MUMAB
The Making of a Modern Mummy

by Nancy Touchette

Tuthmosis III, one of the great warrior pharaohs who ruled ancient Egypt nearly 3,500 years ago, may at first seem to have little in common with Mr. M., an elderly Baltimore man who died of heart failure in 1994. But both departed for the afterworld in the same style: as mummies prepared by ancient methods and swathed from head-to-toe in linen wrappings. While Tuthmosis III can thank Anubis, the Egyptian god of embalmers, Mr. M. owes his legacy to Ronald Wade, director of anatomical services at the University of Maryland Medical School in Baltimore, and Bob Brier, an Egyptologist at the C. W. Post Campus of Long Island University.

Ancient writings reveal much detail about life in Egypt thousands of years ago, but the Egyptians left no record of how they preserved their dead. One of the few accounts of Egyptian mummification was written by Herodotus, a Greek historian who visited Egypt around 450 B.C. and described the mummy-making procedures practiced there. But even with Herodotus' help, many questions remain. For example, how did the Egyptians use salt to mummify a body? And why was the mummy prepared on a table that was wide enough for two corpses?

In an attempt to unravel some of the mysteries of mummies, Wade and Brier conducted a reasonable, yet rather macabre experiment—they created a mummy of their own using ancient Egyptian methods.

Before embarking on their embalming mission, Brier and Wade commissioned a silversmith to make replicas of Egyptian embalming tools, enlisted a master woodworker to construct an authentic Egyptian embalming table, visited Cairo street markets to collect special spices and oils, and ventured to the river Nile to gather natron, a mixture of chemical salts that for thousands of years has been deposited along the riverbed. The final requirement—a suitable body—was filled by Mr. M. who had directed that his body be donated to science.

Tuthmosis III inherited the Egyptian throne at a very young age from his father, Tuthmosis II in 1505 B.C. Unfortunately for him, he was too young to rule, so his father's wife declared herself to be pharaoh. During her 22-year reign, she removed Tuthmosis' name from all official documents and replaced it with her own. After her death, Tuthmosis tried to save face by expunging her name from all monuments. Tuthmosis III went on to lead the Egyptian army in dozens of successful campaigns in Palestine, Syria, Nubia, and other regions of the Middle East. He is remembered not only as a great warrior, but also as an industrious builder who commissioned the construction of many temples and monuments throughout the Egyptian empire.

Egypt, 1450 B.C. *When Tuthmosis III died, he was embalmed with all the ceremony and decorum due a king. From Herodotus' account and from what archaeologists have learned from examining his mummy, it is likely that the body of Tuthmosis was brought to the ibu—the "tent of purification"—to begin the 70-day process. There, it was washed with a solution of water and natron. Next, his brain was removed through the nostrils. The Egyptians considered the brain to be of no special significance with little use in the*

PHOTO COURTESY OF RONALD WADE

After the body had been desiccated under controlled conditions for five weeks, Bob Brier (left) and Ronald Wade begin the slow process of wrapping with strips of linen.

afterlife. According to Herodotus' account, the brain was extracted by poking a hole in the ethmoid bone, a thin bone at the top of the nostrils. The Egyptian embalmers used large bronze needles with hooked or spiral ends to perform this procedure; however, it was not clear how they managed to remove such a large organ through such a small opening.

Baltimore, 1994 "Before doing the mummification ourselves, I had an image that the Egyptians would insert a hook through the nose and the brain would come out in large chunks," says Brier. "But it didn't work that way at all. It was very difficult to remove." With the corpse lying on its back, Brier and Wade inserted a hook through the nose and, by churning it around, managed to pulverize the brain tissue into an almost liquid state. Then they turned the body over onto its stomach, and the liquefied brain tissue drained out through the nostrils.

After removing Tuthmosis' brain, the Egyptian embalmers removed all of his internal organs through a small incision on the left side of his abdomen. Only his heart, which was considered to be a person's essence, was left untouched.

Herodotus described the use of a sharp black stone to slice open the abdomen. Brier presumed that Egyptians used obsidian, a black volcanic glass, but he thought the material was chosen more for ritualistic purposes than out of necessity. "We found that bronze tools simply didn't do the trick—they dulled too quickly," says Brier. "Obsidian, in contrast, made a clean cut. The Egyptians probably used obsidian because it was the best material for cutting through human tissue. That's the sort of thing you can only learn by doing it yourself."

After removing the internal organs, the Egyptian embalmers washed the interior of Tuthmosis' body with the spices frankincense and myrrh and palm wine. The liver, spleen, intestines, and kidneys were then covered with white crystals of natron. After being preserved individually, each organ was stored in a special canister called a canopic jar. The lids of canopic jars were shaped like the heads of Egyptian gods—the four sons of Horus—who are the guardians of the entrails. After mummification of the body, the canopic jars with dried viscera were placed with the mummy at burial.

Brier commissioned the ceramics department at C. W. Post to make four Egyptian canopic jars in which to preserve Mr. M.'s viscera. Wade and Brier rinsed his abdominal and thoracic cavities with palm wine and myrrh, and the cranial cavity with palm wine and frankincense. This ritual probably had a practical purpose as well, in providing a more pleasant aroma than that which typically emanates from a dead body.

Then as Tuthmosis' embalmers had done 3,000 years earlier, they filled the cavities with small bags of natron to dry the corpse from the inside out. Without water, bacteria cannot grow and tissue will not decay. Next they covered the entire body with 270 kilograms (600 pounds) of natron and placed it in a special room maintained at about 46 °C (115 °F) with less than 30 percent humidity—conditions designed to mimic those at which mummification was carried out in ancient Egypt.

Exactly how Egyptians used natron to dry the body has remained an ongoing controversy for centuries. Early Egyptologists, translating Herodotus' writings to mean that the body was "pickled," thought that the corpse was placed in a large vat of an aqueous natron solution. However, no such vats have ever been found to support this idea. Others, including Brier, believe that the body was simply covered with solid natron. In building a replica embalming table similar to one found in an Egyptian tomb, Wade and Brier wondered why it was so wide—it measured nearly 2 meters (6 feet) square—much wider than one would need to hold the body. They found that to fully cover the body with natron, they had to heap the salt in mounds that covered the entire width and length of the embalming table. Brier says that this observation is consistent with the idea that the Egyptians used dry natron to desiccate the mummy.

> Wade and Brier removed tissue samples for biopsy and swabbed the mummy inside and out to check for the presence of bacteria.

After spending 35 days buried in natron, Mr. M. lost 100 pounds of water, out of his original body weight of 160 pounds. He was now a mummy. Brier and Wade named him *Mumab I*.

The bags of natron were removed, and the body was rubbed with a mixture of five oils: frankincense, myrrh, palm, lotus, and cedar. As one of their last research proce-

dures, Wade and Brier removed tissue samples for biopsy and swabbed the mummy inside and out to check for the presence of bacteria. The cultures were negative, indicating that no bacteria were present almost three months after death. The mummification was deemed a success. With a little bit of luck, the mummy of Mumab I will be stable for a few thousand years.

Finally the Egyptian embalmers wrapped Tuthmosis' body in long strips of flaxen fabric. With elaborate ceremony, the body was carried to its final resting place; the canopic jars were positioned around the body; and the tomb was sealed. Tuthmosis would rest, well preserved, for thousands of years.

Guided by photographs of Tuthmosis III's mummy, Wade and Brier replicated the wrapping with linen bandages and shrouds imported from Egypt. The entire wrapping process took several days and required more than 6 layers and 9 kilograms (20 pounds) of linen. Finally, in accordance with ancient practice, an amulet was placed above Mr. M.'s heart. His transformation into Mumab I—and his contribution to our understanding of mummies—was complete.

Drying with Natron

Drying the body with natron is the key to mummification. "Natron works by getting water out of the tissue," says Ronald Wade. "If you don't have water, you don't have decay." Bodies, and all organic matter for that matter, decay by providing the food for invading bacteria, fungi, and other microorganisms. Without water the microorganisms cannot survive and cannot decompose the tissue. Thus, the arid climate of Egypt provided an ideal environment for mummification.

PHOTOS COURTESY RONALD WADE

Geological Formation of Natron

$$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$$

$$CaCO_3 + H_2O + CO_2 + 2NaCl \rightarrow 2NaHCO_3 + CaCl_2$$

$$2NaHCO_3 + Heat \rightarrow Na_2CO_3 + H_2O + CO_2$$

The key step in making the mummy was to remove moisture by exposing the tissue to natron, a mixture of salts. Each organ in the torso except the heart was removed through a small incision, treated with natron, then transferred to a canopic jar (next page). After the cavity was packed with small bags of natron to dry the body from the inside (above), the body was covered with loose natron (below).

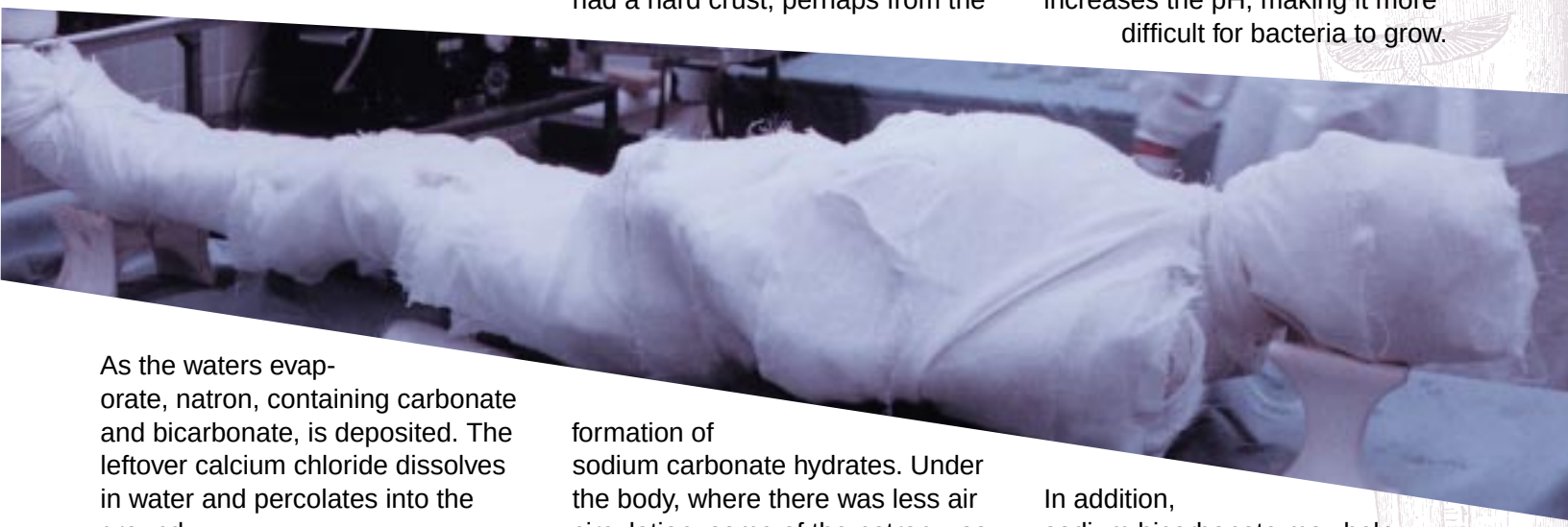
PHOTO COURTESY RONALD WADE

Natron is actually a mixture of four salts that occur in varying proportions: sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), sodium chloride (NaCl, ordinary table salt) and sodium sulfate Na_2SO_4. Bob Brier collected his natron—all 600-plus pounds of it—on the banks of the river Nile in the Wadi Natrun district between Cairo and Alexandria. Here the Nile-fed waters of several lakes rise in the

PHOTO COURTESY OF BOB BRIER

spring and recede in the summer, leaving large salt deposits along the shore.

Napoleon's physician, Bertholet, on an expedition to the Nile in the early 1800s, first figured out how natron forms. Limestone (calcium carbonate, $CaCO_3$), in the presence of heat and humidity, reacts with salt (sodium chloride) to produce sodium carbonate (Na_2CO_3). Limestone can also react with salt in the presence of carbon dioxide and water to produce sodium bicarbonate ($NaHCO_3$).



As the waters evaporate, natron, containing carbonate and bicarbonate, is deposited. The leftover calcium chloride dissolves in water and percolates into the ground.

Just what is it about natron that makes it so good at drying out a body? And how does natron actually suck the water out of a corpse? The essential ingredients of natron are sodium carbonate and sodium bicarbonate; sodium chloride and sodium sulfate are impurities.

Solid salts normally contain positive and negative ions in a highly structured crystalline form. When exposed to water vapor, the charged ions can attract and interact with the polar water molecules. Some salts incorporate H_2O molecules into the crystalline structure, forming solid "hydrates." In natron, sodium carbonate, Na_2CO_3, can change in this way to the water-containing hydrate $Na_2CO_3 \bullet H_2O$, as well as $Na_2CO_3 \bullet 7H_2O$ and others. Even though they contain considerable water, these hydrates remain solid and dry to the touch. In contrast, when water vapor interacts with sodium chloride, NaCl, the solid salt dissolves to form a liquid solution. The resulting sodium ions, Na^+, and chloride ions, Cl^-, become "hydrated"—the positive hydrogen end of the water molecule is attracted to negative chloride ions, and the negative oxygen atom is attracted to positive sodium ions.

After five weeks, when the researchers began removing the natron, they found that the top layer had a hard crust, perhaps from the formation of sodium carbonate hydrates. Under the body, where there was less air circulation, some of the natron was in solution. "It was wet," says Ron Wade. "You could press it between your hands and squeeze out the water."

In addition, osmotic pressure also favors the loss of water to natron. Cell membranes in the body are semipermeable—they allow water to pass freely back and forth, but they do not allow the passage of ions or larger molecules. When the concentration of a solute, such as salt, on one side of a semipermeable membrane is much greater than on the other side, water molecules move to the side with the greater salt concentration until both sides are the same concentration. When solid natron is heaped on a corpse, the water crosses the cell membranes in a vain attempt to dilute the concentrated salt, until virtually all the water has left the body.

Some researchers believe that the sodium bicarbonate is especially effective in suppressing bacteria. When dissolved, the bicarbonate increases the pH, making it more difficult for bacteria to grow. In addition, sodium bicarbonate may help liquefy, or emulsify, the fats of the body, which are later removed during the cleansing process.

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FOR MORE INFORMATION

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