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CELLULAR CHANGES IN THE PSORIATIC EPIDERMIS

VII. The influence of mercury compound on the submicroscopic differentiation of psoriatic epidermal cells

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The paucity of tonofilaments in the cells of psoriatic skin lesions, as well as the poor differentiation of the desmosomes, and the abundance of membrane-bound and free ribosomes and other cell organelles have been reported as characteristic features by v. Wettstein *et al.* (32), Zech *et al.* (34), Brody (5), Lagerholm (13), and Hashimoto and Lever (10). Lagerholm and Frithz (16) and Lagerholm (14) studying tissue cultures and long-term tissue subcultures prepared from psoriatic and unaffected epidermis, reported that the cultured psoriatic cells to a large extent retained the differences in cytoplasmic organization which are found, when non-cultured psoriatic cells ..re compared with non-cultured normal epidermal cells.

Based on electron microscopical studies psoriatic lesions of different age show, as concluded by Lagerholm (13), a gradual proceeding of the aberrant cellular differentiation. The light microscopical observations by Farber and Cox (7) amply support that early lesions of psoriasis in general possess a less characteristic appearance than do older lesions.

Rothman (23) reviewing studies on transepidermal absorption of mercurials for external treatment and Inman *et al.* (12) investigating the possibilities of poisonous absorption of ammoniated mercury stressed the little percutaneous passage of ammonium mercuric chloride.

For many years this and other mercurials have been used to resolve psoriatic lesions. Little or no discussion has appeared, however, in the literature on the mode of action of this heavy metal.

To provide a basis for further exploration of this problem, the present authors have studied the intracellular submicroscopic site of mercury in cells from psoriatic lesions and from normal epidermis pretreated *in vivo* with ammonium mercuric chloride. In these studies aldehyde fixation (excluding post-fixation in osmium tetroxide) was used for the preservation of cellular ultrastructure; thus no heavy metals were introduced that could interfere with the density of mercury compounds. Epidermis not pretreated with ammonium mercuric chloride showed a low contrast in the electron microscope. *In vivo* treatment with ammoniated mercury ointment increased considerably the contrast of certain cellular compounds, i.e. the ribosomes, the chromatin material in both psoriatic and normal epidermal cells and of certain intranucleolar particles. This indubitable site of mercury in the cells could explain the effect of this mercury ointment on psoriasis by (1) a more or less complete blocking or qualitative change of the function of the ribosomes, (2) a change in the synthesis of ribosomes or (3) a modification of the synthesis of messenger RNA.

To investigate the effect of mercury on the cellular differentiation of psoriatic epidermal cells the present submicroscopic analysis was undertaken.

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Material

Six adult male patients, aged 20–56 years, were used as donors of specimens for electron microscopy. Four of these patients originate from the material used for the previous investigation (8). As was the case with those patients, the other two had during the last five months not received any antipsoriatic treatment or been in contact with heavy metals, able to influence on the investigation. The duration of the skin lesions from which the biopsies were taken was in all the investigated cases 3–8 weeks. As in the preceeding studies (8, 17) sensitivity to mercury was excluded by patch testing procedure after the performance of the experiments.

Methods

Ammonium mercuric chloride in a concentration of 5 per cent in a vehicle consisting of 20 per cent adeps lanae and 80 per cent vaseline was applied to psoriatic lesions on the extensor surfaces of the arms. The cases presented in figures 2–10 had been treated with the ointment with applications twice daily for seven days and the cases in figures 11–13 for fifteen days. The specimens for electron microscopy obtained by punch biopsies taken without any anesthesia were all fixed during 6 hours at 4°C in 6.5 per cent glutaraldehyde buffered with a phosphate solution of pH 7. Postfixation was carried out in 2 per cent OsO_4 buffered with veronal acetate at pH 7.4 for 2 hours. The specimens were rinsed in a phosphate buffer solution and dehydrated in increasing concentrations of acetone and thereafter embedded in Vestopal W. Ultrathin sections were cut with the LKB-Ultrotome I and LKB-Ultrotome III. Before the examination and photographing of the sections in a Siemens Elmiskop I and Hitachi HS-7S electron microscope the specimens were stained with a solution of uranyl acetate and lead citrate (31) to enhance contrast in sections.

Results

The micrograph in figure 1 shows a cross section of a small part of psoriatic stratum spinosum, fixed in osmium tetroxide only, from a lesion, aged about 5 weeks. The structural organization of the psoriatic epidermal cells with the aberrant differentiation of the desmosomes and the tonofilamentous system and the abundance of cell organelles is easily observed. The occurrence of the tonofilaments is strongly reduced and tonofilamentous material is only found sporadically associated to the mostly poorly developed desmosomes. Aggregations of an amorphous material resembling in its contrast behaviour the tonofilamentous material associated to the desmosomes, appear haphazardly in cytoplasm.

In figures 2–13, typical cellular details of psoriatic epidermal cells, pretreated *in vivo* with the ammoniated mercury ointment during seven and fifteen days, as they appear after *in vivo* treatment with the ammoniated mercury ointment, glutaraldehyde-osmium fixation and the double-staining with uranyl and lead salts, are depicted using high microscopical magnification.

The detail of cytoplasm of the psoriatic spinous cell in figure 2 shows numerous ribosomes and amorphous masses. The ribosomes are partly spaced randomly in the cytoplasm and partly observed in juxtaposition to these amorphous masses. The investigated material was characterized by a complete absence of unequivocally recognizable tonofilaments. The morphological appearance of the ribosomes show a gross concordance to the ribosomes previously described by the present authors (8, 17). Thus the pentangular configuration of these particles is discernible when favourably sectioned. The ribosomes appearing single in the cytoplasm or in polysomal configuration in the glutaraldehyde-osmium-tetroxide fixed and double-stained material do not show the clearly visible central core as described for the ribosomes of psoriatic cells fixed in glutaraldehyde only and pretreated *in vivo* in the identical manner (8, 17). Suggested central hollow cores are, however, seen in some of the ribosomal structures (Figs. 2, 3, 6, 7, 8 and 9). When favourably orientated within the sections higher electron scattering material in round

aggregations is, however, distinguishable in their periphery. The connections between the ribosomes when in polysomal configuration and described as thin strands by Warner *et al.* (30) and others (1, 6, 9, 18, 19 and 27) are indicated (Figs. 2, 3, 5, 6, 7, 8, and 9).

The cytoplasm of the cells in figure 3 is rich in ribosomes of the same appearance. They are in many places observed closely associated to the amorphous masses. These masses are seen randomly in the cytoplasm but also associated to the desmosomes. The wide intercellular spaces are demarcated by unit membranes. The outer and inner leaflets of the bordering tripartite plasma membrane are recognizable.

The micrograph in figure 4 shows details of the nucleoplasmic and cytoplasmic substructure of a psoriatic epidermal interphase cell pretreated *in vivo* with an ointment containing 5 per cent of ammonium mercuric chloride fixed and double-stained as mentioned. The triple-layered unit membranes are separated by a comparatively narrow intercellular space. The ribosomes are strongly electron scattering and often pentangular shaped. The cytoplasm appears rich in the amorphous masses. The limiting double trimorphous membrane of the nucleus, the nuclear envelope, is not possible to identify unequivocally but the interfaces between the adjacent cytoplasm and the lighter separating space between the two layers of the nuclear envelope and the peripherally distributed, strongly electron dense chromatin material, and the less electron scattering separating space are partly sharply demarcated indicating the location of the outer respectively the inner layers of the nuclear envelope. In the granular nucleoplasm the peripherally and scattered chromatin material stand out because of its generally higher density. High electron scattering structures in cross section having a polyangular, sometimes suggested pentagular, outline occur in the karyoplasm.

The micrographs in figures 5–8 also show the submicroscopic appearance of parts of sectioned psoriatic epidermal cells treated identically as those in figures 2–4. The attachment of the ribosomes closely to the amorphous masses is evident. Many of the ribosomes appear pentangular. In concordance with earlier observations (8, 17) not all of the sectioned particles are of this shape, nor are they of uniform size. Different orientation of the particles within the sections offers an explanation of these observations. In some places, as suggested in figures 5–8, nuclear pores are indicated as discontinuities of the peripherally arranged chromatin material.

In figure 8, 9 and 10, several apparently comparatively well differentiated desmosomes of spinous cells are seen. Amorphous masses of the same electron scattering properties and structural appearance, as those randomly distributed in cytoplasm, are closely associated to the desmosomes. The structure of desmosomes is by now well known (20, 33, 22, 5); they consist of areas of strict parallelism of the plasma membranes, an intercellular space occupied by a disc often seen bisected by a denser material. This is in a gross concordance with the depicted desmosomes. The unit membranes seem highly folded between desmosomes and have many villous projections. There seems to exist a firm adherence of the cells at the desmosomes combined with a moderate dilatation of the separating intercellular spaces.

The ribosomes show a close topographic relationship to the amorphous masses and are observed single or in aggregates. Thin strands are indicated between the free ribosomes arranged as polysomes.

The micrographs in figures 11–13 show the submicroscopic details of sectioned cells from psoriatic lesions pretreated *in vivo* with the ammoniated mercury ointment during fifteen days. In the part of cytoplasm of the spinous cells depicted in figures 11–12 numerous ribosomes single and in polysomal configuration are observed often in close contact to the amorphous masses. The latter have achieved the character of tonofilament bundles, but no individual filaments are distinguishable in the bundle like formation. A presumably well differentiated desmosome is indicated in figure 11. A small part of the unit membrane is recognizable in figure 12.

As can be seen in figure 11–12 and especially in figure 13 the cytoplasm of the cells is strikingly rich in tonofilament bundle-like structures dispersed at random and forming curle-like aggregates throughout the cells. Such large amounts of dispersed bundle-like material as found in the present investigated psoriatic, pretreated cells have only been reported for cultured psoriatic epidermal cells (14, 16). No individual tonofilaments are recognizable within the bundles in the micrographs.

Measurements of the longest diameter of individual ribosomes in the present material were performed with a graduated magnifier. The average length was calculated to 160 Å ± 9.7 (n = 300). The thickness of the unit membrane is about 80 Å.

The ribosomes in each of the two parallel rows of a conjectured helix-like arranged polysome (Figs. 2, 3, 5, 7 and 8) are separated by an average distance of about 100 Å. The distance between ribosomal centers ranges between 250–300 Å. The position of the ribosomes in the two rows appear slightly staggered and the separating space was ranging between 70–100 Å and the center-to-center distance was estimated to about 250 Å.

Discussion

Cross-sections of ribosomes in polysomal arrangements often forming rosettes or circles reveal 4–6 ribosomes (Figs. 2, 6, 9, 11, 12 and 13) in some places possibly more, in the plane of section. It has been suggested that the ribosomal clusters were held together by messenger RNA described as thin strands (9), since RNase at low concentrations destroys the integrity of the polysomes (30). Suggested such strands were observed in the present (Figs. 2, 3, 5, 6, 7, 8, and 9) and in the previously published material [cf. (17) (Figs. 6, 12, 13 and 21)]. The connections seen in the present material and interpreted as RNA strands might also be explained as artefacts due to the accumulation of the heavy metals, used for contrast enhancement, between adjacent ribosomes. The size of the helical polysomes is conjecturably related to the length of the messenger RNA and the number of ribosomes of a polysome might be related to the nature of the protein synthesized. Considerable evidence is available that strongly suggests a correlation of polysome configuration and length with the syntheses of proteins. Among others, Slayter *et al.* (26) and Mathias *et al.* (19) have reached the conclusion that the messenger RNA connecting the ribosomes of the reticulocytes is large enough coding for one hemoglobin polypeptide chain.

Not all of the ribosomes, however, appear on the same level, thus suggesting a three-dimensional form of the polysomes. A difference in orientation and level of the ribosomes within the sections is conceivable, since the thickness of the sections exceeds the largest diameter of the ribosomes. The arrangement of the ribosomes in a zigzag manner interpreted as helix-like structures has been proposed by several authors (6, 18, 19, 24 and 27). Suggested such double linear arrays are roughly indicated in figures 2, 3, 6, 7 and 8 (x-arrow). Membrane-bound ribosomes are usually observed as parallel rows. The distances between the ribosomes of each row corresponding to the width of the endoplasmic reticulum exceed, however, the extent of space between the opposite, mutually obliquely located ribosomes of each linear array. Presumably depending on different orientations of the ribosomes to the electron beam and/or on the level of section variations of ribosomal appearance are observed. In occasional favourable orientations the ribosomes are visualized as pentangular images with suggested central hollow cores. In some filicitous sections possibly peripendicular to the axis of the supposed three-dimensionally formed polysomes, the ribosomes are observed arranged in a circular pattern. Such circular configurations mostly consist of 4–6 ribosomes. Polysomal aggregates of higher number of ribosomes show a tendency of disintegration of the ring-like formations. As already emphasized not all of the ribosomes in the clusters interpreted as polysomes appear at the same level within the section and this is also the case of the ribosomes seen in the

circular arrangements. All this is especially well distinguishable in sections from the material pretreated *in vivo* with ammoniated mercury and fixed in glutaraldehyde only, previously published by the present authors [cf. (17) (Figs. 6, 7, 12, 13, 14)] but also visible in figures 2, 3, 6, 8, 9 and 11–13. Closer examination of the polysomes shows that the distance between adjacent ribosomes is not constant, being of about a ribosomal diameter or less. The observed different appearances of the ribosomes present in the polysomal configurations, presumably depending on varying levels and orientations within the sections, and configurational changes of the polysomes is not in contradiction with the concept of polysomes as a helically cylindrical formation as emphasized by several authors (6, 18, 19, 24 and 27).

Considerable information of the structure and function of ribosomes in polysomal configuration has been obtained by many investigators (1, 3, 6, 9, 11, 21, 24, 26, 27 and 30), emphasizing polysomes active in protein synthesis. The helical arrangement of metabolically active polysomes is provided as the geometry most favourable for protein synthesis and for the resulting cellular differentiation (18).

The submicroscopic appearance of psoriatic epidermal cells from lesions of the investigated age splendiferously shows the prevailing lack in cellular differentiation (Fig. 1) (cf. 13). Electron microscopic observations are available that strongly suggest that psoriatic epidermal cells are rich in membrane bound and free ribosomes, the latter often observed in polysomal configuration (8, 13, and 17). It is conceivable that the ribosomal structures are involved in the cellular replicative process of psoriatic epidermis. Two extreme ways of function of an epidermal cell is imaginable, namely either it could be structureless resulting in poor cellular differentiation, or it could be highly determined and thereby imposing a high degree of organization on all of its processes. The reported observations on the ultrastructural appearance of psoriatic epidermal cells not influenced by any therapeutics (5, 10, 13, and 32) and on the biodynamics of the proliferating cell population of psoriatic lesions (28) indicate a less determined but intensive cellular function causing a delay in the synthesis of substances able to produce the high degree of differentiation peculiarly characteristic of normal epidermal cells. The functional significance of the ribosomes and polysomes of different configurations observed in the cytoplasm of untreated psoriatic epidermal cells is not explored. In spite of the absence of evidence permitting any functional significance to be ascribed to the psoriatic ribosomal structures it is conceivable that their indicated synthesizing activity is limited to certain proteins unable to form or to take part in the production of the cellular structures characterizing the normal highly differentiated epidermal cell. The probable high ribosomal protein synthesizing activity of the psoriatic cells seems—without disavowing other functional possibilities—to be mainly utilized in the known accelerated cellular multiplication significant for psoriatic epidermal lesions (28).

Response of the psoriatic lesions to topical treatment with ammoniated mercury ointment as indicated by light microscopical studies (Lagerholm and Frithz unpubl.) consists of among other things the reappearance of the granular cell layer and gradual disappearance of parakeratosis. The present electron microscopic analysis offers further suggestions as to the mechanism of action of ammoniated mercury on psoriatic lesions in addition to the earlier discussed (8, 17). A comparison of the structural organization of untreated psoriatic cells (5, 10, 13 and 31) (Fig. 1) with that of psoriatic epidermal cells from lesions of the same age, pretreated *in vivo* with the ointment containing ammonium mercuric chloride confirms the expectations of an altered cellular differentiation. The occurrence of the amorphous masses closely related to ribosomes and polysomes in the cytoplasm of the psoriatic epidermal cells pretreated for seven days is salient. Although little can be concluded at present about the amphibological nature and functions of these amorphous masses it seems conceivable that

they are precursors or constituents of the tonofilaments. This supposition is supported by the observations on the cytoplasmic organization of the cells from psoriatic lesions pretreated for fifteen days. The irregular amorphous masses in these cells are no longer demonstrable but seem to have been replaced by structures similar to tonofilament bundles (Figs. 11–13) appearing closely in contact with ribosomal arrangements.

The haphazard arrangement of the tonofilament bundle-like structures, suggests that the epidermal cells during the period of treatment *in vivo* were actively engaged in tonofilament synthesis. The amorphous masses are also seen associated to the desmosomes (Figs. 8–11) similar to the fully developed tonofilament bundles in normal epidermal cells. On account of the large masses of the amorphous material and tonofilament bundle-like structures or/and the poor distinction of certain cellular membranes after the used fixative methods, it was found hard to identify other cell organells in the cytoplasmic matrix of this material. A corrective change of the cellular differentiation during the treatment *in vivo* with the ammoniated mercury ointment might also explain the apparently reduced number of cell organells.

As recently reported by the present authors, particles similar to ribosomes appear in the nucleoplasm of the pretreated normal epidermal cells. Suggested such particles have also been observed in the present material. Their conceived significance in regard to ribosomal RNA or ribosome synthesis cannot be disavowed [cf. Frithz and Lagerholm (8)].

It is not possible at the present time from the morphological observations to elaborate on the functional significance of the ubiquitous ribosomal structures being observed in juxtaposition to the amorphous masses and the tonofilament bundle-like aggregates (Figs. 2–13). Assuming the tonofilamentous material being proteinaceous, may as a hypothesis be proposed that the ribosomes are engaged in synthesizing tonofilamentous substance during which process the messenger RNA strand codes for the peptide chain making up this material. Regarding this possible it would imply either a correction of the altered cellular function of the psoriatic cells by a differentiation of the functional organization of ribosomal/polysomal structures caused by mercury or an inhibition of tonofilament production, both ways permitting the epidermal cells synthesizing tonofilaments. The first-mentioned possibility could be accomplished by a direct effect of mercury on the ribosomes proper or on the cistronal synthesis of the messenger RNA later in attachment to the ribosomes determining the sequence of amino acids in a protein.

The consubstantial submicroscopic appearance of the ribosomes seems to contradict a ribosomal template for the synthesis of different proteins. For a reversion of an inhibition of tonofilament synthesis no corraborative evidence is available at present.

SUMMARY

Studies to obtain information about the amendatory influence of mercury compound on the submicroscopic organization of psoriatic epidermal cells are reported. Skin biopsies from psoriatic lesions pretreated *in vivo* with ammoniated mercury ointment for seven days and fifteen days were fixed in glutaraldehyde-osmium tetroxide and stained with uranyl acetate and lead citrate.

The present investigated material was characterized by an absence of unequivocally recognizable tonofilaments. Amorphous masses resembling tonofilamentous material are observed. Numerous ribosomes are seen partly spaced randomly in the cytoplasm and partly in juxtaposition to these amorphous masses. 4–6 ribosomes in polysomal configuration are often forming rosettes or circles. A staggered arrangement of ribosomes is indicated. The ribosomes show a close topographic relationship with the amorphous masses of tonofilamentous character. The desmosomes are comparatively well differentiated.

In the material pretreated with ammoniated mercury for fifteen days the desmo-

somes appear well differentiated and the cytoplasm of the cells is strikingly rich in tonofilament bundle-like structures randomly dispersed and forming verticilated aggregates.

The observed alterations in the submicroscopical appearance of untreated psoriatic cells indicate a less determined but intensive cellular function. Ultrastructural changes interpreted as a response of the psoriatic epidermal cells to topical treatment with ammoniated mercury is described, and the influence of mercury compound on the cellular differentiation is discussed.

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FIGURES

Abbreviations used

D:	Desmosome
EM:	Nuclear envelope
IS:	Intercellular space
KP:	Intranuclear particle
N:	Nucleus
Np:	Nuclear pore
P:	Polysome
PC:	Peripherally distributed chromatin
R:	Ribosome
SC:	Scattered chromatin
T:	Tonofilament bundle-like structures
TM:	Masses, conceivable precursor of tonofilaments
UM:	Unit membrane

Fig. 1. Micrograph showing a cross section of a portion of the stratum spinosum from a psoriatic lesion, aged about 5 weeks. The desmosomes (D) appear poorly developed. Tonofilament bundles (T) are rare. Ribosomes (R) are ubiquitous. Aggregations of amorphous material (TM) are found in the cytoplasm. 22,500×.

Fig. 2. Detail of cytoplasm of a spinous cell from a psoriatic lesion, treated *in vivo* with ammoniated mercury, aged 3–8 weeks, showing amorphous masses (TM), numerous ribosomes (R) and polysomes (P). Suggested helical arrangements of ribosomes are indicated (X-arrow). 260,000×.

Fig. 3. Section of psoriatic spinous cells separated by intercellular spaces (IS). The unit membrane (UM) is recognizable. Ribosomes (R) are seen closely associated with the amorphous masses (TM). Double rows of slightly staggered ribosomes suggesting a helix-like structure are indicated (X-arrow). 185,000×.

Fig. 4. Part of nucleus (N) and cytoplasm of a psoriatic spinous interphase cell. Within the nucleus peripherally (PC) and scattered chromatin masses (SC) and electron dense intranuclear particles (KP), mostly of pentangular shape, are seen. Ribosomes (R) and amorphous masses (TM) are ubiquitous. UM, unit membrane. 123,000×.

Fig. 5. Micrograph showing details of cytoplasm and nucleoplasm of a spinous cell from a psoriatic lesion treated *in vivo* with an ointment containing 5 per cent ammonium mercuric chloride for seven days. Many of the mostly pentangular ribosomes (R) are observed in juxtaposition to the amorphous masses (TM). A nuclear pore (Np) is indicated as a discontinuity of the peripherally distributed chromatin (PC). N, nucleus. 126,000×.

Fig. 6. Portions of cytoplasm and nucleus of psoriatic epidermal cell from a lesion pretreated as the material in figures 2–5. The ribosomes are seen single (R) and in polysomal configuration (P). Indicated double rows of ribosomes, not all appearing in the same plane of section and slightly staggered, suggesting a helical arrangement, are distinguishable (X-arrow). Many ribosomes are seen in close contact with the amorphous masses (TM). The nuclear envelope (EM) is poorly defined. Discontinuities of the peripherally distributed chromatin masses (PC) suggest nuclear pores (Np). N, nucleus. 187,000×.

Fig. 7. Part of cytoplasmic and nucleoplasmic region of a spinous cell from a psoriatic lesion of the same age as the material depicted in figures 2–6 and pretreated with a 5 per cent ammoniated mercury ointment for seven days. Ribosomes (R) are seen in similar arrangements as in figure 6. TM, amorphous masses. N, nucleus. Np, suggested nuclear pore. PC, peripherally located chromatin masses. KP, indicated nuclear particles. X-arrow, suggested double linear arrays with ribosomes in conjectured zig-zag manner. 202,000×.

Fig. 8. Detail of cell borders and cytoplasm with part of a nucleus of psoriatic granular cells. The trimorphous unit membrane (UM) has many villous projections and can be followed throughout the desmosomes (D). The desmosomes appear well differentiated. Amorphous masses (TM) are seen associated with the desmosomes. Numerous ribosomes (R) are observed in juxtaposition to the amorphous masses and in polysomal configuration (P). N, nucleus. SC, scattered chromatin. PC, peripheral chromatin. NP, suggested nuclear pore. X-arrow, indicated double linear arrays of ribosomes, conjecturably in a staggered threedimensional arrangement. 127,000×.

Fig. 9. Part of cellborder region of two psoriatic spinous cells, showing the tripartite unit membranes (UM), desmosomes (D), amorphous material (TM), scattered in the cytoplasm and associated with the desmosomes and ribosomes in polysomal configurations (P). IS, intercellular spaces. 195,000×.

Fig. 10. Section showing part of junctional areas between psoriatic spinous cells with the triple-layered puckered unit membranes (UM), the leaflets of which show a continuous coseismal discernibleness throughout the apparently highly differentiated desmosomes (D). Ribosomes (R) are perceivable proximately to the amorphous masses (TM). 188,000×.

Fig. 11. Micrograph showing cytoplasmic details of a spinous cell from a psoriatic lesion treated *in vivo* for fifteen days with a 5 per cent ammoniated mercury ointment. Ribosomes (R), single or in polysomal configuration (P), are abundant in the cytoplasm and mostly dispersed at random, but also juxtaposed to tonofilament bundle-like constituents (T) with a contrast behaviour similar to the amorphous masses (TM) also depicted in figures 1–10. A presumably well differentiated desmosome (D) is discernible. 116,000×.

Fig. 12. Cytoplasmic details of a spinous cell from a psoriatic lesion treated *in vivo* with an ointment containing 5 per cent ammonium mercuric chloride for fifteen days, showing tonofilament bundle-like structures (T), numerous ribosomes (R) appearing single or in polysomal arrangement. UM, unit membrane. 116,000×.

Fig. 13. Part of cytoplasm of a psoriatic spinous cell pretreated *in vivo* identically as the material presented in figures 11 and 12. The ubiquitous ribosomes (R) often forming polysomes (P) are in some places contiguous to tonofilament bundle-like material (T). The tonofilament bundle-like formations (T) appear randomly spaced and apparently verticilated. 120,000×.