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PURKINJE'S OBSERVATIONS (1823) ON FINGER PRINTS AND OTHER SKIN FEATURES

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Foreword

In 1823 there was published by the distinguished Czech physiologist and histologist, Johannes Evangelista Purkinje (1787-1869), a thesis entitled *Commentatio de examine physiologico organi visus et systematis cutanei.* A modest octavo pamphlet of fifty-eight pages and one plate, printed by the University Press at Breslau, it is one of the classics of scientific literature, embodying the results of important pioneering studies on the eye and on skin. The document is of no little historical interest to students of personal identification. Galton[1] remarks that the portion concerning finger prints has "been referred to by nearly all subsequent writers, some of whom there is reason to suspect never saw it, but contented themselves with quoting a very small portion at second-hand." Galton's criticism is well pointed, but the defections of authors may be excusable, not only because the thesis is written in Latin, and in a form "that is difficult to translate accurately into free English,"[2] but on account of its rarity, only three original copies[3] having been located after rigorous search extending through several decades.[4] The present translation makes available the entire section of Purkinje's work which deals with skin, placing his observations on finger prints in their proper setting and extending "that very small portion" represented by the same frequently quoted passages lifted from their context.[5]

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† Doctor Kennedy took the principal part in the translation of Purkinje's treatise, work for which she was eminently fitted by the combination of medical training and earlier graduate study in Latin—[Cummins].

1 Galton, F., *Finger Prints* (London, 1892).

2 Galton, *Op. cit. supra.* The present translators find it so, as does Miss Anna Thompson Winecoff, whose unpublished Master's thesis on the *Commentatio* (Department of Latin, University of Wyoming) has been made available to us through the courtesy of Dr. Richard S. Uhrbrock. Miss Winecoff writes: "He stated facts in the best way he knew in a language which did not lend itself to his subject. . . . Purkinje's sentences are long and involved, and appear complicated with far more words than necessary to express his thoughts. . . . His language contains many words which are obviously invented or compounded to meet a situation for which no Latin equivalent could be found. There are few paragraphs in which one does not find words taken directly from the Greek or words with Greek roots and Latin suffixes, or words with Latin roots and Greek suffixes. . . . One refreshing commentary is that he was never completely at loss apparently, for he simply concocted the words he needed from any language which was nearest the idea he wanted."

3 One copy is in the Army Medical Library, Washington, D. C. Another is in the library of the Royal College of Surgeons, London. According to Faulds (Guide to Finger-print Identification (Hanley, 1905)) there is a third copy known, but its location is not indicated. We are indebted to Dr. Richard S. Uhrbrock for the gift of a photostat of the Washington copy.

4 Included among the interested searchers are Faulds (*Op. cit. supra*), Galton (*Op. cit. supra*) and Wilder (Wentworth, B., and H. H. Wilder, *Personal Identification* (2d ed., Chicago, 1932)).

5 The extracts, as is the case with Galton (*Op. cit. supra*), are only descriptions of the nine finger-print pattern types distinguished by Purkinje (*Commentatio*, pp. 43-45).

This is not the place for consideration of all the early contributions to knowledge of finger prints,[6] nor is it fitting here to discuss Purkinje's investigations in fields other than those which have more or less direct bearing on the field of identification.[7] We shall then confine ourselves to the translation and to commentaries directly related to the text (enclosed in square brackets when not placed in footnotes).

The body of the treatise is composed of five sections: I—Physiological practice; II—The individual as a member of a species; III—Physiological examination; IV—External physiological examination of the organ of vision; V—External physiological examination of the integumentary system.[8] These subject headings reflect the general approach which prevails throughout the work. Distinctly physiological in outlook, it shows consistently an appreciation that intimate knowledge of individual peculiarities is requisite to an understanding of the bodily processes in normal and diseased states.[9] This emphasis upon *individual differences,* directed to other purposes as it is, is only by implication transferable to the principle of personal identification. At no point does Purkinje even hint that such differences (in finger prints, the palm, hair and the like) might be useful in the *recognition* of individuals.[10] Following is the translation, with footnote annotations by the translators.

External Physiological Examination of the Integumentary System

In the following pages, I shall consider the important features which demand attention in observing the cutaneous system [integumentary system, i.e., the skin and its appendages—hairs, nails and glands] of an individual.

[6] A digest of this early history, with an evaluation of Purkinje's share in it, is available in: Heindl, R., *System und Praxis der Daktyloskopie* (Berlin and Leipzig, 1927). A special discussion of Purkinje's fingerprint observations is presented by G. Roscher, *Der Altmeister der Daktyloskopie. Ein Gedenkblatt f. J. E. Purkinje,*" Arch. f. Kriminalanthropologie 22:326-335 (1906).

[7] Numerous biographical and bibliographical notices give this information, among them the following. Victor Robinson presents an excellent biographical sketch, carrying three portraits of Purkinje, in the Scientific Monthly, September, 1929. F. K. Studnicka gives a more technical account of his work, in Anat. Anz. *82*:41-66 (1936).

[8] In the original there is a typographical error in the number heading this section, which is set IV instead of V.

[9] Because he recognized this need and attempted to meet it, Purkinje may be ranked among the pioneers in a special field of medical inquiry, *constitution.* It should be noted that among the six "propositions to be defended" in support of his thesis there is this: "The notion of the organic constitution has not hitherto been exactly defined."

[10] There has been considerable misunderstanding concerning the status of Purkinje's contribution to dactyloscopy. Actually, it consists simply in the description of nine fingerprint types. Contrary to the claim of Galton (*Op. cit. supra*), he was not even the first to be credited with "having first drawn attention to the patterns," for anatomists long antedating him (e.g., Malpighi, De externo tactus organo (1686) had done so). Purkinje himself writes: "In general, indeed, some mention of them occurs in every physiological or anatomical epitome." Purkinje does not touch upon the important issues of absolute individuality of each configuration and its permanence. Victor Robinson (*Op. cit. supra*) erroneously states that Purkinje described the "unchanging character of fingerprints," and he quotes Major Arthur Griffiths to the same effect: "The permanent character of the finger-print was first put forward scientifically in 1823 by J. E. Purkinje. . . ."

Faulds (*Op. cit. supra*) writes: "at that time [1880], I think, no one in Europe or America knew even of the existence of Purkenje's (sic!) Latin pamphlet." Purkinje's consideration of finger prints was not entirely overlooked toward the middle of the nineteenth century, however, since E. Huschke quotes his listing of nine pattern types, commenting further that the descriptions are quite exact. (*Lehre von den Eingeweiden und Sinnesorganen des menschlichen Körpers,* Leipzig, 1844; this work was translated into French, appearing as volume 5 of the *Encyclopédie Anatomique,* Paris, 1845.)

The principal objects of interest in this treatise are epidermis, hair, nails, and mucous membranes which communicate with the external surface through various apertures.

1. Upon tactual examination, the skin is hard or soft, moist, oily, clammy, or dry, warm or cold, elastic, rigid or spongy, smooth or rough, loose or taut, pliant or non-pliant. These properties are found combined in different ways and degrees, or variously modified in different states of vital activity. It is to these properties that attention must be directed for the revealing of differences, however slight, in temperament, constitution, age, sex, or even family and nationality.[11] In a study of this sort, the organ of touch itself, the hand, should be considered first. For when it is calloused, or when contact is made unrestrainedly and with violence, or when the attention has not been trained to perceive very delicate degrees of resistance, then there is not obtained a clear sensation of softness or hardness, elasticity or rigidity, and other characteristics of matter.

Since the effect of heat and cold is entirely relative, (as, for instance, the degree of difference between body temperature and the temperature of an external object) the temperature of the hand in this study must be approximately normal, or the ability to judge correctly the temperature of an object must be gained by practice. And things which seem different, but are not, should be weighed judicially. For accurate perception of dryness or dampness, oiliness or viscosity, and most qualities of that sort, the hand must be free from the same qualities. If it were not, its own properties might be confused with those of the objects that are touched. For when the hand is moist with sweat, or is clammy, or is hard and dry, an erroneous interpretation of the characteristics of an object is not surprising. In case of doubt, it is of assistance to note the palm and dorsum of the hand and even the appearance of the nails.

2. Among other characters which the skin presents, the color is especially conspicuous. Let us now direct our attention to it. We shall discuss it first with respect to the differences of color which the human races present; then with respect to mixtures of these colors, hybrid races, as it were. There are innumerable and subtly modified shades, which would be difficult to name, and could be reproduced only by the hand of a master painter.

"Leukopathy," albinism,[12] which occurs with various modifications through all races of man, demands the attention of the physiologist. We must observe not only its more prominent characteristics, but also its lesser deviations.

Opposed to the above in name and character is "melanopathy," presence of pigment,[13] the medium degrees of

[11] See note 9.

[12] Albinism is abnormal reduction in amount of pigment. In its extreme degree, total albinism, melanin pigment is lacking.

[13] Melanopathy signifies a pathological increase of pigment, and it does not embrace "the presence of pigment" found normally in the skin, hair and eyes of white peoples as well as the more heavily pigmented races. The fact that Purkinje refers to its "medium degrees" as blonde and brunette signifies that he is contrasting the tendency to pigmentation (erroneously termed melanopathy) against the lack of pigmentation (albinism).

which, at least in the Caucasian race, are termed *blonde* and *brunette*.

That character of the skin apparent to the eyes alone is not free from color. There occur in the skin both smooth places and places marked by ridges, pores, and prominences, where changes of light and shade exist. Besides, we shall not overlook the transparency and internal refraction of light which give local color and which differ with varying skin texture and vital state. Then, too, color varies with sex, age, constitution and temperament, a statement to which artists at least will gladly attest, since they have expended a great deal of effort along this line. Again, different areas of the skin are found to possess their own peculiar colors. Those regions exposed to wind and light have a deeper color than areas which are constantly protected by clothing. Certain more transparent parts, the temples, around the eyes, the neck, arms, and mammae, are marked by the courses of veins, while cheeks and palms and soles of the feet seem to be colored with arterial blood. The areolae of the mammae, the regions of the anus and of the external genitalia, which resemble mucous membrane, have a darker color. Finally, varying states of the body fluids, which affect the skin in the case of bile, phlegm, blood, or a certain melanosis, are shown by different colors.

3. In a physiological study we must not overlook the odor of the skin. Just as no other sense so abounds in the variety of specific sensations as does the olfactory sense, so we may conclude with reasonable certainty that there are many modifications of odors among different nations. The keen olfactory sense of the dog gives us proof of this.[14]

But it is remarkable that no other sense is so neglected as the olfactory sense, which in every-day life is covered, as it were, with a cloak or shame. Since this scorn is undeserved, it is striving now to gain admittance at the locked doors of the sciences.

4. No less worthy of examination are the peculiar skin sensations, disclosed only by subjective examination. Here are the sensations of warmth or heat, chilliness or cold, bristling of hairs, crawling sensations, pressure, dullness, itching, increased or decreased sensitivity, various kinds of pain — pricking, constricting, tearing, etc.— which affect the skin as a whole or parts of it. All these sensations may be described by suitable comparisons and aptly chosen terms.

5. Now I shall pass from the properties of sensibility of the skin to its anatomical configuration. First let us consider the epidermis. Here are noted pores and tuberosities; small, irregularly tortuous depressions; rugae and sulci.

It has been a matter of dispute among authorities as to whether pores actually are present in the epidermis. It is my own opinion that the epidermis is perforated by pores, that these pores are so occluded by the elasticity of the skin that they open only to emit sweat, even then not being visible with either the naked eye or with the aid of any apparatus. A similar phenomenon is the puncturing of a small elastic gum mem-

[14] How does this serve as proof?

brane with a sharp needle. On each surface a slight furrow is seen; but the canal, even if the material be cut into the most minute layers, is not apparent. So also in the skin nothing is seen except the little furrows on the external surface; yet sweat and suction of blood, even its spontaneous emanation, show that these furrows are connected with small canals through which fluids may pass. These little depressions are most distinctly seen in the furrows and courses of the small hollows with which the soles and the hands are filled, where it is easy to express drops of sweat that can be seen with the naked eye. It must be noted that many of these are occluded in advanced age, which explains the greater torpor of the cutaneous function with advancing years. The size of the sudoriferous passages is different in different parts of the body. For in the cheeks and forehead they are almost large enough to reach the mucous and sebaceous glands[?]; they almost form papillae around the eye [?]; they are most numerous at the roots of the hairs, in the thick folds whence they emerge. Their direction is mostly perpendicular except at the roots of the nails, where they seem to extend obliquely toward the apices. Nowhere does the internal structure of the epidermis show itself more conspicuously than in warts, which are like a heap of concrete tubes for carrying water or blood.[15]

The texture of the epidermis seems to me to be like the hydrophane or pyrophane of the mineralogists, in that it is continually bathed with atmospheric vapor, or by emanations of blood, by which cutaneous transpiration and resorption from the exterior are accomplished. And in truth there will soon scarcely be anyone who will not be convinced of this innate quality of the epidermis, since we find it in our own bodies now swollen with liquid, now dry and wasted. The creases are different in different parts of the skin. Their sizes and directions are vastly different. Some correspond to the flexion of the joints. Others are related to the roots of the hairs, and, as it were, converge on them, facilitating their movements while they are elevated in bristling. It is the province of anatomy to undertake to describe the forms and modifications of this kind of fold thoughout the entire surface of the skin.

In the regions between the folds, very minute tubercles are seen, which are nothing but circumvallations or craters of the pores. Mention should be made, too, of the greater furrows which are found in the inner portions of the palms. They are especially noteworthy because they formerly gave origin to the groundless teachings of the palmists. No one will doubt that they are determined by the different movements of hands and fingers. There arose, too, applicable names for these furrows. I distinguish the lines of opposition, abduction, adduction, extension, and flex-

[15] Reference here to a figure is deleted. The original illustration, Figure 21, shows "The structure of a wart upon horizontal section, magnified." At this point it may be explained that of the sixteen figures illustrating skin structures, only the nine (Figures 7-15) relating to finger-print types are reproduced here. Each of the others is characterized in a footnote.

ion. The following should be enumerated:[16]

1) The line of opposition of the thumb, called by palmists the life line, which outlines the thenar eminence.

2) The line of adduction of the thumb, the line of Mars, follows this in an almost parallel direction.

3) The line of abduction of the little finger is situated at its base on the ulnar margin of the hand; it is called by palmists the line of matrimony.

4) The line of closing of the three ulnar fingers, the line of the table, which, when we point out anything with the forefinger, is made into a fold by the flexion of the rest of the fingers; I have therefore called it the pointing line.

5) The line of the closed hand, the nature line, which runs through the middle of the hand almost parallel to the pointing line.

6) The line of flexion of the ring and middle fingers, the line of Venus, which in some individuals encircles the bases of these fingers.

7) The line of flexion at the wrist, the line of Rascetta.

8) The lines of opposition of the ulnar three fingers, less conspicuous than the others and running from the wrist toward the roots of the index and middle fingers in a direction almost parallel to the line of opposition of the thumb, called by palmists the lines of honor and fortune.

9) Finally, the lines of extension which are often seen running longitudinally in the joints of the extended fingers.

Certain analogies will be found in the sole of the foot, although its mobility is more limited in proportion to its uses. Even though I admit that there is some physiological significance in these lines, since the hand is the special instrument of human labor, and though the different types of movement for which it has been designed show how conjecture can be made as to the character of the individual and then as to the events of life that are to come, yet I am convinced that there is scarcely any truth in palmistry. In my opinion the work of palmists ought to be considered equal to the prophecies of soothsayers and augurs who prophesy from the flights of birds and the motions of the intestines.

Our attention is now attracted by the remarkable disposition and flexures of the contiguous rugae and sulci in the inner part of the hand and foot, especially in the terminal phalanges of the fingers. In general, indeed, some mention of them occurs in every physiological or anatomical epitome. But in an organ of such great importance as the human hand, which serves not only for movements of many different types but also for the sense of touch, every inqury, however minute, brings to light some worthwhile information. After innumerable observations, I have found nine important varieties of patterns of rugae and sulci serving for touch[17] on the palmar surface of the

[16] References to Figure 6 are deleted in the following descriptions of flexion furrows. The illustration shows "The furrows in the palm of the hand which are related to its joints and flexions."

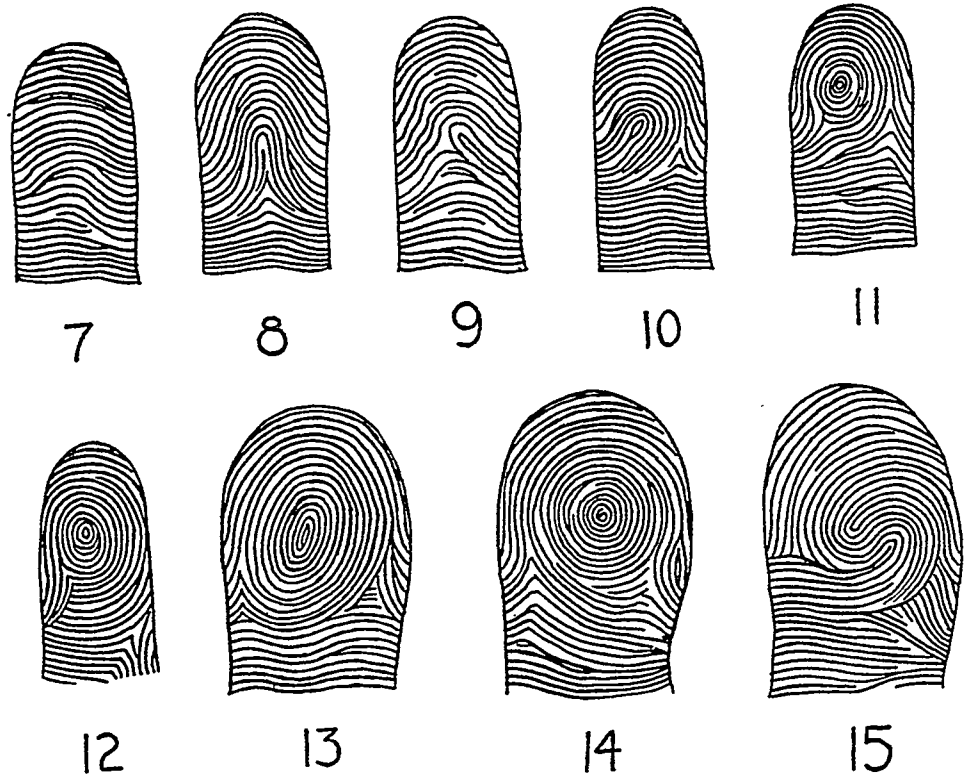
[17] It is thus suggested that Purkinje regards the pattern formations as agents of enhanced tactile sensibility, a position held by some later workers (in contrast to the opposing but not irreconcilable view that they serve primarily for frictional augmentation).

terminal phalanges of the fingers. I present these nine, though the lines of demarcation between types are often obscure;[18] the figures will explain them.

1) The transverse curves, fig. 7 [simple arch]. From the articular fold, rugae and sulci first course in almost straight lines transversely from one side of the phalanx to the other; then little by little they become more curved in the middle, until they are bent in arches which are nearly parallel with the periphery of the phalanx.

2) The central longitudinal stria, fig. 8 [tented arch]. This is of almost the same conformation as the above, the only difference being that the transversely coursing ridges are wrapped over a little perpendicular stria, as if it were a nucleus.

3) The oblique stripe, fig. 9 [loop, ulnar or radial]. Between the transverse curves [of a figure such as type 1, above] a single oblique line is interpolated from one side or the other; it runs forward [distally] and ends almost at the center.



Figs. 7-15. "Nine principal configurations of the rugae and sulci serving the sense of touch on the terminal phalanges of the human hand." [Copied from photostat.]

4) The oblique loop, fig. 10 [loop, ulnar or radial]. Now if this oblique stripe by a simple curve returns to the side from which it came, and follows many others in a similar curve, an oblique loop is formed, which may be more or less erect or may bend forward. Near its base, on one side or the other, a triangle is formed from the dif-

[18] This recognition of the intergradations of types is noteworthy.

ferent directions of the rugae and sulci. Their configuration in the form of the oblique loop is the commonest, and, I may almost say, typical of man, while groups of longitudinal rugae and sulci are typical of apes. Usually the vertex of the loop is inclined obliquely toward the radial margin; yet the contrary is often noted on the index finger, the vertex being directed toward the ulnar side. On the toes almost no other form except this occurs. Frequently, also, when oblique or other simple forms are present in the other fingers, the ring finger presents a more complicated arrangement.

5) The almond, fig. 11 [whorl]. In this form, the previously described loop, running back on itself, incloses an almond-shaped gyrus, blunt at the vertex, pointed at the root, and composed of concentric ridges.

6) The spiral, fig. 12 [whorl]. Transverse curves described under [type 1] are to be imagined as changing from straight lines to loops, not gradually, but suddenly and markedly; thus a semicircular space must be formed which rests on the straight transverse lines as if on soil. This space is filled with a spiral line, either simple or compound, twisted on itself. The spiral is simple in the geometric sense of the word; I call it compound, because from the center many ramifications go out from the same point or intervals, and are twisted on themselves. From either side, where the spiral is contiguous to the departure of the straight lines or curves encircling it, two triangles arise. Such an oblique loop bears much to one side.

7) The ellipse — elliptical whorl, fig. 13 [whorl]. As previously described, a semicircular space is filled with concentric ellipses, which surround a simple short line placed in the center.

8) The circle—circular whorl, fig. 14 [whorl]. Where in the ellipse a simple line occupies the center, here a small tubercle [island] does so; it is surrounded with concentric circles which reach the rugae of the semicircular space.

9) The double whorl, fig. 15 [twin loop]. If a part of the transverse lines runs forward and is bent back upon itself half again as much, and another line embraces it similarly on the other side, thence two whorls are formed entwined on themselves. This figure is present for the most part only on the thumb, index, and ring fingers. The vertices of the incurving loops are bent in different directions, extending either longitudinally, obliquely, or transversely.

In all the descriptions under numbers 6, 7, 8 and 9, a triangle [delta] appears on each side, where the transverse lines leave the incurving ones. In the rest of the phalanges of the fingers, transverse lines from one corner to the other are disposed in a straight or slightly curved direction.

Concerning the paths and curves of the rugae and sulci in the hollow of the hand, there occur variations which must be noted. In the region of the wrist joint a trivium (point where three lines meet) is seen which is terminated at a base in the transverse lines in the wrist, and rugae and sulci are contin-

ued toward each side in great numbers, onto the ball of the thumb and little finger.

From the interval of the index finger and the thumb run great numbers of parallel lines, which pass in diverging directions across the palm, next to the linea palmiformis, into the margins of the metacarpals of the thumb and little finger. Thus triangles are formed whose vertices are at the wrist. This is their most common conformation. Other parallel lines from the roots of the fingers meet and accompany the lines running across from the interval of the thumb and the index finger toward the external margin of the fifth metacarpal. Running out from these intervals, loops and whorls are interposed; but it would take too long to explain in this paper the many varieties of these.[19] On the thenar eminence a trapezoidal region occurs where the rugae and sulci are set transversely to the circles. On the hypothenar eminence, toward the radial margin of the metacarpal, often a larger loop is observed where the rugae and sulci going out from the margin are again reflected onto it. Sometimes even an elliptical whorl is seen on this eminence.

Also in the hands of apes,[20] even in their prehensile tails,[21] similar lines occur, the distinction of which adds to the knowledge concerning the characteristics of the species. Zoologists, unless they consider them unimportant, will make them known further.[22]

The physiological significance of these rugae and sulci I have left to discuss in a somewhat more convenient time and place.[23]

6. The hairs and the nails most closely resemble the epidermis in origin. The amount of hair; the length, thinness, curl and direction of growth from the skin; the shape, structure, color, transparency, hardness or softness; the firmness with which it resists tension, or the ease with which it yields; the electricity, hygroscopic quality, chemical reactions—all these properties must be examined in different individuals. Besides these physical properties, its organic vegetative properties must be observed. These are, for instance, the swiftness or slowness of growth, distribution over the different parts of the body, times and ways of growing and falling out, whiteness and other discolorations.

We set down in this place certain observations[24] which we have made on the different directions of lanugo[25] through lines of separation, whorls, and quadrivia variously distributed over the average male fetus of about six months.[26]

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[19] The subordination of the palmar features is a curious parallel to the treatment accorded them by many later writers, as if the finger prints were regarded as having larger importance (which of course they do in identification).

[20] Figure 19 illustrates "The distribution of the rugae and sulci such as is found in the hand of the tail-less Inuus."

[21] Figure 20 shows the ridge arrangement in "The hollows in the lower surface of the tail of an Ateles coaita (spider monkey)."

[22] A number of workers since have engaged in comparative studies, and research in this field continues.

[23] He gives but a hint of his view; see note 17.

[24] These observations on hair direction appear to have been completely ignored by later workers in the field, doubtless because of the obscurity of Purkinje's publication.

[25] The delicate hairs characteristic of the fetus.

[26] Three figures illustrate regional characteristics of hair direction: Figure 16—"The line of separation of lanugo in the fetus, in the form of a quadrivium in the midline"; Figure 17—"The separation of hairs on the top of the head";

Lines of separation (natural parts) are best distinguished in the median line of the body, anterior and posterior; then there are two lateral ones; finally there occur palmate lines where the line of the hairs curves; loops; and the quadrivia where in four places the hairs part by diverging and converging in crossed directions.

First, the anterior median part must be noted. On the manubrium of the sternum this line of separation contains a quadrivium. In this quadrivium the hairs coming from the neck and from the umbilical region in the median line diverge and run in a transverse direction, laterally. Descending to the umbilicus and converging, they proceed on its circumference and continue in a line which is occasionally broken by the opposite direction of single hairs. In the hypogastric region this line again deviates into a quadrivium, in the superior angle of which the hairs again point upwards, as in the quadrivium of the sternum. In the inferior angle they point downwards, and they almost disappear near the mons veneris. Another quadrivium is observed in the neck between the hyoid bone and the larynx. Its inferior angle is formed by hairs extending upward from the quadrivium of the sternum in the median line and running out to the sides of the neck; in a similar manner in the superior angle the hairs going out from the beard run towards the sides. On the nose, for the most part free from hairs, an irregular central place, as it were, of a quadrivium is located. Its superior angle is made to extend forward by hairs ascending from the root of the nose to the forehead; its inferior angle is continued downward by hairs descending from the septum of the nose through the upper and lower lips and beard toward the quadrivium of the neck. Finally, there is a quadrivium on the forehead. Its inferior angle is formed by hairs ascending from the root of the nose and diverging toward the eyebrows. The superior angle is formed by hairs descending from the head. Then there is the vertex, where the hairs depart from the center anteriorly and posteriorly, and toward the sides in the shape of a bow. On the left side—or rather, on different sides in different individuals—they are separated in a palmate arrangement, and on the back of the head, near the region of the first vertebra, they converge into a little fringe; thence they run down the back in a broad and almost double line of parallel hairs, and are continued to the coccyx, where again they converge rather prominently into a little tail. In this feature there is a great likeness to the young of animals. Around the anus, the direction of the hairs is partly toward the margin of the coccyx, partly toward the genitalia; whence, with outspreading hairs from the mons veneris, a double quadrivium is seen to be formed in relation to the anus and the genitalia.

And so there are many quadrivia to be distinguished, in which hairs either relatively converge or diverge at the median line. Convergences are found in the neck, in the umbilical region, on the genitalia and coccyx. Divergences

Figure 18—"The line of separation of lanugo which spreads out to the quadrivium of the sternum, the lateral quadrivium of the breast and the quadrivium of the arm."

occur on the nose, vertex, sternum, in the hypogastric region, and about the anus. Each kind of quadrivium appears five times.

Besides these, two lateral lines of separation are noted, which begin at the fifth rib, approximately where it is joined to its cartilage, and are limited below by the anterior part of the crest of the ilium.

In the region of the fifth rib where they take origin, a converging quadrivium is present. Its superior angle passes into a palmate line which, proceeding through the anterior fold of the axilla, is terminated in a quadrivium in the region of the insertion of the deltoid into the humerus. The other end of this lateral line of separation is found over the anterior angle of the crest of the ilium. Here, too, is a diverging quadrivium, its inferior angle being continuous with a palmate line over the femur. And so the lateral lines of separation, the upper ends passing into converging quadrivia, the lower into diverging quadrivia, are continuous with the palmate lines of separation of hairs on the arm and thigh.

The quadrivium of the arm diverges superiorly and inferiorly. The lateral angles are formed by concurring palmate lines from each side, which start at the axilla. And so the axilla, although it possesses the fewest hairs (the opposite being true in adults), may be considered the center of the two palmate lines. The more anterior of these lines is continued in three directions to the lateral quadrivium, and to the sternal and brachial quadrivia; the more posterior is deflected to the arm and there it determines the posterior lateral angle of a quadrivium. The other directions of the hairs are toward the medial side of the arm, the side of the trunk, the back, and the breast.

On the lateral side of the arm, the hairs run down toward the olecranon process of the elbow; in like manner those on the medial surface run toward the elbow. On the anterior surface of the forearm the hairs diverge toward either side as far down as the palm, so that they extend in almost transverse arches, whose convexity on the radial margin looks toward the hand; on the ulnar side, in the opposite direction. Hairs run also from the back of the hand toward the olecranon process, where they meet the hairs of the brachium and converge into a bundle. On the ulnar margin of the forearm, the hairs combining suddenly and taking different directions, a line is formed which terminates in the bundle of the olecranon. On the dorsum of the hand hairs run anteriorly and obliquely from the radial margin to the ulnar margin.

Where the lateral lines of separation of the hairs are terminated at the crest of the ilium, the quadrivium, at its inferior angle, becomes continuous with a palmate line. This line curves obliquely forward about two-thirds of the way down the inner margin of the thigh, where it splits, and the hairs run in opposite directions. Part of them run through the calf of the leg; partly they are directed backward on the posterior surface of the thigh toward the buttocks. For the rest, the hairs on the anterior surface of the

thigh run downward; those on the medial and lateral surfaces wind transversely; but on the posterior surface, as already noted, they are directed upward from the popliteal space toward the buttocks. In the lower leg all are directed downward.

On the posterior margin of the helix of the external ear, hairs ascend from the lobe to the top, which is a little pointed as in animals. The arrangement is similar on the outer surface, so that coming together at a point the hairs form a small bunch. In the inner part of the auricle which looks toward the cranium, hairs run toward the periphery. In the lower transverse part of the helix, where the smaller muscle of the helix is seen, the hairs run toward the interior of the concha. The internal appearance of the tragus, which in adults is filled with hair, is found to be almost bare.

The disposition of the hairs on the trunk between the lines of separation is easily understood if we follow, in imagination, their directions from the quadrivia and palmate lines. At the sides of the neck the disposition is the most ambiguous, yet I do not doubt that there the line of separation is present, though inconspicuous.

From the above it is apparent that many characteristics are found in the fetus which demonstrate a certain analogy to animals; here, in the pointedness of the hairs in the ears, and in the bundle on the coccyx; there, on the lateral surface of the arm and forearm, in the opposite directions of the hairs meeting on the olecranon process. This last characteristic has been attributed formerly to the Simian, Satyr, and Troglodyte only.

Further, so great a likeness exists between the directions of the hairs and the forms of the rugae and sulci serving the sense of touch—gyrate, palmate, angular, etc.—that it is plain that nature, which everywhere is one and the same, from the epidermal substance which serves to make hairs forms for her own uses these rugae and sulci, which seem to have grown by a gathering together of hairs and a storing and accumulation of them under the skin.

It would not be aside from the subject to begin experiments concerning the growth of hairs and nails in different individuals, since this matter can be subjected to measurements of almost mathematical accuracy. Further, the different shapes of the nails in individuals; their absolute dimensions, and those relative to the hand and the rest of the body; their color and discoloration; the size and shape of the moons—these demand attention no less than the rest of the subjects hitherto enumerated.

In general, the growth of the skin system is easily open to observation and experimentation if, by cutting or pressing or by the use of chemical substances, we provoke it to react. But different diseases of the skin—cachexy, eruptions, and exanthemata, all of which alter the physiological laws of growth—cause innumerable modifications of form.

7. The Malpighian rete does not open up so easily to external investigation in vivo, unless you take it to be the gelatinous substance which comes

into sight when the epidermis has been destroyed by burning or blistering.

I am not able at this time to discuss the elastic fibers. These fibers, of about the same diameter as ordinary sheep's wool, are easily seen when the epidermis is macerated, loosened, and slowly lifted and drawn back from the palm of the hand or the sole of the foot. When this is done, they appear in the angle formed by the corium and the inner surface of the epidermis, almost evenly spaced and yielding elastically to a continued stretch. Indeed, it is my belief, although it is but human to err in dealing with so small an object, that these filaments, emerging from the middle of the contiguous papillae, terminate in the pores which occupy the depressions of the epidermis at evenly spaced intervals. Whether these are vessels or solid threads, or excretory canals, is hard to demonstrate. By chance it fell to my happy lot to demonstrate them in a dried state. While investigating the analogous action of infusion of coffee and pyroligneous acid, I had left a human thumb to dry, after first treating with an infusion. Where the epidermis was drawn back and stood away from the corium because of its lessened contractibility, these fibers were visible either intact or split in the middle.

Likewise in warts, when their structure is made more visible by maceration, it is distinctly seen that the fibers are continued from the outer surface of the corium. These fibers are seen on the epidermis, as the wart is pulled away, like the hairs of a little paint brush, but the rest of the wart appears to be bored with small holes. More than once I have had the opportunity to observe, from an infected wart on my own hand, that it was nothing but a clump of tubules. Upon perpendicular section these are separated and through their transparent sides blood-stained fibers are seen running toward the outer end. Upon horizontal excision, they exude lymph or blood from evenly spaced pores.

8. The rete of the capillaries, which envelops the entire surface under the epidermis, is also offered for external inspection in a living subject. A lens is constructed having a focal distance of almost half a thumb-length. This is adjusted to an apparatus such as buyers of linens use for counting the threads in a certain space, where, in the focal distance, a horizontal plate perforated by a quadrangular opening is fixed for observing the object. By this apparatus redness of the skin, produced by rubbing or sucking, may be observed. The epidermis is more transparent if rubbed with oil and looked at in the sun. Then, especially in younger subjects, a rete of the most minute vessels will be observed, and also the roots verging upward in the epidermis and there ending in a red spot.

By this medium, over all the surface of the skin the modifications in the distribution of the vessels and their branches can be conveniently observed; and thus somehow a way will lie open by which it will be easier to observe and investigate externally the vascular system. Such a method is efficient for observing certain skin affections, eruptions, exanthemata, and various forms of inflammation and ulceration in a living body.

9. The close union of the skin with the fibrous and muscular system we may conjecture from sulci and little depressions which are seen in both fat and lean individuals, in the arms, and which are formed by fibrous union between the skin and aponeuroses.

Indeed, this junction is plainest in the sole of the foot, where the plantar aponeurosis is joined with the underlying corium by fibrous sheets closely interwoven with fat. An equally close union is seen in the aponeurosis and fascia lata of the thigh, where single longitudinal sheets, penetrating the fat of the corium, are woven into it. This is especially conspicuous over the glutaeus maximus, whose separate fasciculi are interwoven with fibrous extensions from the skin; but particularly over the great trochanter, where the glutaei are inserted, this fibrous junction with the skin is conspicuous, where even in the fat on the external surface a depression is seen. If you pinch up the skin here with your fingers, it is pulled back by the contraction of the glutaei and the tensor fascia lata. In the linea alba and in the abdomen where the transverse tendinous inscriptions are attached to the recti, fibrous retinacula are also continued into the corium. In the palm of the hand the palmar aponeurosis and the tendons of the palmaris are closely bound to the skin over carpals and metacarpals. Such a union is seen also over the olecranon and on the arm, during vigorous muscular exercise, when the skin is stretched and is seen to adhere to the bones. By this union between muscles and skin, rugae and sulci are formed, which run almost at right angles to the course of the powerful muscular fibers under the skin.

Of great importance, in this matter of the relation of the skin to the fibrous and muscular system, is a somewhat more careful inquiry into the anatomy of sculptors and painters, where neither empiric imitation of a nude body nor the delineation of decorated arms completes the whole work; where one investigates the most minute elevations or depressions of an organic nature on the surface of the body with steadfast and subtle attention.

10. Similarly, the panniculus adiposus which lies under the skin must not be neglected in the investigation, since it most of all determines the external surface, and so the shape of the body. The distribution and the quantity of fat can be not only observed, but also palpated. Certainly, in different individuals there occur differences in consistency, color and amount of fat. Even at a distance it may be noted that the buttocks in man contain two mounds of somewhat hard fat interwoven in the copious and firm tela subcutanea. This calls to mind an analogy to the thick-skinned buttocks of apes.

11. Finally, the mucous membrane must be observed in the orifices through which it lies open to view from the outside. Here must be considered the varieties of soft palate and of tonsils, but mostly of the papillae of the tongue. For all this suitable material will contribute to the specialized knowledge of man, which is of greatest importance in practice, and is of no less moment than is general knowledge.