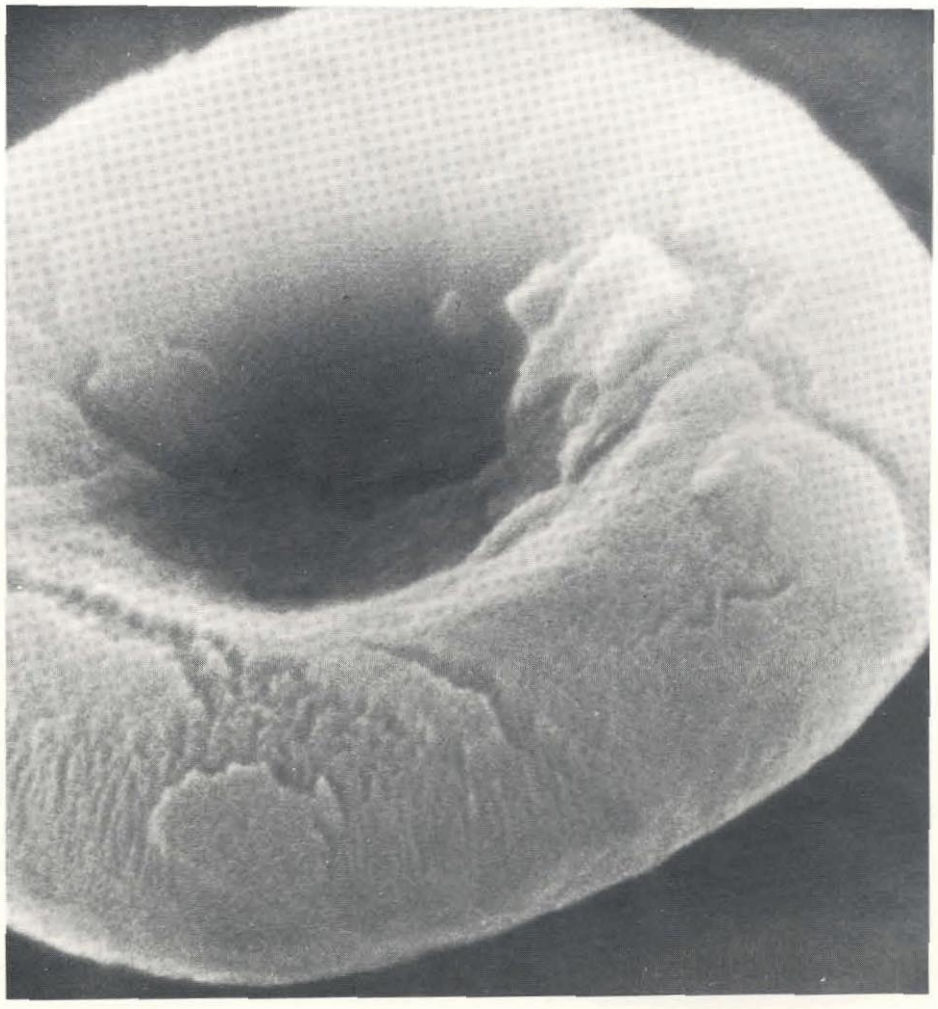
An Engineer Looks at Red Cells

The scanning electron microscope has provided a unique way to look at the external surface of biological materials. The technique gives a large depth of field —resulting in a vivid impression of three dimensions—allows large specimen area, and permits a wide magnification range. There are some disadvantages of the method, including limited resolution (100-200 Angstroms, compared with 5-10 Angstroms using transmission electron microscopy), the need to fix the specimen both physically and chemically, and the need for a conductive coating on the material being studied.

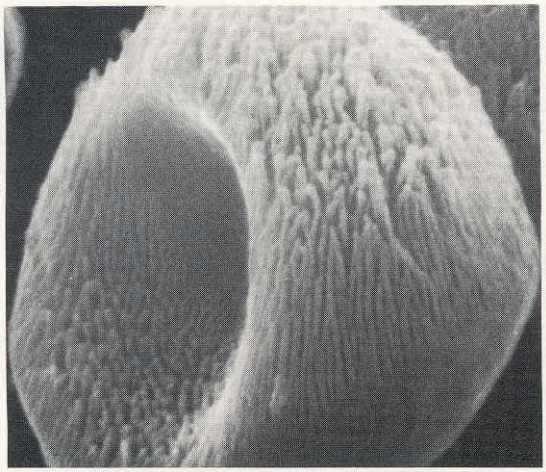
Because, with biological specimens, it is a thin metal coating whose "picture" is being taken, methods have to be used to enhance the surface contrast. Although either physical or chemical etching of atoms might be used for this purpose, physical removal of atoms from the target by ion bombardment was the technique used for producing the effects shown in these photographs of red blood cells. The pictures were made by Richard F. Baker, professor of microbiology at the USC School of Medicine and a research associate in engineering science at Caltech.

Baker's work, done with an electron microscope located at the Jet Propulsion Laboratory and operated by engineer John Devaney, has shown that a low-frequency glow discharge is useful for ion etching of biological specimens and that the patterns seen in the etched red cells do not represent preexisting structure within the cell, but are reflections of heterogeneity in or near the plane of the membrane of the cell. He suggests that if a pattern of etch-resistant sites exists in the membrane, the ion beam would produce a mosaic of holes and high points as it begins to etch. Even after the high points had been eventually eroded, the palisade pattern already established would continue as the beam worked on the homogeneous cell interior.



1. Red blood cells, as shown on this month's cover, are coated with a 100-Angstrom thick gold film preparatory to etching with an ion beam. Here, about 15 seconds of etching with the beam has removed portions of the cell's membrane and is beginning to show traces of a fenestrated pattern.

2. *After 2¼ minutes of etch, the membrane has been almost completely removed except for the lower part of the cells, which have been shielded from ion impact. The cell at the top has a few fragments of membrane still attached. An array of parallel channels is seen around the rim of both cells.*



3. *While most cells lie flat on the aluminum surface on which they are placed, high concentrations lead to crowding, and an occasional cell may be seen standing on edge supported by close neighbors. When this occurs, it is seen that the palisade pattern on the rim does not rotate through 90 degrees with the cell, but remains parallel to the incident ion beam. This is direct evidence that the filaments did not preexist in the cell, but were created by action of the ion beam.*

4. *Sixty seconds of etching on an isolated red cell membrane produces a mosaic of holes. The larger holes are formed from the merger of smaller holes.*