The sulfonic acid group of homocysteic acid appears to be necessary for physiological activity since homocystine, homolanthionine sulfoxide, and homolanthionine sulfone have no growth hormone activity when tested by the tail growth assay. Previous work has shown that homocysteic acid is a precursor of phosphoadenosine phosphosulfate, the coenzyme necessary for sulfate ester synthesis (*6*).

The growth promoting effect of homocysteic acid supports the validity of previous suggestions that homocystine derivatives initiate arteriosclerosis in individuals with homocystinuria (*3*) and in animals given homocystine thiolactone (*4*, *5*). The finding also explains why individuals with homocystinuria have accelerated skeletal growth (*2*), since homocysteic acid is a known metabolic product of homocysteine (*6*) and is present in the urines of patients with homocystinuria (*12*). The increased sulfate binding and the abnormalities of cellular growth observed in cell cultures from individuals with homocystinuria (*13*) may possibly be related to the cellular effects resulting from the metabolism of bound forms of homocysteic acid.

The findings of our study are of importance because they establish a relation between an area of sulfur amino acid metabolism and the physiological action of growth hormone.

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Peripheral Blood Elements Found in an Egyptian Mummy: A Three-Dimensional View

Abstract. *Intact peripheral blood elements were found within an intracranial mass, possibly either an antemortem subdural hematoma or a postmortem blood clot, removed from a 2200-year-old Egyptian female mummy. Surface topographies of neutrophils and lymphocytes were similar. Some erythrocytes partially retained their biconcave disk shape; others were spherical. Individual platelets exhibited pseudopodia.*

Tissues of mummies have been studied by light microscopy to determine whether they contained intact elements of peripheral blood (*1*). Preserved erythrocytes and probable autolyzed leukocytes were observed in a thoracic vein of a 2000-year-old mummy (*2*). To date, none of the other peripheral blood elements, such as intact leukocytes or platelets, have been found in these mummified tissues.

An autopsy was performed on a 2200-year-old Egyptian female mummy, Pum III (*3*), and a brown mass (22 cm in diameter and 1 cm thick) that adhered to the occipital region of the skull was removed for subsequent study. Presumed to be brain tissue, the mass was placed in 10 percent formalin. After 4 days, it was dehydrated and embedded in paraffin, and sections 6 μm thick were cut from several portions of the mass. No recognizable brain structures were found by our light microscope examination of the sections after they were stained with hematoxylin and eosin; however, we did observe a group of preserved peripheral blood elements. Each of the leukocytes present was identified as either a granulocyte or a mononuclear leukocyte according to its nuclear and cytoplasmic characteristics.

Two tissue sections containing the focalized group of peripheral blood elements were prepared for further study in the scanning electron microscope. The cover slip was removed after the microscope slide had been immersed in xylene for 24 hours. The adherent section was exposed to a change of xylene to remove any remaining traces of mounting medium. Tissue sections were then coated by the sputtering technique with a thin layer of gold, and coated samples were viewed

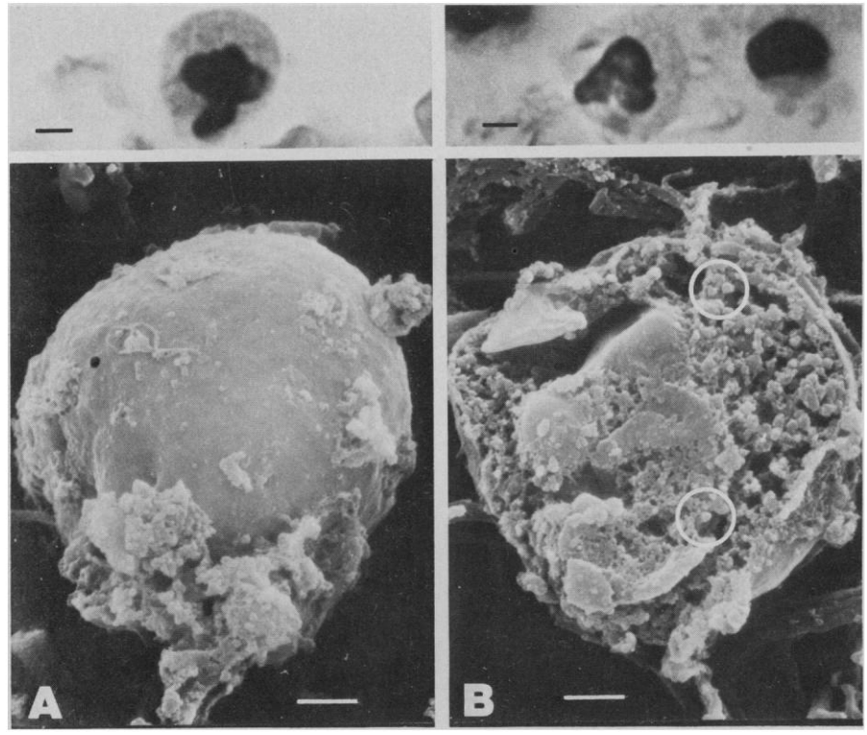

Fig. 1 (A) Scanning electron micrograph (scale equals 1 μm) of the exterior surface of the same intact neutrophil depicted at the top as it appeared by light microscopy (scale, 2 μm). (B) Interior of the neutrophil (scale, 1 μm) depicted at the top (scale, 2 μm). Note the presence of small, round structures (circles) compatible in morphology and size with specific granules of the neutrophil.

with an ETEC scanning electron microscope operated at 20 kv. Our three-dimensional view of the focalized group of peripheral blood elements revealed that these leukocytes and erythrocytes were enmeshed within a fibrous network. We characterized the network as fibrin by using Mallory's phosphotungstic acid hematoxylin stain. Each leukocyte and many erythrocytes previously identified as to cell type by light microscopy were relocated in the scanning electron microscope and their surface topographies were displayed.

Neutrophils identified by light microscopy exhibited a round to oval shape with lobed nucleus and an abundant, granule-containing cytoplasm (Fig. 1A, top). By scanning electron microscope, this population of neutrophils measured, on the average, 5.7 by 6.1 μm. The surface topography of these neutrophils exhibited a relatively smooth exterior except for the presence of a few pieces of material, irregular in shape and uneven in distribution (Fig. 1A). The internal architecture of some of the neutrophils was visible because they had been sectioned at various planes. In these neutrophils, we observed the general contour of some of the nuclear lobes and noted the presence of many small, rounded structures located in the area of the cytoplasm. These structures had a mean diameter of 0.2 μm and were compatible in both their shape and size with the specific neutrophilic granulation, an identifying feature for this type of leukocyte (Fig. 1B).

A few lymphocytes in the group of peripheral blood elements were identified by light microscopy on the basis of their round shape, their large, rounded nucleus, and the scant rim of cytoplasm (Fig. 2A, top). Lymphocytes were smaller than neutrophils, measuring from 4.1 to 4.7 μm across. The exterior surface was either smooth in appearance or roughened by occasional microvilli and several broad folds (Fig. 2A). Interior details of lymphocytes were not available for study.

Erythrocytes, which were easily visible by light microscopy, were distributed either singularly or in small aggregates. Using the scanning electron microscope, we found that most of the erythrocyte population consisted of intact cells varying in size, shape, and surface contour. They ranged in diameter from 3.4 to 4.3 μm. The shape of the erythrocytes varied; some of them appeared as spheres, and others retained a part of their classic biconcave disk form (Fig. 2B). Exterior surfaces of erythrocytes were either smooth, wrinkled, or had a pebbled appearance.

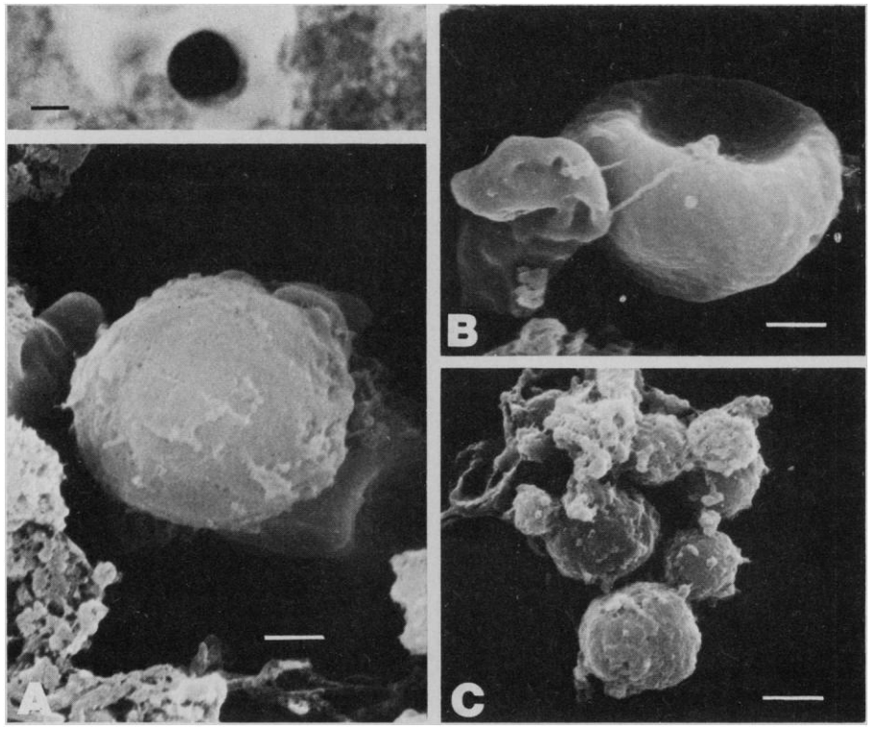

Fig. 2. (A) Scanning electron micrograph (scale, 1 μm) showing the three-dimensional appearance of the exterior surface of the same intact lymphocyte depicted at the top as it appeared by light microscopy (scale, 2 μm). (B) A three-dimensional view of a preserved erythrocyte exhibiting its partially retained biconcave disk configuration (scale, 1 μm). (C) Scanning electron micrograph of a group of aggregated platelets closely aligned with the fibrin network (scale, 1 μm).

With the scanning electron microscope, we also observed some small, rounded structures, approximately 1.2 μm in diameter, which were closely associated with the fibrin network either as single units or in a small group. The exterior surfaces demonstrated a roughened texture and displayed the extrusion of a few, short, blunt pseudopodia (Fig. 2C). These morphologic features are consistent with those of individual or aggregated blood platelets.

We did not observe any pathologic changes in these leukocytes, erythrocytes, or platelets with either the light microscope or the scanning electron microscope. In fact, with light microscopy, we could recognize the various types of leukocytes from the same nuclear and cytoplasmic characteristics in the mummified specimen that we would use in the identification of their modern counterparts. Both leukocytes and erythrocytes were reduced in size by about 50 percent, but blood platelets remained within their normal size range of 1 to 3 μm. Likewise, the specific neutrophilic granules were within the normal size range, 0.2 to 0.5 μm.

Whether the focal collection of leukocytes, erythrocytes, and platelets associated with the fibrin network represents an antemortem subdural hematoma or a postmortem blood clot introduced into the cranium during the mummification process is debatable. Our study, nonetheless, has for the first time revealed intact leukocytes and detailed the three-dimensional surface topography of peripheral blood elements in ancient mummified tissue.

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