To produce plots such as Fig. 2, an integer array is used to record the coordinates of the particle centres. To reduce the particle placement time, the shape of one-quarter of a particle is stored in an integer array (further details required to make the method feasible are given in ref. 3).

A great advantage of the method is that the computer time required to find a location for each particle is the same for each placement (parking). Particles are placed until there is no space available for a particle centre. While the time required to place a particle is quite long (48 ms to place each $(65/2)\times(65/2)$ square particle, including all book-keeping, on IBM 370/168), it remains independent of the number of particles placed. (The time and memory requirements of the program increase drastically with the accuracy of the placement desired. To add one

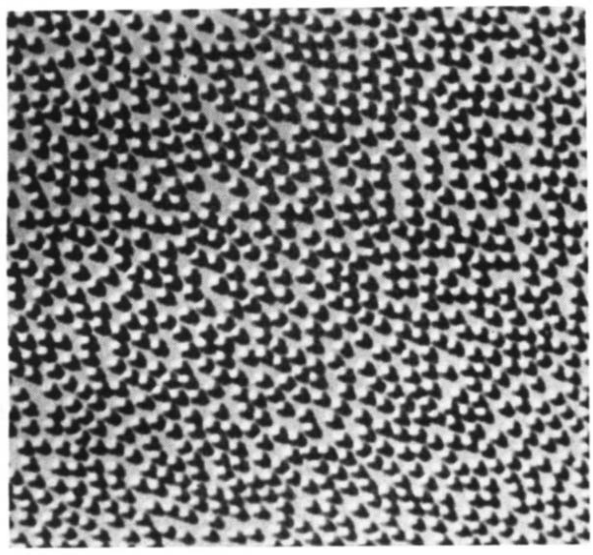

Fig. 2 Sample of fine mesh method for randomly sequentially placing circular particles (disks) into a square region. (The area shown is covered by a square mesh—not shown—of $1,024\times1,024$. Also, the disks have been synthetically shadowed so as to simulate the appearance of freeze-fractured particles, which usually seem to be hemispherical.)

significant figure of accuracy in the two dimensions would increase both the time and memory requirements of the computer program 100-fold.)

The new result for the fractional area covered by maximally packed disks is 0.5027 ± 0.0020. We are not aware of any theoretical (or previous experimental) estimate (and simply note that this result is not inconsistent with the difference in shape between circles and squares, and that the squares were all orientated with sides parallel). For the maximum fractional area f covered by non-overlapping orientated square particles on a surface, in addition to Palásti's[5] conjecture of 0.5589 and Akeda and Hori's[7] extrapolation of a simulation with rigid boundary conditions of 0.5626 ± 0.0006, we now have simulations with more realistic periodic boundary conditions which do not require extrapolation. These new results are for the coarse-mesh method $f=0.5629\pm0.0016$ (lower bound) and $f=0.5649\pm0.0016$ (upper bound) (errors are 95% confidence limits about the estimated mean), and for the fine-mesh method $f=0.5538\pm0.0035$. (The nominally low error quoted[6] is statistical, due to taking many samples, and will not affect the methodological problem associated with rigid boundaries in their simulation.) These new results bridge Palásti's conjecture[5]. Hence, in contradiction to other simulations[7] these new results together show that simulations give no reason to reject her[5] conjecture for orientated squares.

The areal density of particles in the human erythrocyte membrane[2] is substantially close to that of the maximum placing of disks. As during membrane biogenesis[8,9] proteins may be inserted into the membrane in a sequential process, it seems that to avoid the time and energy costs of many insertion attempts, the membrane must permit the protein to move laterally after insertion, that is, there must be at least short-range membrane fluidity[9].

This work was supported by NSF grant PCM 75-03542 A01 to L. F., and by Drexel University Graduate School. J.T.D. received a graduate fellowship. We thank Drs T. K. Lim and B. F. Schall, for comments, and W. L. Page and the library service to the faculty of the university.

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Received 1 September 1978; accepted 25 January 1979.

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The greening of polar bears in zoos

POLAR BEARS (*Thalarctos maritimus*) normally have creamy-white fur, presumably an adaptation for camouflage in a snowy environment. However, during the summer of 1978, the fur on the back and sides of three adults in the San Diego Zoo turned green, though the animals remained otherwise healthy. (Of these bears, one female was born in the zoo in Calgary, Alberta, Canada, in 1966 and was transferred to the San Diego Zoo in 1969; a second female was born in the wild, having been caught at Spitzbergen in 1951; the third, a male, was born in the San Diego Zoo in 1970.) This phenomenon, though less marked, has been noted in several previous summers, both here and in zoos elsewhere, for example, in Cologne, Germany (C. Hill, personal communication). The coloration was particularly evident on the flanks, on the outer fur of the legs and in a band across the rump: fur on the head and belly and inner sides of the legs was white. We first supposed that the colour was due to green algae such as *Chlorella* or *Scenedesmus* on the surfaces of hairs, growth of such algae being promoted by the presence of nitrogenous wastes in the waters of the bears' pool. (The pool in the exhibit area, which contains 12,500 gallons of tap water, is drained and cleaned twice weekly.) However, microscopic examination of samples of hair taken from the three San Diego bears and from a similarly green polar bear in the zoo at Fresno, California, revealed that this was not so. The outer surfaces of the hairs appeared clean and smooth, except for the normal squamation. The coloration was clearly attributable to the presence of algae inside the hairs, specifically in the hollow medullae of many of the wider (50–200 μm), stiffer guard hairs of the outer coat. (The thinner (<20 μm) and more undulant hairs of the under coat, which were not hollow, were colourless.) Some of the lumina were apparently filled with air, but many of these hollow spaces were partly occupied by masses of small greenish cells, which we describe here.

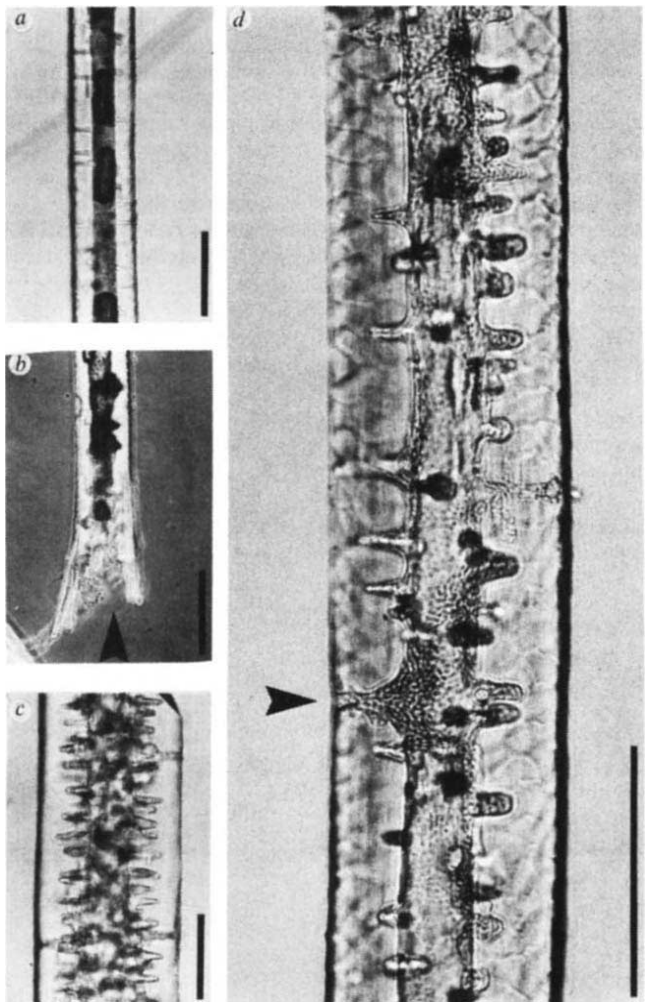

Fig. 1 *a*, Portion of green polar-bear hair, showing medulla containing air cavities and sections filled with algal cells. Note lateral ducts. *b*, Broken end of green polar-bear hair, showing medulla containing algal cells. *c*, Portion of green polar-bear hair, showing medulla with numerous lateral ducts. *d*, Portion of green polar-bear hair, showing medulla with lateral ducts (some communicating with outer surface: arrow) containing algal cells. Phase-contrast; scale bar, 100 μm.

The interior surfaces of the lumina of the narrower guard hairs were smooth. Many of those of intermediate width had pits and channels, more or less perpendicular to the hair axis, extending part of the way to the surface. Some were expanded into chambers parallel with the hair axis, especially near the broken distal end. Those of the stoutest hairs had very many such transverse channels (5–10 μm wide), some extending fully to the outer surface. These features, visible by light microscopy (Fig. 1*a*, *b*), could be clearly seen in stereoscan electron micrographs of sectioned hairs (Fig. 1*c*, *d*), which also showed pits in the hair surfaces where some of the side channels opened to the outside (Fig. 2*a*, *b*).

We have been unable to find any reference to such lateral ducts in the hairs of any mammal[1]. Hairs of comparable size from the head, shoulders and flanks of two wild polar bears from Spitzbergen, killed at Isfjord in May 1912 and at Svalbard in July 1967 were white, as were those of three bears obtained this year at L. Churchill, Manitoba: they had similarly hollow medullae but lacked any signs of lateral channels or of algae. (Hairs from four other marine mammals, a sea-otter (*Enhydra*), a northern fur seal (*Callorhinus*), a California sea-lion (*Zalophus*) and a harbour seal (*Phoca*), appeared solid: they too were alga-free.) It is possible that the transverse ducts were formed by keratolytic bacteria, which initially entered the lumina through broken distal ends. However, in the sections of green bear hairs examined by electron microscopy we saw little evidence of bacterial degradation of the keratin (Fig. 2*c*, *d*).

The fact that some of these lumina were in connection with the external air or water could explain how the algal cells could have entered the hairs in the first place, and how exchange of O_2 and CO_2 and uptake of water and mineral salts would be facilitated and could permit growth of the algae if suitably illuminated. Indeed, such a habitat has certain advantages, being warm and protected from most kinds of potential predators.

The algal cells from the green zoo bears were spherical, 2–4 μm in diameter. They were clearly prokaryotic; no plastids or nuclei could be distinguished, either by phase-contrast microscopy or in thin sections examined under the electron microscope. They divided by equatorial constriction; no other mode of reproduction was seen. In size and form they resembled *Aphanocapsa montana* Cramer, a blue-green alga in the order Chroococcales, though they appeared more green than blue-green.

Pure cultures were obtained by grinding a washed sample of the green hairs with sterile mineral nutrient medium in a Potter-type homogeniser and streaking a drop of the supernatant algal cell suspension on a 1% agar medium containing mineral nutrient salts[2]. The cells were constantly illuminated at ~2,000 lux from cool-white fluorescent lamps at 27 °C. After a week, individual algal colonies were visible under low magnification. Virtually all colonies were of the same size and form, confirming what had already been indicated by microscopic examination of the hairs, that is, that their algal cells were almost all of one type. (Among hundreds of thousands of colonies, only a dozen were of an evidently different kind: a filamentous blue-green alga, similar to *Phormidium*, with cells <2 μm wide.) Apparently clean colonies were selected, transferred to liquid Maertens' medium and illuminated in the same way. When tested on medium supplemented with 0.1% yeast extract, although most were contaminated with bacteria, a few were axenic. Pure cultures were subcultured in Maertens' medium in flasks on a shaker; they grew well, and were comparable in colour, cell size (2.5–4.5 μm), form and fine structure with those observed in the bear hairs (Fig. 3*a*). They required no organic factors for growth. In older cultures, possibly depleted

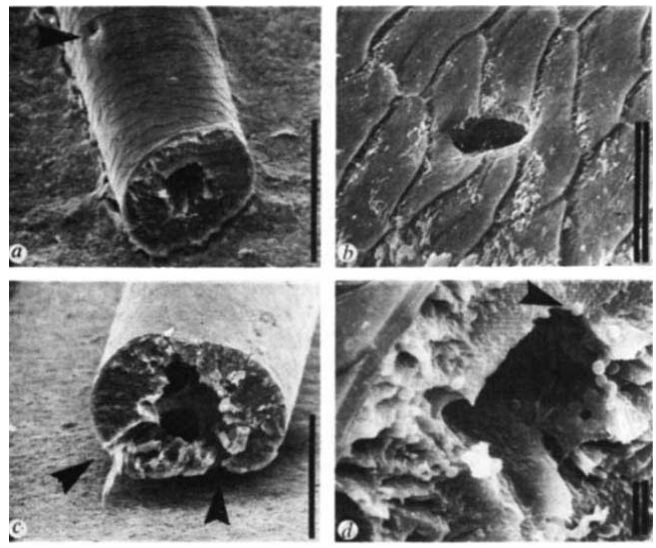

Fig. 2 *a*, Cut end of green polar-bear hair, showing hollow medulla and lateral pore (arrow) among imbricate scales. Stereoscan electron micrograph (SEM); scale bar, 100 μm. *b*, Pore among imbricate scales on surface of polar-bear hair. SEM; scale bar, 100 μm. *c*, Cut end of green polar-bear hair, showing hollow medulla with lateral ducts opening to surface (arrows). SEM; scale bar, 10 μm. *d*, Cut end of green polar-bear hair, showing algal cells (arrow) in lumen. SEM; scale bar, 10 μm.

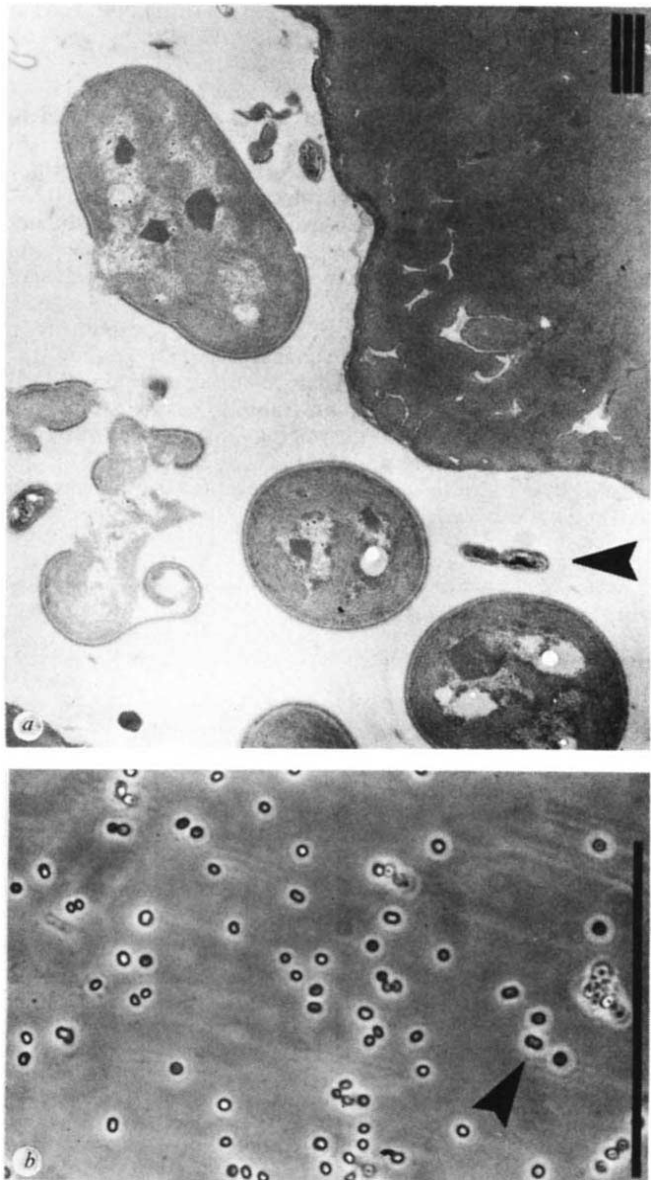

Fig. 3 *a*, Thin section of green polar-bear hair, showing cells of cyanophytes and bacteria (arrow) in medullary space. Transmission electron micrograph (TEM); scale bar, 1 μm. *b*, Cells of *Aphanocapsa montana* (?), showing division stages (arrow), in clonal culture isolated from green polar-bear hair (San Diego Zoo). Phase-contrast; scale bar, 100 μm.

of a fixed source of nitrogen, the cells became enveloped in colourless mucilaginous sheaths (Fig. 3*b*) which often developed asymmetrically. Growth was most rapid at 33 °C; above 36 °C the algae did not grow. When tested in a range of salinities they behaved like many freshwater species; at salinities below one-third sea water they grew well, but at higher concentrations growth was inhibited. Although we know of no record of keratin digestion by any alga, we tested for this by incubating sections of white polar-bear hairs with a pure culture of this alga in a mineral medium constantly shaken with air at 27 °C in white light. After 12 weeks, although cells grew in the lumina, we could see no indication of erosion of the hairs.

The cultured algal cells were usually bright green. When extracted with non-polar solvents they were found to contain chlorophyll *a* (but no chlorophyll *b*) and various carotenoids. When grown in white light, the cells produced no detectable phycobilin pigment; but when grown in red light they developed a distinctly bluish tinge and formed appreciable amounts of phycocyanin (tested by *in vitro* absorption and fluorescence spectra). We therefore concluded that the alga is a cyanophyte.

Similar cultures were isolated in the same way from hairs of the green polar bear at Fresno, mentioned above. Apparently the alga commonly infests the hairs of polar bears in zoos. It is a freshwater species, the cells of which probably originate from the pond water in the bears' enclosures and enter the medullary lumina of the guard hairs through broken distal ends or through the patent lateral ducts.

Few other chordates are known to harbour algae on their surfaces. Certain colonial ascidians in the family Didemnidae are associated with prochlorophytes[3]. Freshwater turtles may bear branched filamentous chlorophytes in the genus *Basicladia*[4]. Unidentified green algae may colour the pelage of monk seals (*Monachus*)[5], while brown or red algae (*Ectocarpus*, *Erythrocladia*) have occasionally been found growing on the hairs of fur seals[6]. On two-toed and three-toed sloths (*Bradypus* and *Choleopus*) grooves on the outer surfaces of their guard hairs bear algae of two kinds; filamentous chlorophytes assigned to the genus *Trichophilus* (Chaetophorales) and purple cyanophytes which have been called *Cyanoderma* (Chamaesiphonales)[7]. Several genera of pennate diatoms grow on the skin of various kinds of whales, including the 'sulphur-bottomed' whale[9]. These algae are all quite unlike the species found in hairs of captive polar bears, described here. The African prosimian primate *Galagoides* has been reported to have green algae associated with its fur[8], but this could not be confirmed.

We thank Dr Lanna Cheng for the stereoscan electron micrographs, Dr Norman McLean for transmission electron micrographs of thin sections of alga-infested hairs and Drs William Vidaver and Nancy Withers for the information on photosynthetic pigments. This work was partly supported by NSF grant 76-21405 (to R.A.L.).

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Received 18 December 1978; accepted 26 January 1979.

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Receptor for IgG(Fc) and human β_2-microglobulin on *S. mansoni* schistosomula

HOST antigen uptake by schistosomes is generally considered from circumstantial evidence to be a potent mechanism by which schistosomes can evade immune response and has therefore stimulated several investigations on the chemical nature of the molecules as well as their possible mode of incorporation[1]. These studies have indicated that the parasite can acquire host material in the form of glycolipids of erythrocyte origin[2] and gene products of the murine major histocompatibility complex[3]. As an alternative to host antigen incorporation, the possibility of immunological blockade has been suggested. Host immunoglobulins have been demonstrated to be associated with the tegumental surfaces of *Schistosoma mansoni* from mice and baboons, and recent experiments[4,5] have shown the presence of