1

THE BODY SURFACE

Skin is the organ which forms the boundary between the body and the external world. It helps to maintain internal homeostasis by thermoregulatory secretory activity, forms a self-repairing barrier against physical and chemical assault, provides an important route for the transmission of information about the external environment, and retains, in the layer immediately subjacent, a major food reserve. The appearance of skin, including hair and nails, provides both social signals and clues to the general state of well-being.

AREA

The skin comprises about one-twelfth of the body mass, yet the apparent surface area of the adult is only 1.2–2.0 m^2. This is due largely to the absence of major folds, plication and villi, and to the relatively smooth contours of the overall body surface. An approximate value for the surface area can be obtained from a knowledge of the height and body weight of an individual. A simple nomograph relating these variables is given in Fig. 1.

Calculation of the true body surface area is very complex and requires the summation of a large number of small measurements. Even then, assumptions relating to the creases and micro-folding of the stratum corneum need to be made. Hence attempts to measure total skin surface area are seldom made and it is questionable whether such measurements would have any useful applications in either dermatology or cosmetics.

TOPOLOGY

Skin surface patterns are formed by folding or ridge formation. In the early stages of development, the epidermis is formed from the ectodermal embryonic layer, and gives rise to hair follicles, apocrine, sebaceous and eccrine glands. The classical work of Pinkus (1910, 1927) forms the basis on which most later descriptions rest.

The early embryonic epidermis consists of a uniform sheet of cells two layers thick; the outer includes the periderm and epitrichial layer which completely covers the embryo, and the inner includes the stratum germinativum, (Fig. 2*a*). By 11 weeks, three layers are visible (the middle layer now being termed the stratum intermedium) (Fig. 2*b*). The basal layer now shows evidence of increased mitotic activity and the cells have become taller and

Cambridge University Press
978-0-521-10681-8 - Skin
P. F. Millington and R. Wilkinson
Excerpt
More information

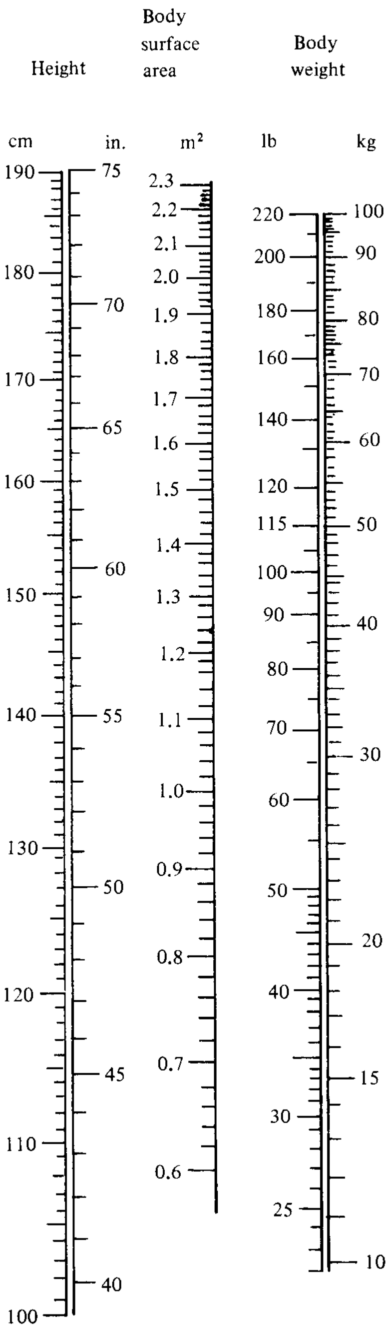

Fig. 1. Nomograph for determining body surface area from two variables: body weight and height. To use the nomograph, lay a straight edge to intercept height and weight at appropriate points. Read area from the intercept of the straight edge with the surface area line.

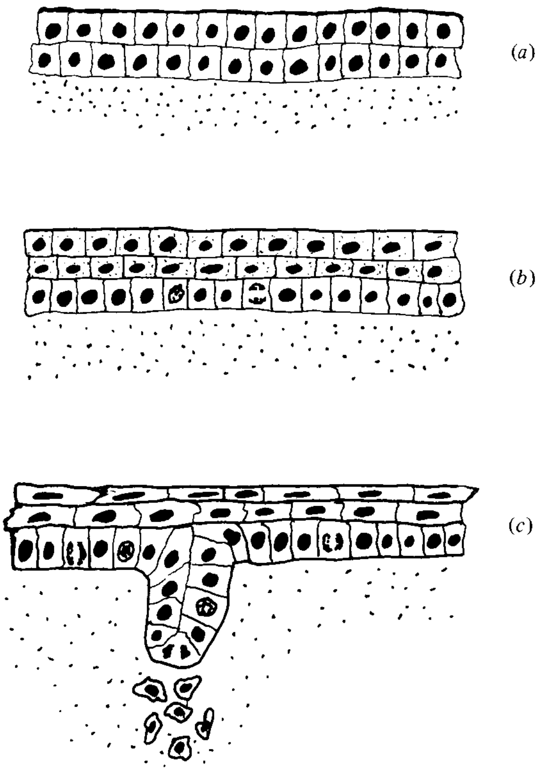

Fig. 2. Diagrammatic representation of embryonic growth of epidermis. (*a*) *Early embryo*. Two layers, the outer periderm and epitrichial layer, and an inner stratum germinativum. (*b*) *About 11 weeks*. Three layers; the middle layer is known as the stratum intermedium. (*c*) *About 12 weeks*. Basal layer becomes more columnar and begins to grow downwards. Below the downward growth, mesenchymal cells form focal aggregations. It is from these cells that hair follicles will develop.

more closely packed. The nuclei are rounder and larger. After a very short time, mesenchymal cells begin to aggregate below selected areas, some of which will develop later into hair follicles. Columnar basal cells begin to grow downwards (Fig. 2*c*), and a basement membrane develops at the epidermal–dermal junction. It is shortly after this that foetal ridges and lines are noted.

The first surface ridges are formed about the thirteenth week on the palmar and plantar surfaces of the tips of the digits and later extend over the entire volar surfaces of the hands and feet (Hale, 1952). The ridges lie over the dermal papillae through which the sweat ducts will penetrate to emerge through the elevated portions of the ridges. The patterns that develop at this time remain essentially the same throughout life, although the ridge width increases at the same rate as the growth of the hands and feet (Hale, 1949).

During the early period of growth, up to 14 weeks, the epidermal cells contain large quantities of glycogen, and the periderm displays microvilli. As the number of intracellular fibres increases, the glycogen diminishes, so that, by the sixteenth week, the periderm contains both fully keratinised and unkeratinised cells, with many subjacent cells containing keratohyalin. By the seventeenth week, the outer layer of cells is fully keratinised and exhibits only minimal glycogen content. The epidermis has all the essential structural characteristics of the adult.

Until the early 1970s there had been few attempts to describe systematically and in detail the surface characteristics of skin, other than the ridge patterns of the fingers, hands and feet. From both direct photography and impression or printing techniques of skin, descriptions were added to histologically derived information to build up a record of the body surface necessary for the medical needs of the time. Major developments in plastic surgery from 1937 to 1945, necessitated by the demand for urgent treatment of burns inflicted during World War 2, caused renewed interest in the cosmetic achievements of surgery. This in turn led to a number of attempts to add detail to the description of skin surfaces (Wolf, 1937, 1939; Hambrick & Blank, 1954; Oberste-Lehn, 1962; Moynahan & Engel, 1962; Sarkany, 1962; Facq, Kirk & Rebell, 1964).

The advent of scanning electron microscopy led to an increased interest in the surface structure of skin. However, the procedures used in the preparation of specimens had been based on those of conventional histology and caused large distortions primarily through shrinkage. A search for methods to give accurate topographical information has been a major concern since 1960.

Sarkany (1962) described a replication method for studying skin topography using a plastic material, but the method later introduced by Facq *et al.* (1964) has been the one on which most replica techniques have been based. They devised a system wherein a short length of acetone-soluble film with high adhesive properties was laid on a clean glass slide in a small pool of acetone and allowed to dry. Any slides with small bubbles showing Newtonian rings were discarded, as were any where the film edges were curled. Replicas were obtained by two variants of their basic technique. Flat resilient areas of the body (trunk or fleshy parts of the limbs), when held as near horizontal as possible, were flooded with acetone and the slide-borne film rolled onto the area so as to exclude all air between the film and skin. On highly contoured areas, such as the nose, digits or bony prominences, one or two drops of acetone were allowed to fall onto the film and the appropriate area of skin lowered onto the slide. In either case, contact was maintained until the film had dried, when it was carefully removed, starting at one corner and lifting evenly.

Various replica materials have been tried from time to time. The use of synthetic rubber was reported by Goldman *et al.* (1969) as being excellent for the relatively dry outer surface of skin. Kuokkanen (1972) used a silicone rubber paste, Xantopren (manufactured by Farbenfabriken Bayern, A.G., Germany), to obtain some excellent impressions of skin. She used a method similar to that of Facq. A small quantity of the paste was placed on a glass slide, and after mixing with a few drops of hardening substance, pressed onto the skin. When hard, the replica loosens readily from the skin but adheres to the slide. An alternative method employs Silcoset (ICI) which has been mixed with a fast-setting catalyst. A small quantity may be applied to the skin with a 'swab' stick which is rolled in a direction counter to that of the movement across the skin. Since all available catalysts can produce an unwelcome skin reaction, a small test area should be tried before undertaking multiple replicas or applying to a visible area of the skin. The replica can be lifted away as soon as set with the aid of a pair of forceps, holding it at one corner. Because Silcoset has good elastic properties, any small extension or distortion introduced during lifting, recovers almost immediately to give an excellent replica of skin.

A variation of the replica methods that is claimed to be an improved technique for studying the stratum corneum, was introduced by Marks & Dawber (1971). They replaced the plastic film and acetone of the earlier method by ethyl cyanoacrylate, which in the presence of small quantities of water or water vapour adheres very firmly to both skin and glass. A thin biopsy specimen of the stratum corneum can thus be obtained. Such a preparation may be stained before inspection by light microscopy to display not only the outer surface of the stratum corneum, but also the underlying surface of the removed corneocytes. Direct photographic enlargement of the adhered specimen permits the visualisation of major crease patterns.

Replicas and stripped specimens may be inspected directly and then photographed. After coating with a suitable conducting material, such as gold or gold–palladium, they may be mounted on a stub for inspection by scanning electron microscopy at magnifications up to × 50000.

First reports contained many illustrations of differences in skin patterns at different body sites, but most were concerned more with the techniques employed than with the site variations. Nevertheless, a general sequence of patterns was quickly established and forms the basis of the following descriptions.

Because of the need to shave away hair from sites of dense growth, skin patterns for scalp, pubic region, and mid-ventral thoracic regions in men are poorly documented. Except for the volar regions of the body, there appears to be a simple basic pattern to the creases in skin which is modified locally according to the direction and frequency of movement. In all major areas of the body the skin surface has a geometric pattern. The vertical direction of the crease is inwards towards the dermis, but the principal planar region is not flat, but curved outwards. These two features represent a built-in redundancy, which is essential for extensive movement of the skin surface

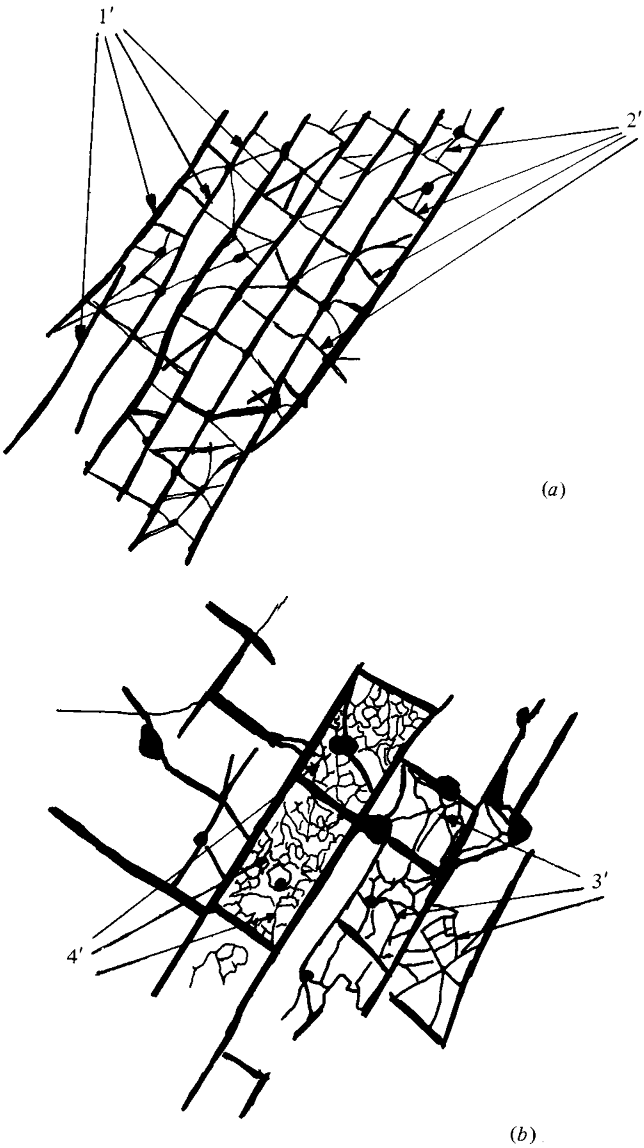

Fig. 3. Epidermal surface lines. (*a*) Primary (1′) and secondary (2′) lines. (*b*) The much smaller tertiary (3′) and quaternary (4′) lines. The quaternary lines coincide with cell outlines.

(Schellander & Headington, 1974). The linear creases cross each other to give rise to a lattice-type pattern. Although it has been reported that over limited areas these patterns are isometric, this is seldom the case. Generally the repetitive spacing in one direction is longer than in the other, and the commonest repeat figure is a rectangle or parallelogram. The rectangles are

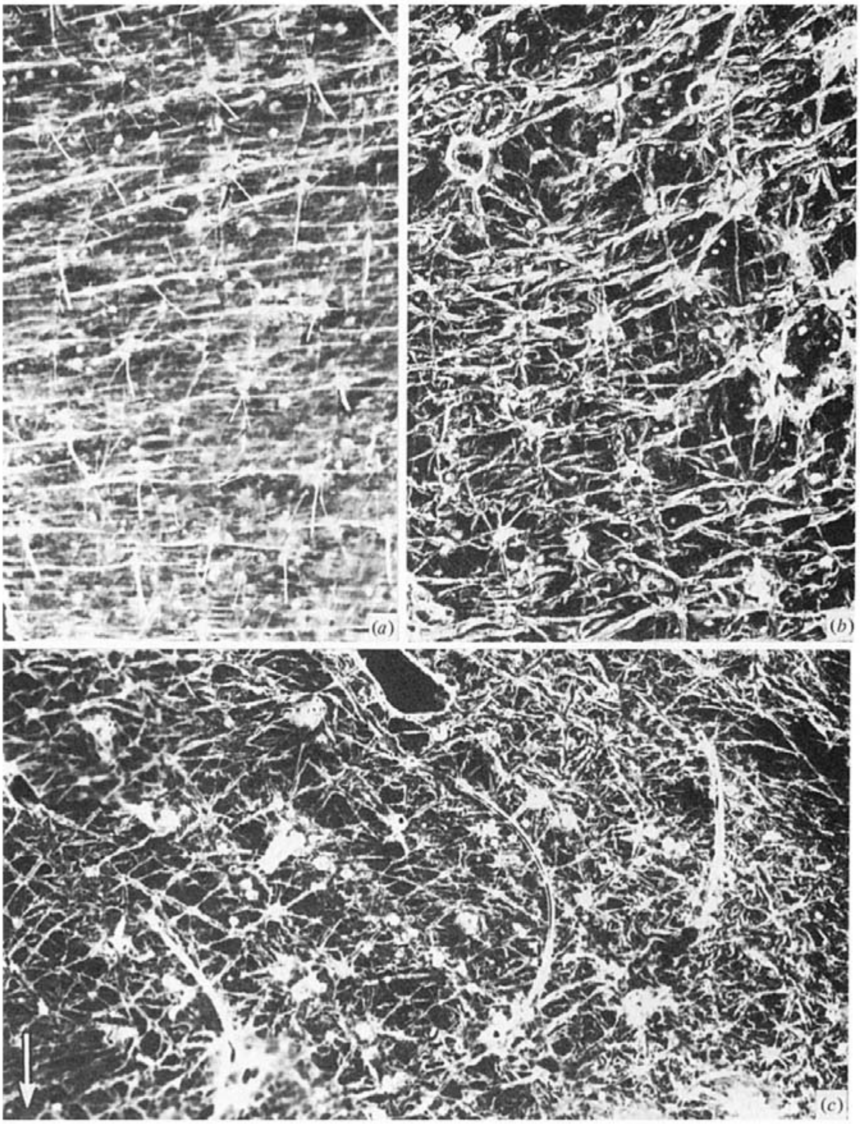

Fig. 4. Photographic enlargements (× 9.5) of crease patterns in stripped epidermal skin. (*a*) Forehead, (*b*) lower jaw, (*c*) neck. The arrow indicates the direction of the long axis of the body. Hairs are prominent in both jaw and neck specimens.

in turn crossed by one or two diagonals, which subdivide them into two or four triangles.

From low-magnification study, it would appear that the triangles are the smallest unit on many areas of skin, and these correspond to the primary and secondary lines proposed by Wolf (1939) and later subscribed to by Fujita

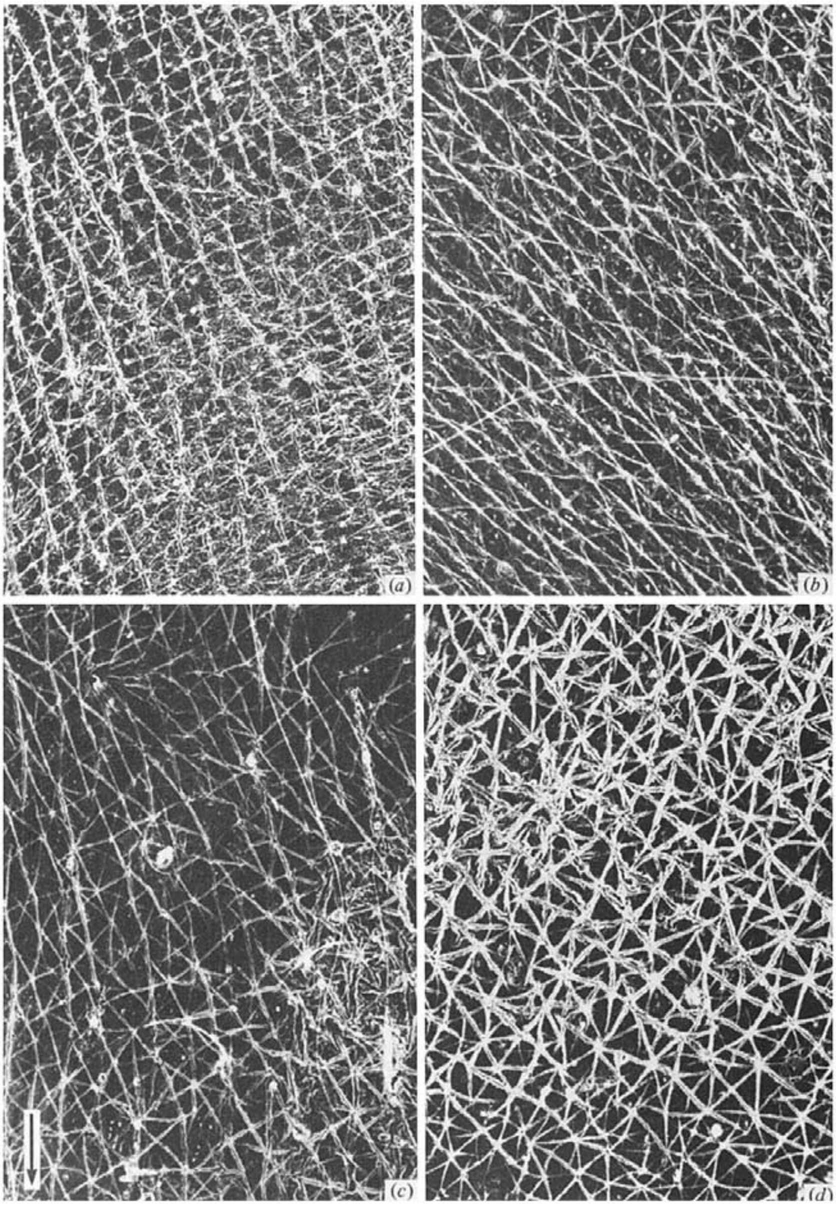

Fig. 5. Photographic enlargements (× 7.5) of crease patterns in stripped epidermal skin. (*a*) Thorax, (*b*) abdomen, (*c*) back, (*d*) buttock. The arrow indicates the direction of the long axis of the body.

(1973) & Hashimoto (1974) (Fig. 3*a*). At higher magnification, smaller creases can be detected along the edges of groups of corneocytes (tertiary lines), and the boundaries of individual corneocytes have been termed 'quaternary lines' (Fig. 3*b*).

Each triangle or sub-unit encloses a variable number of horny cells, which themselves are geometric, the most common shape being either hexagonal or pentagonal. The presence of the sub-units or tertiary lines is more common in sites with pronounced flexibility (wrist, knuckle, elbow, instep, etc.) and less common over the flatter surfaces of forearm, shin and trunk. The primary system of creases usually represents the macroscopically visible skin creases. The finding that this pattern prevails throughout the entire thickness of the horny layer can be demonstrated by successive strippings taken from the same site.

The *scalp* surface pattern would appear to be an unusual system of hexagonal lines, with finer lines tending to radiate from the centre, but with smaller hexagonal patterns occasionally visible (Schellander & Headington, 1974). By contrast, the *forehead* shows a very rudimentary rectilinear pattern (Fig. 4*a*). Orientation of the primary creases is in line with the major vertical and horizontal body axes. Secondary creases radiate from certain cross-over points which contain hair follicles. These creases seldom extend beyond the first primary crease. The *cheek* presents a pattern dominated by crease lines radiating from the insertion points of hair follicles. The lower jaw, too, is dominated by radiating creases, but the rectilinear creases can be readily distinguished (Fig. 4*b*).

The *neck* pattern is dominated by the circumferential creases, which appear to bifurcate and anastomose to form an interlinked network, (Fig. 4*c*). By scanning electron microscopy the same patterns appear to have numerous short cross-creases.

The *thorax*, *abdomen*, *back* and *buttock* all have very similar surface patterns. The dimensions of the patterns vary from site to site and are distorted wherever the skin is relaxed (Fig. 5*a–d*). The basic pattern described above dominates the normal appearance and in all cases the two primary creases are inclined to the vertical axis of the body so that they appear as a pattern of diamonds, interlaced by secondary creases. In many areas the apparent pattern is one of triangles. The length of the sides of the triangles varies from about 0.5 mm to 0.9 mm.

The *calf* has a pattern which is principally one of simple parallelograms, with sides inclined at an angle of approximately 30° and 40° to the vertical (Fig. 6*c*). The patterns of the *thigh* are similar (Fig. 6*a* and *b*), but the lateral thigh surface has unit dimensions approximately 50% higher than the medial surface.

Lateral and medial surfaces of the *arm* also show differences in unit primary crease dimensions and the patterns near the joints are dominated by the creasing required for joint movement. At the *wrist*, circumferential creases

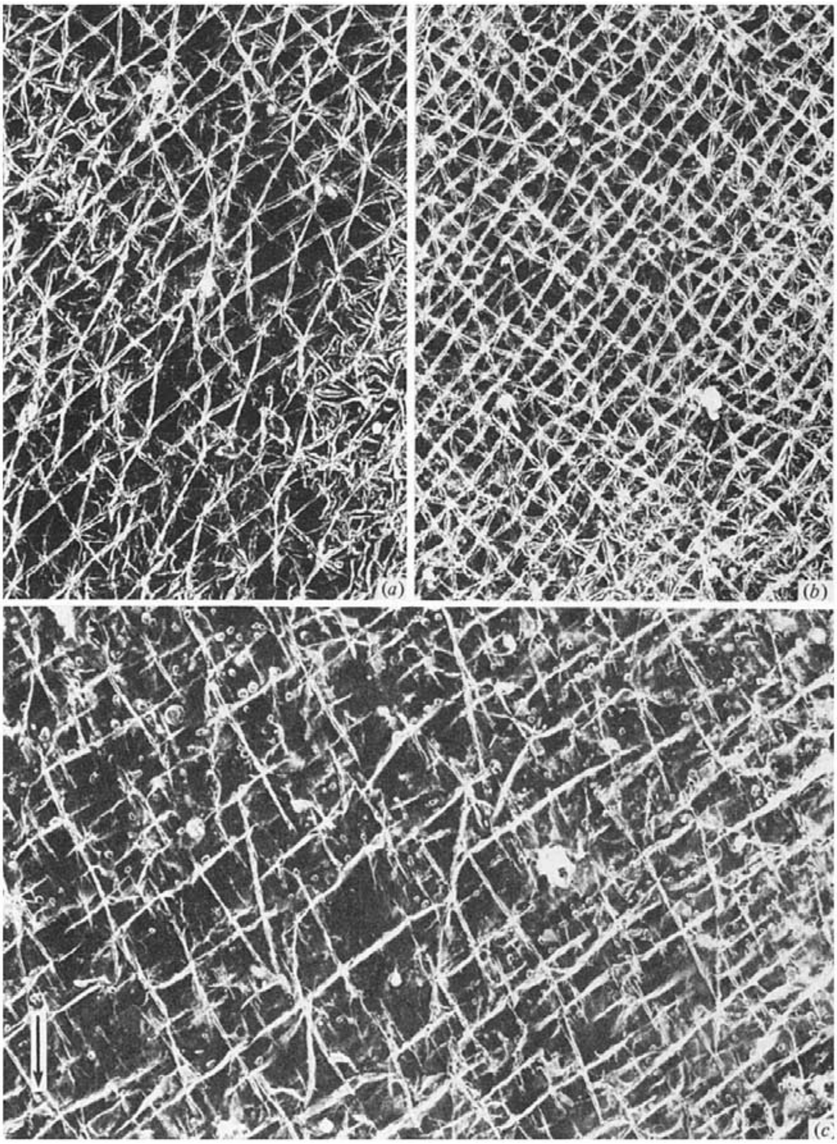

Fig. 6. Photographic enlargements (× 7.5) of crease patterns in stripped epidermal skin. (*a*) Thigh, lateral aspect, (*b*) thigh, medial aspect, (*c*) calf. The arrow indicates the direction of the long axis of the body. Note the very great differences in the crease pattern sizes on the leg.