comycetes in rocks of Carboniferous age provides the potential impetus upon which the origin and subsequent evolution of this widespread group of organisms may be better understood.

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Mummy of the "Elder Lady" in the Tomb of Amenhotep II: Egyptian Museum Catalog Number 61070

Abstract. *An unidentified female mummy found in a cache of great kings and queens in 1898 in the Valley of the Kings was examined from the viewpoint of Egyptology, x-ray cephalometry, biostatistics, and biochemistry. The result was the identification of Queen Tiye, of the Eighteenth Dynasty, wife of Amenhotep III and mother of Akhenaton.*

In 1912, Elliot Smith (*1*) described from the viewpoint of an anatomist the mummified remains of the kings and queens of the New Kingdom of Egypt (1575 B.C. to 1070 B.C.). Their mummies had been deposited in two hiding places at Thebes; the first cache, discovered in 1881, was in the reused tomb of the early Eighteenth Dynasty Queen Inhapy at Deir el-Bahari, and the second find, made in 1898, was in the tomb of King Amenhotep II of the middle Eighteenth Dynasty. From these two caches were recovered the mummies of most of the kings of the New Kingdom and a number of the queens. The mummies had been hidden in these two tombs about 3000 years ago after robbers had plundered the original tombs of the kings and queens in the Twentieth Dynasty. During the Twenty-first Dynasty, these mummies were collected and restored or rewrapped, since for the most part they had been badly damaged by tomb robbers looking for treasures placed on the mummies beneath the wrappings.

In a number of cases no identification whatsoever was found on the wrappings or coffins of these mummies. This should not be completely surprising since the grave robbing had occurred over a long period of time, and the royal mummies, after having been badly damaged at the hands of the grave robbers, had been moved from place to place for safety. The priests of the Twenty-first Dynasty were rewrapping mummies some of which were even then as old as 500 years (*2*).

Some of the royal mummies' identities are therefore in question; perhaps none is more intriguing than that of No. 61070, titled by Smith "The Elder Lady in the tomb of Amenhotep II" (*1*, p. 38). He describes her as "a middle aged woman with long (0 m. 30 cent), brown wavy, lustrous hair . . . the left hand was tightly clenched, but with the thumb fully extended: it is placed in front of the manubrium sterni, the forearm being sharply flexed upon the brachium" (Fig. 1).

One of us (E.F.W.) has suggested that the unique position of the arms of this lady indicated that she was of great importance and was perhaps Queen Hatshepsut or Queen Tiye. The former queen had indeed ruled Egypt as a pharaoh and had assumed the titles and raiment of a king as depicted in temple scenes and in statuary after the death of her husband Thutmosis II and during her coregency with her stepson Thutmosis III, who had been born to Thutmosis II by a minor queen. Queen Tiye was the beloved wife of Amenhotep III and mother of the heretic pharaoh Amenhotep IV who changed his name to Akhenaton. Her importance during her husband's reign and the reign of her son Akhenaton was reflected in statuary, inscriptions, and reliefs in temples and tomb chapels. She was even involved in diplomatic correspondence with heads of foreign states. Representations of a queen illustrate a similar arm position to that of the mummy 61070 (Fig. 2).

Since 1967, the University of Michigan, together with the Egyptian Department of Antiquities, has been conducting an investigation of the royal mummy collection in the Egyptian Museum in Cairo. In order to expand the studies of Smith, whose observations had necessarily been limited to visual examinations, the Michigan team used a radiographic approach, which was in fact suggested by Smith in 1912. Not only were conventional full body x-rays obtained from the ventral position, but also cephalometric or specially oriented, lateral head plates were obtained. The cephalograms are similar to those obtained in the orthodontist's office, and they permit the comparison of measurements between one cephalogram and another. A special cephalometer, developed by one of us (A.T.S.), uses an optical orienting device which directs the central x-ray beam through porion (the ears), where conventionally it is accomplished mechanically with ear rods. The delicate condition of the mummies and the fact that most of their ear openings are plugged with resin necessitated the development of the optical approach.

By the early 1970's, the University of Michigan had surveyed radiographically the entire Egyptian Museum collection of Royal Mummies. The mummy of the "Elder Lady," however, was not in the collection, to the dismay of the research team. One of us (I.E.N.) traced the mummy back to the Valley of the Kings and a side chamber in the tomb of Amenhotep II. In 1975, permission was received from the Egyptian Department of Antiquities to open this side chamber, and the mummy was fully examined by x-rays. These x-rays revealed that the mummy was indeed that of a woman in

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her forties (3) and that the arm positions were original and had not been rearranged at a later date during rewrapping by the priests of the Twenty-first Dynasty.

The cephalogram or lateral head radiogram was then compared with those of the ten other queens previously studied at the Egyptian Museum. Each x-ray was traced after a method developed by Walker and Kowalski (4) and measured or quantified. Then, through the use of a statistical approach called cluster analysis, each queen was compared with every other queen. The results of this study suggested that the "Elder Lady" was most like that of the mummy of Thuya, the mother of Queen Tiye, from the viewpoint of similarity of craniofacial morphology (5). This is illustrated in Fig. 4, where one of the dendrograms from a cluster analysis is shown. This analysis was done using complete linkage and the Minkowski "city block" metric, but entirely similar results were obtained when other combinations of clustering algorithms and distance measures were used. Of all the queens considered, the two that resembled each other the most (were linked together at step 1) were always Thuya, the mother of Queen Tiye, and the "Elder Lady" (Figs. 3 and 4).

The Michigan expedition presented these findings to the Egyptian Department of Antiquities, which agreed to provide a minute sample of hair from a small

Fig. 1. The mummy of the "Elder Lady" with her left clenched hand placed over her sternum.

Fig. 2. A statue from Karnak of a queen or princess holding a flail in her left hand.

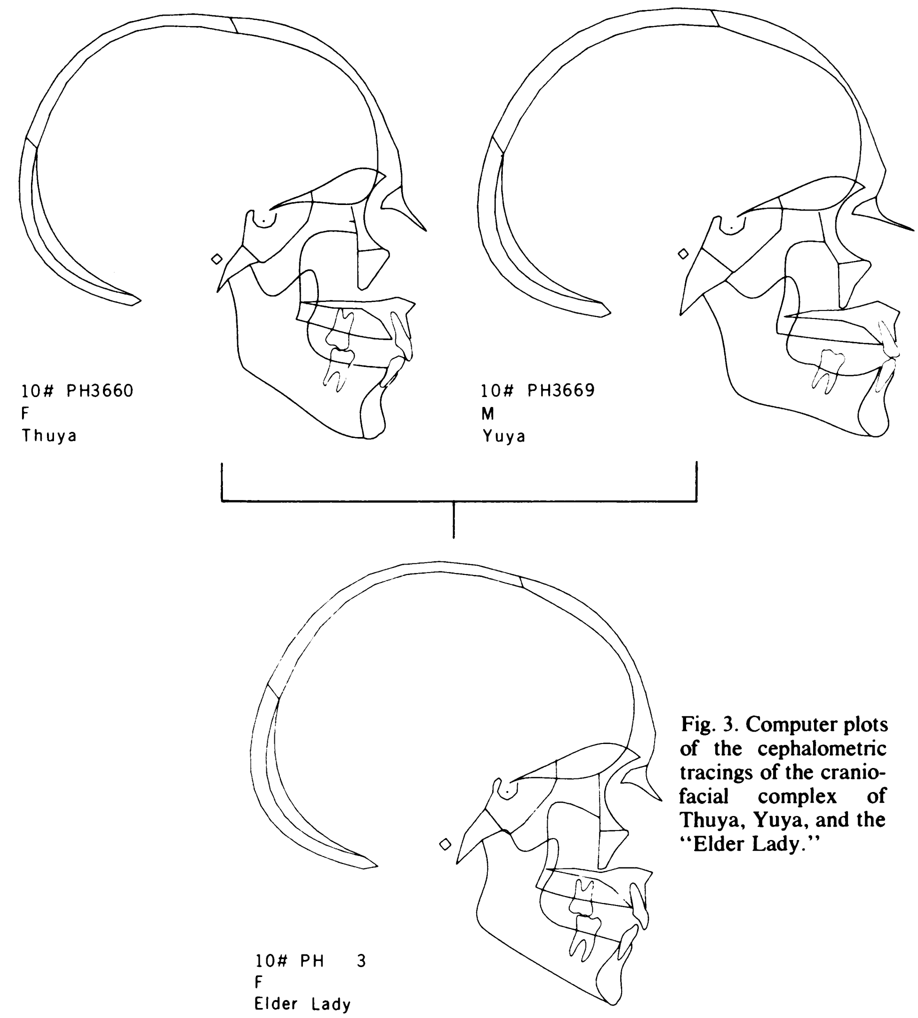

Fig. 3. Computer plots of the cephalometric tracings of the craniofacial complex of Thuya, Yuya, and the "Elder Lady."

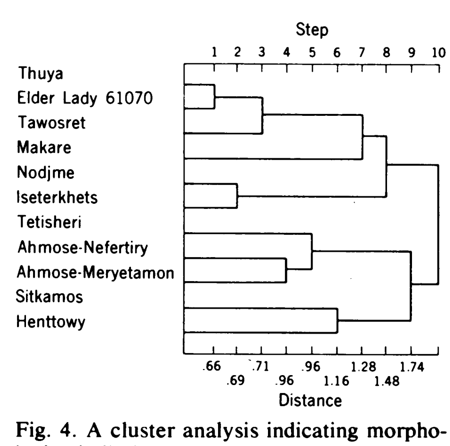

Fig. 4. A cluster analysis indicating morphologic similarity between Thuya and the "Elder Lady" in step 1.

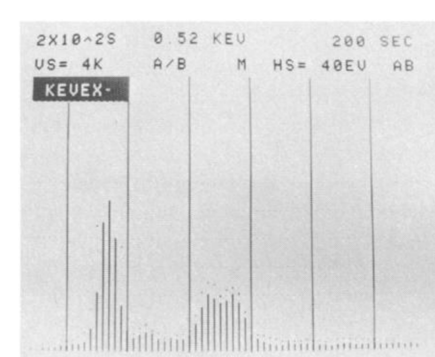

Fig. 5. Near perfect superimposition of a scanning electron microprobe analysis of the hair samples of Thuya and the "Elder Lady."

wooden sarcophagus from the treasures of King Tutankhamon, which bore the inscription of Queen Tiye. In 1975, the Michigan expedition reopened the side chamber of the tomb of Amenhotep II to secure a sample of the hair of the "Elder Lady" and the following week obtained a hair sample from the locket of Queen Tiye in the Egyptian Museum.

In the summer of 1976, a series of control hair samples along with mummy hair samples were analyzed. They were subjected at cross section to ion etching and scanning electron microprobe analysis. The correlation of data allowed the identification of dispersive x-ray energy for the various elements present in each sample. The results of this information when recorded in a memory control center allowed for the recall and comparison of many samples on a cathode-ray tube. The results show a near perfect superimposition of two samples on a graphic display tube (Fig. 5). These results strongly support the argument that the hair samples from both King Tutankhamon's tomb and the mummy from Amenhotep II's tomb are indeed those of the same person—Queen Tiye of the Eighteenth Dynasty, wife of Amenhotep III and mother of the heretic pharaoh Amenhotep IV or Akhenaton.

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Visualization and Transport of Positron Emission from Proton Activation in vivo

Abstract. *Heavy charged particle beams can be widely used for cancer therapy if control in heterogeneous tissue is proved practical. A beam of protons at 200 million electron volts has been visualized in plastic and in a living animal by using an on-line positron camera. The fraction of the activity retained in the radiation site was found to be at least 70 percent of that produced in a dead animal. The sensitivity of the technique was established for a typical geometry.*

The application of heavy charged particles (pions, protons, alpha particles, and heavier ions) in radiation therapy is prompted by the potential improvement they offer in dose distribution compared to neutral radiation (*1*). Differences in radiobiological properties of some of these particles may also be useful. Energetic beams of heavy charged particles are penetrating enough to irradiate deep-seated tumors. The depth of the peak dose and of the maximum beam penetration is dependent on beam energy and tissue composition, particularly inhomogeneities of density in the beam path (*2*). General therapy with these beams requires control of the beam distribution in heterogeneous tissue; and of particular importance is the surface of maximum beam penetration. If the end of the beam path is used to spare normal tissues just beyond the tumor, failure to compensate accurately for density variations in the beam path may result in overdose to those normal tissues or underdose to part of the tumor.

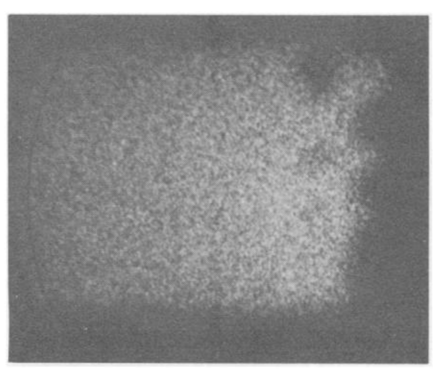

Fig. 1. Scintigram of positron emission activity induced in an acrylic plate by a proton beam. The acrylic was 4 cm thick, and holes with diameters of 1.9, 1.3, and 1.0 cm were bored through the plate at a depth of 17.8 cm from the beam entrance face (to the left of the camera field). Increased depth of penetration of the beam passing through the holes is clearly seen. Reduced activity within the holes can also be noted. The beam was 1 cm thick and 10 cm high; the dose was 22 rads. The initial beam energy was 190 MeV, corresponding to a maximum penetration of 23.7 g/cm^2 in acrylic. The threshold energy for positron activation is 20 MeV, corresponding to a residual range of 0.5 cm; thus the last 0.5 cm of beam penetration produces no activation. The event density is nearly constant along the beam path, but it appears to increase since the sensitivity is maximum at the center of the camera field, near the locus of maximum beam penetration.

One method for controlling heavy charged particle beams is visualization of the radioactivity generated by the beam in tissue. The primary radionuclides produced are ^{15}O (half-life, 2.05 minutes) and ^{11}C (half-life, 20.4 minutes). Both are positron emitters and are produced by nuclear interactions of beam particles with oxygen and carbon nuclei in tissue. Each positron interacts with an electron, producing a pair of 0.5-MeV gamma rays with nearly opposite directions. If the two gamma rays are detected in coincidence by two separate detectors, the positron-electron annihilation must have taken place somewhere along the straight line connecting the two detection sites.

This technique was suggested earlier for control of therapeutic beams of heavy charged particles (*3*). Previous studies were limited to physical measurements (*4*), calculations (*5*), and off-line localization of long-lived activation products, particularly ^{11}C (*6*). Further development has been hampered by the requirement of a suitable, dedicated imaging device, the danger of activation of the detector itself, and questions of the mobility of the radionuclides generated.

We report here preliminary results of studies of the distribution of positrons generated by a 200-MeV proton beam and detected by an on-line positron cam-