—an "action far from ungraceful. The foot is then cleaned "quickly with the teeth or tongue, and restored to its first "use. Then the other leg does duty. Perhaps the hairs with "which the foot is set may add to this end. I often have "seen them do this in confinement; and probably the numerous "Bat-flies with which they are infested may be the cause "of extra dressing." The suggestion that the hairs that spring from the lateral digits of the pes aid in carrying out the toilet of the coat is, so far as I know, the first allusion to one of the most remarkable toilet appliances seen in the mammals. Among the distinguishing features of the Molossine Bats is the character that "the feet are broad, the "outer and inner toes much thickened and larger than the "others, and furnished with long curved prehensile hairs." (9) I think it would be a mistake to suppose that these hairs had a prehensile function. No hint of their being useful iu this way can be gleaned from watching living examples of our common Molossine Bat—*Nyctinomus australis*—but on the other hand this Bat will readily demonstrate the truth of Osborn's observations on the Jamaican member of the Genus.

In some Bats the brush is confined to the first digit only, and then this digit is considerably stouter than any of the others; in our Free-tailed Bats the marginal digits, the first and the fifth, are both thickened and both furnished with brushes. The brush is a complex and beautiful structure. The hairs composing it are stiff and bristle-like, and each is crooked at its tip. The hairs project from the margin of the first and fifth digits, and are so arranged that their free extremities all end on a common level, the outer hairs being longest, the inner ones shortest. The recurved tips of the hairs are a striking peculiarity, for each bristle is bent at a right angle just short of its tip. (See Figure 12.) The little hooked ends of the hairs are so arranged that the free tips are directed towards the middle line of the foot. In this way the little brush functions somewhat after the fashion of a rake, and after it has been passed through the soft fur it leaves its furrowed imprint clearly defined.

Probably this molossine hair brush is not unique in the mammals, and it is to be noted that, in the sense that it is a flange added to the side of a digit, it somewhat recalls the

(9) Dobson, G. E., *Catalogue of the Chiroptera in the British Museum*, 1878, p. 403.

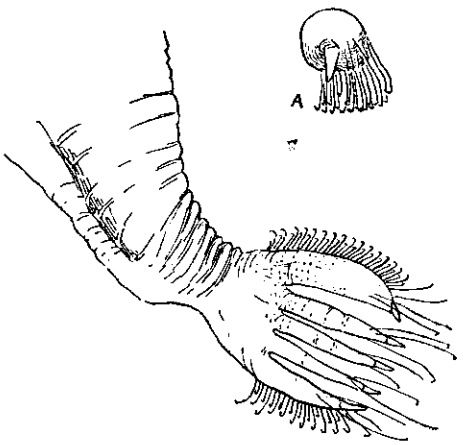

Figure 12.—The pedal hair brush of a Free-tailed Bat (*Nyctinomus australis*), which inhabits Australia and Tasmania.

avian pectinated preening claw which has recently been thoroughly re-investigated in Australian birds by Dr. A. M. Morgan. (10) It is of interest that in Osborn's account of the use of this hair brush the teeth or the tongue are ultimately called upon to cleanse the brush. Here again is seen the sequence we noted in the Lemur; the specialised toilet implement needs a mechanism for its own cleansing.

(8) BY SCRATCHING OR COMBING WITH NAILS OR CLAWS.

Here we may encounter mere generalised scratching, with claws not specially modified for this purpose, or we may meet a deliberate toilet carried out by a definite toilet implement fashioned from claws specialised for this purpose. Of the general use of the human nails for the purpose of the toilet an anonymous author wrote in 1724 (11) :—"A further Use of the Nails is, that they, like Hooks, are "serviceable in drawing anything to us, and are Weapons "to defend us from the Trouble that arises to us from some "small living Creatures that often make their Habitation "upon the Surface of our Bodies, and to allay the uneasy "Titillation by scratching."

(10) The Pectinate Middle Claw in Australian birds, *South Australian Ornithologist*, Vol. VIII., part 2, March, 1925, p. 44.

(11) *An Essay concerning the Infinite Wisdom of God, manifested in the Contrivance and Structure of the Skin of Human Bodies.* By a Lover of Physick and Surgery. 1724. p. 9.

Although we have seen that in certain very remarkable directions our several fingers are allotted separate toilet offices, nevertheless, all unite in discharging the general business of body scratching when this scratching is done on a large scale. But for what might be termed precise and localised scratching the index finger is the elected member. In many other animals this election and specialisation of a scratching toilet digit goes much further, and a definite toilet implement is begot. It is impossible here to trace the office of the nails as toilet implements through the whole of the mammalia, a vast amount of observation must be carried out and recorded before the facts are available. We must content ourselves with noting one or two outstanding examples among the higher mammals, and then confining our attention to the Monotremes and Marsupials where assertions as to behaviour and the use of toilet digits may readily be checked by watching the living animals.

We have previously noted the dental hair comb of the Lemurs; but this is not their only toilet implement. They possess a pedal hair comb also. Lemurs are peculiar in that though flat nails are developed on all the digits of the manus and on four digits of the pes, the second pedal digit bears a strong erect claw. Of *Lemur mongos* Cuvier recorded (12) :—"Nous ne les avons jamais vus se serve de cet ongle à autre "chose qu'a l'introduire dans leurs orielles." This strange nail may, therefore, function in the special toilet of the ear as well as in the wider office of tending the general coat toilet. (See Figure 13.)

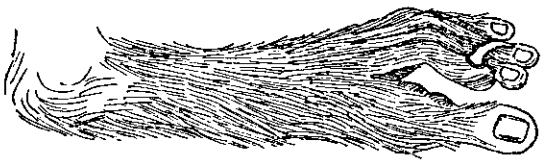

Figure 13.—The pes of a Lemur, to show the only claw—that of the second pedal digit—the animal possesses.

One of the most remarkable toilet digits, the function of which seems to have had little attention devoted to it, is the greatly elongated claw of the second pedal digit of *Echidna*. That the great claw is a toilet implement there is no doubt;

(12) *Op. cit. sup.*, p. 214.

it is begot for scratching down to the roots of the spines, and the length of the claw is in proportion to the length of the spines. In the very much larger and longer spined race of *Echidna*, which lives in the South-eastern portion of South Australia, the claw of the second pedal digit is harmoniously enlarged. In the small-spined form of *Echidna* that inhabits Kangaroo Island the toilet digit measures 35 mm., while in the long-spined Southern South Australian form it has increased to 50 mm. (See Figure 14.)

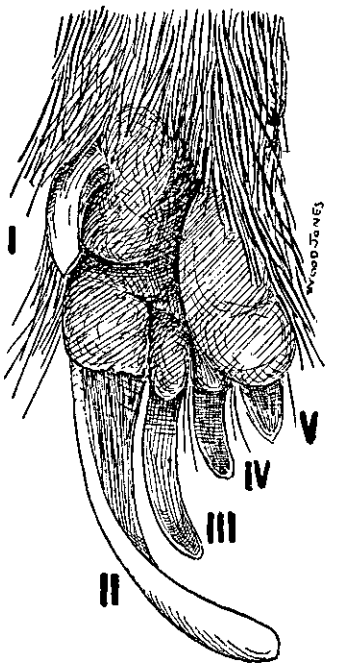

Figure 14.—The enlarged claw of the second pedal digit of the common Spiny Ant-eater (*Echidna*).

It is to be noted that the pedal toilet digit of *Echidna* is the same member of the series as that of the *Lemur;* and we may make a generalisation and say that the hallmark of pedal toilet digits is that they tend to be on the inner side of the foot and on the inner margin of the digit. This is the side of the foot and the side of the digit most readily brought into apposition with the body in performing what may be called the down stroke of scratching. The

pectinated claw of the birds follows the same rule. With most animals the first pedal digit is too valuable for its own sake to be given over to the toilet, and the second accepts the office. But where the first digit has lost this value, as in the Bats, it becomes the toilet digit of the pes, and in certain Bats an exceptional implement is placed on the fifth digit; Bats being apparently capable of passing their feet over parts of their body in both directions with equal effect, or of performing up stroke, as well as down stroke, scratching.

It is not always the second pedal digit only that takes over the functions of the toilet when the first is too valuable to be spared for this purpose. The second and third pedal digits may both be set aside for this function. In the true Lemurs the second pedal digit alone bears a claw, but in that Lemur, which is no Lemur—*Tarsius spectrum*—the second and third pedal digits are clawed, whilst all the rest have flat nails. Fortunately we have accurate observations upon the use of these toilet digits of *Tarsius*. (See Figure 15.)

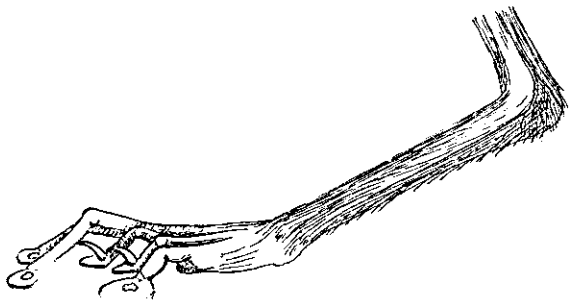

Figure 15.—The pes of *Tarsius spectrum*, to show the second and third pedal digits, which both bear claws.

It is also the second and third pedal digits that are involved in that most interesting of all digital toilet implements—the conjoined pedal digits of the syndactylous marsupials. In 1839 Sir Richard Owen wrote of these peculiar little toes that "they look like little appendages at the inner "side of the foot for the purpose of scratching the skin and "dressing the fur, to which offices they are exclusively de-"signed." (13) No better statement could be made con-

(13) In Robert Todd's *Cyclopedia of Anatomy and Physiology*, 1839-1847, Art. Marsupialia, p. 286.

cerning their structure and function, nevertheless Owen's clear pronouncement—like so many of his dicta—has often been overlooked. We cannot pretend to approach any more nearly to accuracy by adopting Pocock's more recent

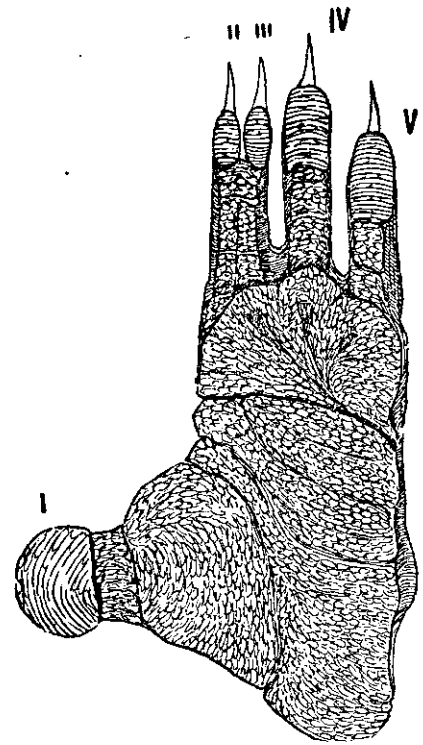

Figure 16.—The pes of the Native Bear (*Phascolarctus cinereus*), to show the elongated syndactylous second and third digits.

suggestions (14) that in *Phascolarctus* they are sufficiently well developed to assist in climbing, and in *Phascolomys* are large enough to be subservient to digging. It is enough to

(14) *Proc. Zool. Soc.*, 1921, Part III., p. 602.

know that they are used in the toilet and not in climbing or digging; that they are large enough to be used in either of these latter processes is a piece of information of no importance. That our hands are used for a variety of refinements of function is interesting, that they are large enough and strong enough to support the body weight in quadrupedal progression is no sound argument that their use lies this way. Pocock's reference to the function of the syndactylous elements of the Marsupial foot is added to this 1921 paper in the form of a footnote. In 1920 I had named the syndactylous digits as "toilet digits" in a paper dealing with the Common Opossum (*Trichosurus vulpecula*) (15), and at the time was unaware of Owen's previous dictum.

The correctness of this designation of them, and the truth of Owen's original assertion that to "these offices they "are exclusively designed" is confirmed by every observation that I have since made.

The syndactylous pedal digits of the Marsupials are definite hair combs, put to no other use whatever. They are not degenerate or rudimentary digits; they are highly specialised and highly functional members adapted to the single end of being fitted to comb the particular type of hairy covering possessed by the animal. Just as the toilet nail of *Echidna* varies in development with the growth of the spines, so those marsupials which possess long woolly or hairy coats have elongated syndactylous digits, whilst those with short coats have the elements far less developed. (See Figures 16 and 17.) We may contrast the elements in the long woolly coated Native Bear with those in the short smooth coated Red Kangaroo. Not only are they specialised toilet digits, but, as we have seen, there is reason to believe that they are begot when, in response to a change of diet, the many little sharp front teeth are replaced by few and larger chisel-shaped teeth. To those who have opportunities for watching Marsupials there is no need to dwell further on the matter. The wonderful mobility and aptitude of this little instrument are so easily observed in living animals that half an hour of observation will teach more than the reading of many books.

(15) *Trans. Roy. Soc. South Aust.*, Vol. XLIV., 1920, p. 372.

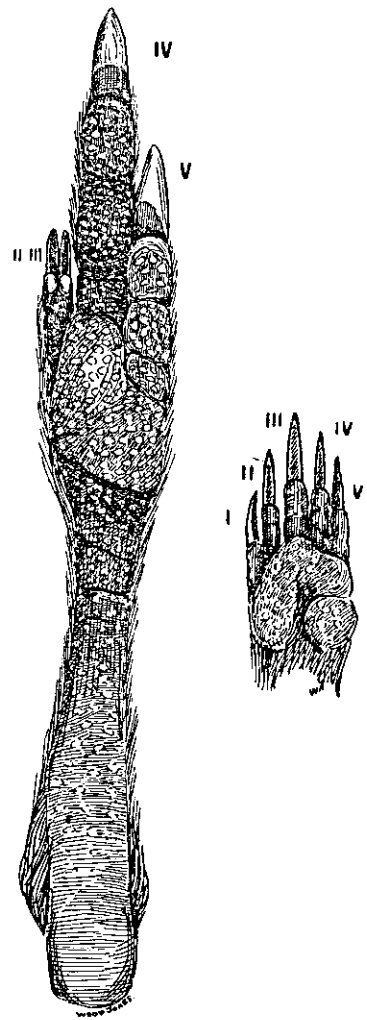

Figure 17.—The pes of the Dama Wallaby (*Thylogale eugenii*), to show the short syndactylous second and third digits.

MANUS SCRATCHING OR PES SCRATCHING.

With which member does any particular animal conduct its coat toilet? All of us have certain generalised pictures of animals scratching themselves; but it is astonishing how few printed records there are of the actual operation. We know that a dog scratches itself altogether with its pes; we know that a cat cleans certain parts of its body with its manus, others with the tongue directly, and that it seems to confine scratching with the pes to its "ticklish" spot at the base of the ears. We know that a monkey conducts the toilet of its whole body or the body of its neighbour with its fingers, and here let it be definitely laid down that a monkey's digital toilet is a pure skin and coat toilet, and is not, as is so commonly assumed, an unending pursuit of parasites. Monkeys are pre-eminent among the mammalia for being free of ecto-parasites. There is no such thing as a monkey flea or a monkey with fleas.

After prolonged investigations upon all the monkeys dying in the gardens of the Zoological Society of London, careful search for parasites proved vain until the arrival of a consignment of closely packed, ill-conditioned monkeys, that, during their long journey in overcrowded cases, had become infested with a *pediculus*. The ordinary monkey that is so assiduous in its toilet has no parasites to capture, and it will apply the process to a human hand and arm with as much zest as it displays in the case of its neighbour or itself.

In the case of that most interesting of the Primates—*Tarsius spectrum*—we have, thanks to Professor Le Gros Clarke, (16) an accurate description of the toilet, for he says:—"The hind limb is used for scratching purposes, the "digits of the pes being flexed on the sole in such a way that "only the two claws on the second and third digits are left "protruding." This animal also conducts its toilet with its tongue "by licking the fur after the manner of a cat." With the great majority of the higher animals we need more extensive study and a better recorded series of observations. One little detail may, however, be recorded. During the stay of a party on Pearson Island in January, 1922, all the members were much struck with the ability of the otarid Hair Seals to scratch themselves over a large area of the body with the nails of the pes, when the flipper membrane was flexed from the free extremities of the nails. The

(16) *Notes on the Living Tarsier, Proc. Zool. Soc. Lond.*, 1924, p. 219

toilet of these Sea Lions is conducted with the nails of the pes, and a long-contiuued and oft-repeated toilet it is. The interest of this toilet of the Seals lies in the fact that the phocid Seals are unable to conduct a pedal toilet, since their hind limbs are permanently turned backwards as the tail flipper. In the Phocids then, the limited toilet is conducted by the claws of the manus. This example of the toilet of the two divisions of the *Pinnipedia* is of interest, for it shows us that a vast number of observations must still be made and recorded upon the toilet methods of the higher mammals. In the case of the Monotremes and Marsupials we are on more certain grounds. I think that none will dispute the pedal toilet of the bristles conducted by *Echidna*; certainly no critics will arise from the ranks of those who have ever given room to this most difficultly housed and most tiresome of pets. With *Ornithorhynchus*, however, the case is very different. Dr. George Bennett made many observations on the toilet of the Platypus, and nowhere iu his writings can I find any reference to the employment of the manus as a toilet implement. (17) In his numerous admirable accounts he always mentions the employment of the pes; he notes that the toilet of the coat is an oft-repeated affair, and he makes several references, of which the following may be taken as typical:—

(1) *Op. cit.*, p. 119. "In this process of cleansing the "skin the hind claws were brought into use—first the claws "of one hind leg, then those of the other; but finding that "it could not use the one to which the string was attached so "well as the other, which was disengaged, after repeated "trials it gave up the attempt. The body being so capable "of contraction, was readily brought within reach of the "hind feet, the head also coming in for its share of the pro-"cess." (2) On page 143 he records that they "reclined on "one side, scratching themselves with the hind claws." (3) He also noted, p. 135, that, "besides combing their fur to "clean it when wet, I have seen them preen it with their "beak (if the term may be allowed) as a duck would clean "its feathers."

Dr. Bennett, we may therefore conclude, noted that the coat toilet was conducted with the pes, aided by the occasional preening with the "beak." That the coat toilet should be conducted by the pes we would expect from the anatomical

(17) *Gatherings of a Naturalist in Australia*, London, 1860.

conditions displayed in the manus and pes respectively, and also from a general knowledge of the use of the pes and manus in early mammalian forms.

Of late, however, a disturbing note has crept in, for Mr. Harry Burrell (18) has declared for the manus toilet of the Platypus. In that paper he says:—"Having studied "the Platypus in captivity as well as in its natural haunts, "I am convinced that most of the principal duties are per- "formed with its active and powerful fore-limbs" . . . . "in grooming or scratching itself, this quaint contortionist "squats 'tripod fashion' on its haunches, and imitates every "antic peculiar to a flea-infested monkey."

It must be remembered that Burrell is here attempting to establish the thesis that the soft, rubber-like hands "are "used for manipulating the eggs." It is possible that they are. But are the "soft, rubber-like hands" used for the toilet of the fur, as he describes, to the exclusion of the better adapted pes, as Bennett maintained? It can only be said that anatomical probability supports Bennett's observations, but that wider and more extended observations are needed to settle the point. Meanwhile, we may safely affirm that when Burrell likens the Platypus to a "flea- "infested monkey" he may be making genuine and astute observations on the Monotreme, but he does less than justice to the Primates. It must not be forgotten in this connection that even the spur of *Ornithorhynchus* has been deemed a toilet implement.

Of the *Didelphia*, I have watched many species at their toilet. Of the Didactylous forms, all the species that I have had under observation, including various Pouched Mice and Native Cats, have conducted the coat toilet with the pes, aided by the teeth. All scratching is done with the foot, and the manus is never employed in this occupation. With the *Syndactyla* the methods vary. I have had several members of the *Peramelidæ* living in captivity, and all of them, from the Short-nosed Bandicoots (*Isoodon*) to the Bilbies (*Thalacomys*), employ the pes only, aided by an occasional nibble with the front teeth. So great is their reliance on the pes for the performance of the coat toilet that one Bilby (*Thalacomys nigripes*), which lived for long in captivity and had suffered the loss of a hind leg in a steel rabbit trap, made vigorous efforts to scratch with its stump, but never

(18) *The Australian Zoologist*, Vol. I., Part 4, 1917, p. 87.

replaced the office of the absent pes by attempting to employ the manus. Most of the *Phalangeridæ* employ the pes for the regular coat toilet, but in many of them the manus has a limited and occasional use over a restricted area of the body. The members of the *Macropodidæ* vary in their usage. The only member of the *Potoroinæ* that I have had under observation is *Bettongia lesueuri grayi*, and this animal I have never caught employing the manus in its toilet. Many examples of this species I have had under observation in captivity for several years, but since they are nocturnal in their activities they are not easy to study. Nevertheless, as the pedal toilet has been witnessed on many occasions, it is safe to say that if the manus is used for this purpose at all its employment is no regular thing. Among the *Macropodinæ* there is also a difference in individual methods, for though the manus toilet is only a very occasional affair in the little Wallabies of the Dama group, it is a constant and regular proceeding with some of the larger Wallabies and with all the Kangaroos that I have observed. In all the Kangaroos the manus and the pes are employed each for its special office in the toilet, and herein lies the interest in the study of these animals.

It is much to be hoped that all field naturalists who have opportunities for observing animals at their toilets will record their observations, for so many intimate details are lacking in our knowledge of these habits of even the commonest animals.

THE SPECIAL NEED FOR TOILET APPLIANCES IN CERTAIN ANIMALS.

We have seen, even within the limits of this very partial survey, that whereas some animals possess well defined toilet appliances, some are apparently not so well endowed. It may be asked, why are some animals so lavishly supplied whilst others apparently go lacking? In the first place we may be fairly sure of our ground when we assert that if an animal retains fairly generalised digits such as are possessed by the higher Primates, toilet appliances will be few. The nimble, resourceful, inquisitive fingers have supplanted the specialised toilet implements.

But suppose the digits become so altered that they are useless for the performance of the toilet, then there is need for specialisation. This is the case with the Bats, and in

lesser degree, with the Flying Lemur, which, as we have seen, possess such cunningly contrived toilet appliances.

Into this category fall most of the *Ungulata*, and in them there seems to be but little provision made to compensate for the loss of the individual digits. *Ungulata* must use their tails, their horns, even their hoofs, and over certain areas their tongues. They must rub against external objects, roll in herbage, wallow in the mud, or, in extremities, resort to a bath.

Then, again, the texture of the coat has to be considered; and here the *Ungulates* are compensated by nature, for most of them have coats which do not require an elaborate toilet, and some are practically naked. Nevertheless we may note here that when, by artificial selection, man develops an abnormally thick coat, which requires a toilet, on an *Ungulate* that cannot conduct the toilet, disaster is likely to occur. We rightly blame the blow fly for the havoc it plays among sheep; but we must not overlook the fact that we have developed for commercial purposes a coat which needs a toilet on an animal which is incapable of carrying out the toilet. Another consideration is also of importance. Just as, according to the anonymous writer of 1724, our finger nails were provided as weapons against the small creatures which pestered us, so are the toilet digits of the mammals adjusted to their prevalent ecto-parasites. Osborn noted in connection with the toilet of the Jamaican *Nyctinomus* that "probably the "numerous Bat-flies with which they are infested may be "the cause of extra dressing." These ecto-parasites of the Bats are peculiar creatures and the *Nycteribiidæ* infesting Australian bats have recently been reviewed by Musgrave, of Sydney. (19)

I have elsewhere alluded to the importance of the Marsupial parasites known as *Mallophaga* or Biting lice. (20) These parasites have been studied by Launcelot Harrison and Harvey Johnston, (21) and their presence in the coats of the Marsupials possibly accounts for the need of the elaborate Marsupial toilet. The study of Mammalian ecto-parasites and mammalian toilet mechanisms is one which stands in need of correlation. But it is not to be doubted that the parasite is to be considered in the question.

(19) *Records of the Australian Museum*, Vol. XIV., No. 4, 1925, p. 289.
(20) *The Mammals of South Australia*, 1924, p. 135.
(21) *Parasitology*, Vol. VIII., No. 3, 1916, p. 338.

THE MAMMALIAN COAT.

So much for some of the numerous ways in which the mammals conduct the toilet of the coat, and for some of the factors which demand the creation, and determine the type, of the special toilet implements.

It is necessary, as a further step in this study, to examine what may be described as a typical mammalian coat. For this purpose we may select a primitive member of the *Didelphia* and Krefft's Pouched Mouse (*Dasycercus cristicauda*) provides an admirable example of such an animal. (See Figure 18.) In the adult animal the fine

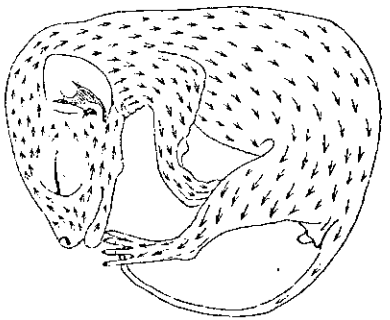

Figure 18.—Pouch young of Krefft's Pouched Mouse (*Dasycercus cristicauda*), to show the primitive type of hair tracts.

soft hair lies smoothly all over the body, and the tips of the hairs are all directed backwards, so that the animal can be stroked from head to tail in order to smooth its hair. We can learn more when we examine an immature young animal upon which the hair is only just beginning to appear. In such a specimen the direction of the short hairs is readily detected, since each individual hair is short and stiff, and is like a nail driven obliquely into a piece of wood. The hair is not yet long enough to have its direction altered by brushing or parting.

It must be insisted here that the study of hair direction can only be undertaken properly upon such young animals, and that it is much to be desired that hair charts of suitable specimens should always be recorded. Accounts based on the examination of living adults may also attain to a high degree of accuracy, but descriptions written from skins or from prepared or mounted specimens are likely to be extremely misleading.

In *Dasycercus* the hairs of the muzzle and chin point directly backwards, and those of the face, running to the anterior angle of the eye, part into two slightly curved streams, which run around the eye and meet again at the front of the ear. Upon the head and neck, the chest, and the whole of the back, sides, and ventral surface of the body the hairs are pointed with their free tips directed backwards and slightly downwards. Along the tail the hairs follow the same direction, pointing to the tip. Upon the backs of the ears the hairs stream from the sides of the head, and are directed towards the tip of the auricle. On the limbs, the hairs point downwards from the body to the digits and also backwards from the front (pre-axial) aspect of the limb to its hinder (post-axial) aspect.

This may be taken as the picture of the primitive hair pattern of the mammal, and it may be summed up by saying that the hair is directed caudad and ventrad upon the trunk and distally and post-axially upon the limbs. Among the primitive Marsupials that present this simple type of hair pattern we may mention the Banded Ant Eater (*Myrmecobius fasciatus*), the Native Cats (*Dasyurus*), and the Tasmanian Devil (*Sarcophilus*), as well as the little Pouched Mice, of which we have taken *Dasycercus* as an example.

Besides these marsupial animals, the primitive hair pattern may be seen in a large number of less specialised higher mammals. But the primitive hair pattern is upset in some way or another in many types, and these upsets lead to the development of the well-known hair tracts.

HAIR TRACTS AND THEIR CAUSATION.

It is well known that whilst some animals have a uniformly directed hairy coat, others show partings, whorls, convergences, and reversals in certain areas of their bodies. Everyone is familiar with these things upon the coats of domestic animals or even the poorer manifestation of them, upon the hairy covering of man himself.

Why is the hair of some animals arranged in the pattern of basal mammalian simplicity, and how are any alterations in this basal simplicity effected in those animals showing departures from the primitive mammalian type? At once we encounter theories, and many such have been put forward to account for the varying hair trend in the mammals.

When once the hair trend has been altered from the primitive caudad, post-axial, direction, many factors might possibly be invoked to account for this alteration. We may summarise those that have been suggested as follows:—

Schwalbe, who studied the question exhaustively, postulated that, for the most part, body contour and the stretching of skin during growth accounted for the disposition of the hair. Voigt had previously put forward very much the same explanation; for he imagined that the course which the enlargement of the body takes, in the early stages of development, produced that stretching of the skin which caused the hairs to slope in different directions. Eschricht believed that the alteration of hair pattern depended upon the distribution of the vascular system. Thompson, who looked at the matter from an altogether different angle, broke fresh ground when he postulated a functional cause in the necessity for offering the least resistance to the air, to grass, brushwood, and other obstacles through which the adult animal moved. It was Thompson who also enunciated the watershed theory which found expression in the work of Darwin and subsequently of Leonard Hill. Dr. Walter Kidd followed Thompson in the upholding of external causes, these external causes being gravity, posture, movement, and the habits of the animal. (22)

Lastly, in 1924, Bolk, of Amsterdam (23), rejected all the findings of Kidd, and returned to the internal causation, which he imagines rather vaguely to be "certain conditions "of the growth of the skin." It is difficult, at first sight, to understand why the very simple explanation put forward, for some cases by Thompson and for others by Kidd, did not at once gain practically universal acceptance. Any one, who is an observer of living animals, could appreciate the fitness of the explanation when applied to certain hair tracts, no matter if its correctness did not seem to be revealed by all. On the other hand, even the advocates of the contour, stretching, and growth theories do not appear to have a clear notion of the actual production of any individual hair tract, and, for one who is not an advocate, it is a difficult matter to picture the processes involved.

When the primitive hair trend is upset, it may merely be modified or slightly distorted, obviously by the dictates of the proportions and contours of the body; or it may be completely reversed.

(22) *Initiative in Evolution*, 1920.

(23) *Journal of Anatomy*, Vol. LVIII., Part iii., p. 206.

It is those cases in which there is a complete reversal of hair trend that are most likely to reveal the causation, since, in order to turn the hair stream into a direction directly opposite from that which is primitive, the causal factor must be potent and probably the more easily discernible. In studying these reversals we will mainly confine our attentions to the Marsupials, since in them our opportunities for observation are so much more extensive and our conclusions the more easily checked.

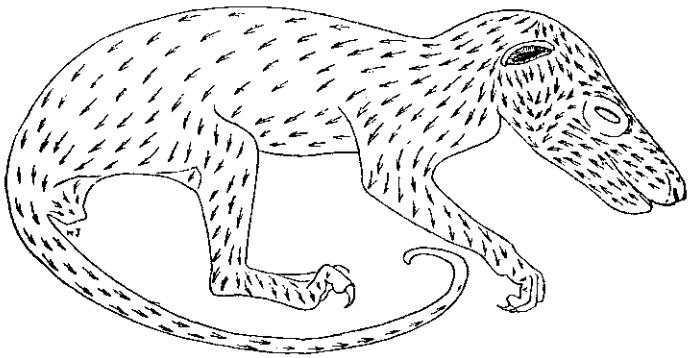

Figure 19.—Pouch young of the Rock Opossum (*Pseudochirops dahli*), showing pes reversal on the side of the head, and the preocular reversal in front of the eye.

The first striking reversal of hair trend to be noted in the Diprotodonts is that tract which involves, as a rule, the vertex of the head, the forehead, and sides of the face. A simple example of this may be taken from *Pseudochirus* or *Trichosurus*. As seen in these animals, the reversal area starts at a whorl situated somewhere on the crown of the head and, from the whorl, the hair radiates (1) straight forwards along the forehead, (2) downwards and forwards to the posterior angle of the eye, (3) directly outwards to the dorsum and posterior surface of the large ears, and, at its hinder limit, becomes normal by merging with the unreversed nuchal stream.

The making of this area I have watched repeatedly, and, from the experience thus gained, have no hesitation in affirming it to be caused by the scratching of this region, in a direction reversed from the normal hair trend, by the syndactylous toilet digits of the pes.

If *Trichosurus* be watched at its toilet it will be seen that, when it scratches itself with its hind limb, the syndactylous hair comb is raised to the anterior part of the body and the hair comb comes in contact with the animal's vertex in the neighbourhood of the whorl. From this point, at which it starts its work, it scratches the hair forwards to the forehead, forwards and downwards to the eye, and outwards on the ears. The anterior limit of this reversed tract marks the forwards sweep of the syndactylous digits as they pass down the face behind the eye. This reversed tract, made by the forward combing of the pedal syndactylous digits, I have termed the *main area of pedal reversal*. Now it is manifest that this area, if caused by pedal reversed scratching, would be liable to some variety in its exact position; for, depending upon the relative proportions of the hind limb and the trunk, there will probably be a variation in the exact area of the body accessible to pedal scratching.

In most Marsupials the caudad limit of the area is in the neighbourhood of the vertex; it may, however, extend back to the occiput, to the nuchal region, or even (in *Phascolarctus*) to the scapular region. (See Figures 20 and 21.)

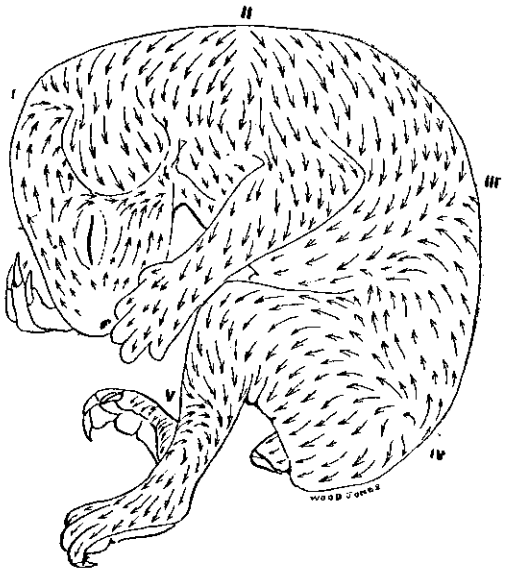

Figure 20.—Pouch young of the Native Bear (*Phascolarctus cinereus*), showing pes reversal, I.-II., and manus reversal, III.-IV.

In *Phascolarctus* the area is extremely large, and it extends from a whorl situated in the middle line of the back over the shoulders, to the crown of the head just anterior to the ears. In all the species that I have examined, so far, the area takes caudad origin in a single middle-line whorl. In

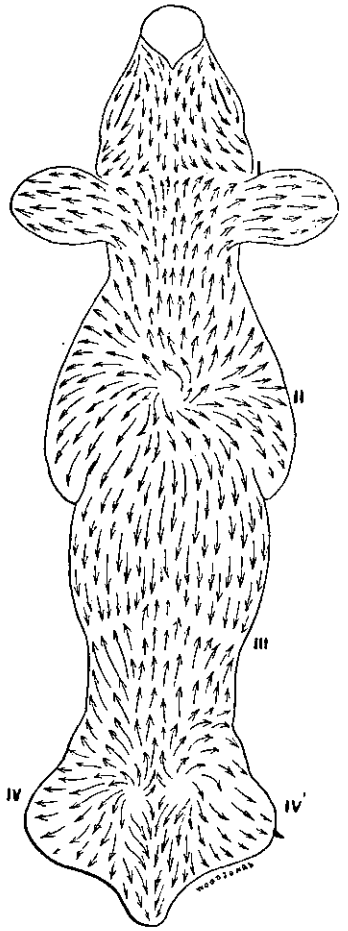

Figure 21.—Dorsal view of young Native Bear (*Phascolarctus cinereus*), showing pes reversal, I.-II., and manus reversal, III.-IV.

addition to this main pedal reversal there is a smaller and less constant reversal area, which is almost certainly caused by the reversed scratching of the syndactylous pedal digits. This area is situated upon the muzzle in front of the eyes, and is best termed the *pre-ocular reversal.*

So far as I know, no animal, in scratching its head and face, includes the actual area of the eye in its field of operations. The eye is avoided, and the combing digits pass downwards from the crown and ears behind the posterior canthus of the eye, to start operations again between the anterior canthus and the rhinarium.

Regarded in this way the pre-ocular muzzle reversal and the main pedal reversal may be regarded as being constituent parts of a single field interrupted by the presence of the eye. The pre-ocular reversal has been noted, so far, only among the *Phalangeridæ*, and it is well developed in *Pseudochirus* and in *Trichosurus*, but is not present in *Phascolarctus.*

In addition to scratching with the specialised digits of the pes, many Marsupials systematically scratch their coats with the digits of the manus. This habit is especially well marked in the *Macropodidæ*, but it is also typical of *Phascolarctus*, and probably of other Marsupials not yet studied.

In the business of conducting the coat toilet by the manus, a fairly wide area of the body may be subjected to scratching without there being any tendency to reverse the direction of the hair trend. There are certain areas of the body, however, where scratching by the manus is definitely done in a manner to cause hair reversal. One such area, which I have termed the *main area of manus reversal*, is of particular interest.

This area, like the main area of pedal reversal, is subject to some variation in its actual position, since its site naturally depends upon the relative proportions of the body and the fore limb. In *Phascolaretus* it is extensive, and it starts low down upon the lumbo-sacral region as two bilateral whorls situated close together upon either side of the middle line. From these whorls the hair streams forwards upon the dorsal surface in a direction completely reversed from the normal. The reversed field terminates in front at a convergent hair line, situated in the lower costal region, which extends farthest forward in the mid line and passes down the flanks with a caudad trend to reach the ventral surface in the flexure of the groin.

The stream lines from the lumbo-sacral whorls pass downwards and forwards at the anterior limit of the area, and downwards and backwards, merging with the normal stream at the hinder extremity. This is the area which is

scratched in a forward direction by the strong claws of the Koala, and it represents the normal reach of the manus in scratching the coat in a reversed direction.

In *Wallabia* (*Macropus*) *greyi* the main area of manus reversal is situated nearer to the anterior end of the body, since the short arms have a more limited reach in performing the action of reversed scratching. (See Figures 22 and 23.)

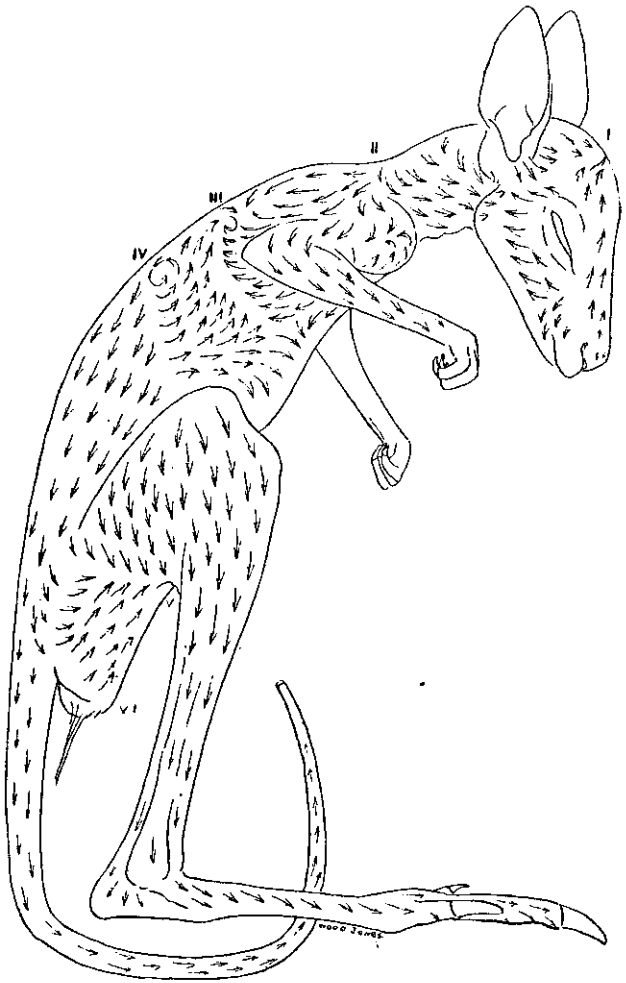

Figure 22.—Pouch young of the Toolache (*Wallabia greyi*), showing pes reversal, I.-II., manus reversal, III.-IV., and ventral manus reversal, V.-VI.

In this animal the start of the area is again in bilateral whorls, which, instead of being situated over the lumbo-sacral region, are shifted forward to the lower costal region. From

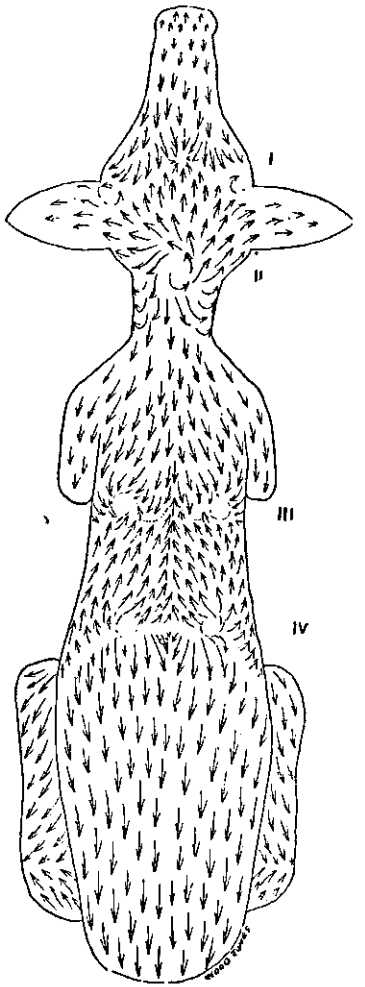

Figure 23.—Dorsal view of young Toolache (*Wallabia greyi*), showing pes reversal, I.-II., and manus reversal, III.-IV.

these whorls the reversed area runs forward and terminates at a convergent and whorled line over the scapular region. It is interesting to note, that, whereas the main area of pedal

reversal starts at a single mid line whorl, the main area of manus reversal starts, in these types at least, in bilateral whorls.

In *Wallabia greyi* and in the Kangaroos, there is another area of manus reversal upon the ventral surface of the body, extending over the perineal and lower abdominal region. This area I have termed the *ventral manus reversal area*. Now the designation of these reversed fields as areas of manus and pes scratching is no mere matter of abstract nomenclature; for this manus and pes scratching in a direction reversed from the normal hair trend is the hall-mark of the animals under consideration.

The coincidence of reversed scratching by manus and pes with the areas of hair reversal is a thing which may be witnessed constantly during observation of the living animal. There is still another reversal present in many Marsupials (as well as in many Monodelphians), which I have termed elsewhere the *rhinal reversal area*.

This area involves the very fine hairs situated just above and behind the naked rhinarium. From watching *Trichosurus*, I have come to the conclusion that this reversal is created by the forward licking of the area by the tongue. Many animals sweep the tongue around their mouths—lick their chaps—at the completion of a meal; and, in this licking, the area immediately behind the rhinarium tends to be reversed. This action is well seen in the domestic cat, in which animal the rhinal reversal is particularly well displayed. I have, therefore, come to the conclusion, from observations on living animals, that the rhinal reversal is a licking reversal. I have suggested elsewhere (24) that the well-known groin reversal of horses is in reality caused by the upward licking at that part of the body which a horse can reach with its tongue. To this point it is to be hoped that those in constant association with horses would direct attention.

If these hair tracts of mammals have every appearance of being caused by the method of the coat toilet, it may well be asked if the hair of our scalps, subjected for so long to the attentions of our artificial toilet implements, shows the development of hair tracts that might be correlated with the use of these implements. In 1901 Dr. Walter Kidd wrote

(24) *Journal of Anatomy*, Vol. LIX., Part I., p. 76.

an admirable paper on the hair tracts of man (25), and in it he pointed out the high probability that the human scalp hair pattern was "due to the inherited effect through "numerous generations of the method adopted in dressing the "hair." Although Professor Bolk (*op. cit.*) has since opposed those views he has substituted no sufficient alternative factor. In a later paper (26) I have pointed out further evidence in favour of Dr. Kidd's hypothesis, and likened the human scalp reversals to those noted in the *Phalangeridæ*. In that paper the question is summarised as follows:—"In the case "of *Pseudochirus*, the area is a pes reversal, for it is made "by the use of the syndactylous toilet digits of the pes. Of "that I think there is no doubt whatever. In the case of man, "I regard it, with Kidd, as a manus reversal, being made by "the artificial toilet appliances used in the hands. Let "anyone scratch his head in idleness and see if the fingers "do not naturally encounter the whorl, and then traverse the "stream lines forwards to the forehead, sideways to the ears, "and backwards to the nape. *Pseudochirus*, with its pedal "hair comb, carries the reversal further back than man does; "but for the rest the cause and effect are similar." For myself, I believe that the casual formation of hair tracts by brushing and scratching may be extended in the human body beyond the scalp area. Indeed, just as I would recommend anyone desirous of understanding mammalian hair tracts to watch the animals at their toilet, so would I recommend the student of human anatomy to watch a man brush his hair, scratch his body, and brush his clothes.

Now, though I think it is perfectly fair to state that no one who watched a living Marsupial and compared its actions with a chart of its hair trend could fail to see that the habitual actions of the animal coincided, in a remarkable manner, with the distribution of its hair reversals, it must be remembered that in assigning habitual actions as the *causation* of hair trends, a far-reaching implication is involved.

It is this implication—that an oft-repeated external action produces hair reversals—that has probably led to the general non-acceptance of the conclusions of Thompson and of Kidd. And yet I can see no escape from accepting these conclusions. It is inconceivable to me that internal factors, such as growth and stretching of the skin, could determine

(25) *Proceedings of Anatomical Society*, 1901, p. xxx.
(26) *Journal of Anatomy*, Vol. LIX., p. 80.

the reversals in the embryo, and that then the adult animals should scratch or perform movements which would coincide with these reversals.

I am quite convinced, from my experience of observing living Marsupials, that it is the habitual actions of the animal that determine the causation of those hair trends that I have described. But here we are faced with a difficulty. An apparently trivial, habitual, action of the animal determines the disposition of its hair tracts; but these hair tracts are already fully determined in the embryo as soon as ever its hair appears, and long before it has performed any of its habitual actions. It would be idle for anyone to deny that the alteration of the hair trend by scratching was anything other than a trivial acquired character, begot during the lifetime of the adult; a character stamped on the animal from the repeated performance of a trivial action. And yet we see that, in the embryo, the effects of this habit are visible in the hair tracts as soon as ever these are determined in the developing hair, and long before the young animal has started to rehearse any of its inherited habits.

It is difficult to understand how these hair tracts of the Marsupials can be construed as anything other than as instances of the inheritance of an acquired character.

Almost certainly it is the Lamarckian import of Kidd's work that has caused it to be adversely criticised, and which has led Bolk back again into the vagueness of expressions concerning the internal factor of the growth of the skin.

The ultimate implication of any explanation of a natural phenomenon must, of course, be borne in mind; but, if the explanation seems to be the true one, then we should consider well before we reject it, even though its acceptance imperils certain cherished beliefs.

It may be that to-day we are over given to estimating the value of facts by measuring them as items that do, or do not, fulfil the demands of existing theories. The day of true science will not dawn until we measure our existing theories by the metre of known facts. When it is appreciated that no single, well-established fact can be rightly disregarded, but that a dozen theories may be relegated to the scrap heap any day, without loss to science—then will science reign.