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Autopsy of an Egyptian Mummy

A mummy can be a scientific treasure chest; to unlock its secrets, a multidisciplinary approach is needed.

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The autopsy described here was the third in a series undertaken by the authors and their colleagues (*1*). All involved were volunteers, who donated their skills and resources because of the fascination of the subject. No direct funds were available for this study. The aim of this article is to provide an overall picture of the way in which a mummy autopsy should be conducted to produce the maximum of information from scarce and valuable tissues.

The autopsy was performed at Wayne State University School of Medicine, Detroit, Michigan, on 1 February 1973, as part of a seminar on death and disease in ancient Egypt (*2*). The mummy, Pum II, was loaned by the Philadelphia Art Museum (*3*). A record of the complete autopsy was made in color videotape (*4*), and about 1000 color photographs were taken by professional photographers (*5*). Special care was used in labeling and listing specimens (*6*).

Pum II is now on display in the National Museum of Natural History, Washington, D.C., on loan from the Philadelphia Art Museum to the Smithsonian Institution. Angel (*1*) has prepared it for exhibition, together with its highly decorated coffin and color photographs illustrating the steps in the autopsy, the histologic preparations of tissues, and the pathologies found.

Autopsies have been performed on thousands of Egyptian mummies. In the first decade of this century, when the first Aswan dam was being built, more than 8000 mummies were examined (*7*). Many of the studies, however, were done hastily, so that most of the diseases reported were those obvious to the naked eye. However, A. Ruffer laid down the basis for the histologic preparations of soft tissue [cited in (*7*)]. In more recent times interest has revived (*8*), but still there has been little advance on what was reported many decades ago. Yet the nature of diseases prevalent thousands of years ago in ancient Egypt is not solely a matter of academic interest, but is of practical importance, for in many instances the eradication of a disease may not be achieved until the way in which it evolved has been determined (*9*).

It seemed, therefore, that the whole question of disease in ancient Egypt should be reexamined. The difficulties today are of two kinds, procedural and political. The first refer to the kind of tests to be done on a body thousands of years of age, the second reflect the fact that the Egyptian government no longer favors the export of mummies.

The mummies available for autopsy in the United States are few. Therefore, every autopsy done in this country must be approached as though the mummy were the last in the world, so that every scrap of information possible is extracted. A multidisciplinary approach is essential, using the latest resources of science and technology. In practice, a compromise is usually necessary, balancing what is desirable against what is possible.

Radiologic Examination

Pum II was one of three mummies considered for autopsy. The choice was made as the result of radiologic studies, which indicated that it was in good condition and properly treated. Xerograms taken by Wolfe (*10*) and radiograms by McGinnis (*11*) revealed that the brain had been removed and replaced by resin, that the body cavity contained four packages, and that the right fibula and adjoining tibia had a pathologic thickening resembling periostitis. There was also a transitional or sixth lumbar vertebral body. No amulets were seen in the radiologic examination.

After the autopsy further radiograms were taken of the right leg, and polytomographs were made of the skull and temporal bone regions. The polytomographs showed the hole punched through the cribriform plate for the removal of the brain, which had been missed, although looked for, in earlier radiological studies.

Fracture of the skull is frequently reported on the basis of radiograms of wrapped mummies, and the diagnosis was made in this instance also. The fractures proved later to be merely superficial scratches of the scalp that had filled with radiopaque material. Obviously, care must be taken in diagnosing skull fractures in mummies while they are still wrapped.

Removal of Wrappings and General Examination

There proved to be about 12 layers of linen wrapping of varying qualities of cloth. The outer layers were generally larger sheets or strips of fine weave. Hot liquid resin had been poured liberally over the body at many of the stages, so that most of the wrap-

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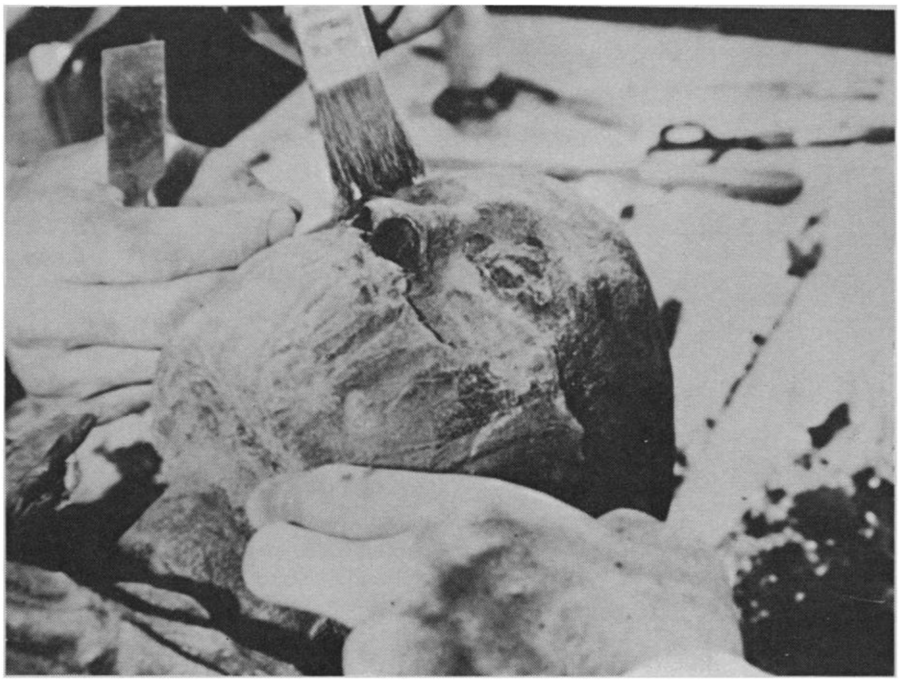

Fig. 1. Face of the mummy Pum II emerging. [Photograph by Nemo Warr, Detroit Institute of Arts]

pings had been converted into a hard, solid mass that could only be removed with hammer and chisel or cut through, several layers at a time, with a Stryker saw. After the general broad wrapping had been removed, it was found that limbs and even individual fingers and toes were wrapped separately. As many as nine people worked simultaneously, but it still required almost 7 hours to completely strip away all bandages (see Fig. 1).

The skin and tissues were as hard as plastic and were cut with the Stryker saw. The anterior abdominal wall and the incision made by the embalmers in the left side were cut out and removed. Inside the abdominal and thoracic cavities were four packages. Hot resin had been poured in, covering both the packages and the floors of the thorax, abdomen, and pelvis. The packages were removed with the chisel and were found to be covered with insect pupae preserved by the resin; further study showed that one package contained spleen and some intestine and the three others contained lung. Some of the aorta and a piece of heart tissue were found coated with resin. The kidneys and urinary bladder were not seen. Incidentally, when the saw cut the resin, the resin burned and gave off a most fragrant odor.

The penis was intact and held in an upright position supported with a small piece of wood. There had been no circumcision. The testes were missing, probably having been removed via the pelvis. The right leg was abnormal and is discussed below.

Radiograms taken before the autopsy had shown a fluid level in the skull, so a window on the cranium was cut above this level. It was found that resin had been poured into the skull through a hole punched through the base of the skull by a tool forced up the left nostril. Presumably, the brain had been removed in a liquid state through this same hole and replaced by the resin.

The eyes were intact and on removal proved to be well preserved. At a later date the temporal bones containing the ears were removed with a circular Stryker saw and taken out through the window in the skull. Also at a later date the anterior part of the lumbar vertebral column was removed in order to search for the spinal cord. The cord had vanished and been replaced by resin trickling down from the skull through the foramen magnum.

Tissues at the location of the thyroid and parathyroids were collected, but later studies failed to reveal these glands. Lewin (*1*) noted that the color of the mummy changed from a light brown to a darker brown within 24 hours. At the present time, the skin is almost a black-brown. Angel estimated the age of the individual, on the basis of anatomical studies, as being between 35 and 40 years, and his height as approximately 162 centimeters (5 feet 4 inches).

Fungi, Parasites, and Insects

The body cavities were swabbed to obtain specimens immediately after they were opened, and cultures were prepared. All the specimens proved to be sterile. In two previous mummy autopsies, T.A.R. had found almost all tissues to be riddled with fungi; in this case, fungus was absent. The explanation for these findings is probably the abundant use of resin. It was obviously very hot and fluid when applied, for it penetrated not only into larger cavities, but also into the mastoid air cells via the foramen of the eighth nerve and into the middle ear through a perforation in the eardrum, and even trickled from the skull down the whole length of the spinal canal.

Angel measured the thickness of the skull vault bone for evidence of porotic hyperostosis, which is an indicator of malaria, but found the bone to be of normal thickness. Nelson and Denham (*12*) tested abdominal muscle for *Trichinella* with negative results. According to Frazer in *The Golden Bough* (*13*), pigs were sacred to Osiris in ancient Egypt and were eaten only once a year, on his nameday. A special search was made for intestinal tissues, but only a tiny piece turned up in one of the packages. A single helminth egg was identified in this specimen. It has been examined by a number of parasitologists, who agreed unanimously that it was a helminth egg, probably *Ascaris*. Gooch and Khalil (*14*) stated definitely that it was indeed *Ascaris*. Lice have been reported from ancient bodies in Nubia (*15*), 40 percent of the bodies being infested. Pum II was completely bald, possibly shaved, and had no pubic hairs, so that apart from eyelashes and a sprouting of whiskers on the face, the body was hairless.

Certain groups of insects have specialized to breed in decaying flesh or on carrion. The insect fauna of human graves was studied in 1898 by Motter (*16*), who found a wide range of genera. A number of pupae and a larva were discovered in Pum II, and T.A.R. found an adult in the vertebral column of the first mummy fragment examined in this series. The adult was identified by Kingsolver (*17*) as being in the genus *Dermestes*, near to a cosmopolitan species, *frischii*. Pupae found by A.C. on a packet of organs in the abdomen were covered with resin. These were determined by Steyskal (*17*) to be *Piophila casei*, known commonly as the cheese skipper. In examining the left eardrum, Lynn and Benitez (*1, 18*) found a beetle larva, which has been placed by Anderson (*17*) in the family Staphylinidae near *Atheta* sp. Lewin (*1*) also discovered pupae on packets of organs, and these belong to the blowfly family (Calliphoridae), according to Shewell (*19*). They might be a species of *Chrysomya.*

Histopathology. The tissue from Pum II, such as bone, cartilage, and muscle, was found to be in good condition by T.A.R. (*20*). The skin was preserved and showed intact glandular structure (but without nuclei), hair follicles, and an intact basal layer of epithelium with ghost forms of nuclei and melanin pigment.

Both eyes were collected, and the whole section of one revealed the lens to be present, although the cornea had disappeared. The choroid and ciliary body were intact and contained neuromelanin pigment, but there were no traces of the retina. Large nerves, probably those to the extrinsic eye muscles, were well preserved in the retrobulbar fat and muscle. The remaining eye is still untouched in storage; suggestions for studies to be made on this specimen would be appreciated.

The aorta and other vessels from Pum II were found to be in excellent condition. Large and small atheromatous plaques were present in the portions of aorta removed from the mediastinum and thoracic cavity. In the other organs found within the visceral packages, large and small arterioles and arteries also has areas of intimal fibrous thickening, typical of arteriolar sclerosis. In some of the vessels, partially and completely intact red blood cells could be seen.

The lung tissue from the visceral packages contained intact bronchi and bronchioles with normal cartilage and connective tissue. The pulmonary parenchyma had areas of diffuse and nodular fibrosis. In some sections, the alveolar septa appeared normal. Within the fibrotic areas, there were anthracotic (carbon) and silicotic (silica) deposits. The silica content of the lung was 0.22 percent, the normal value having an upper limit of 0.20 percent and usually being less than 0.05 percent. These findings indicate that the man had a pneumoconiosis, probably from inhaling sand during desert dust storms. Whether he had symptoms of this pulmonary disease is difficult to assess.

A small amount of cardiac tissue found in the chest was normal. No coronary arteries were identified. What originally was thought to be the whole heart proved to be mostly pericardium and the bifurcation of the trachea and not the ventricles of the heart.

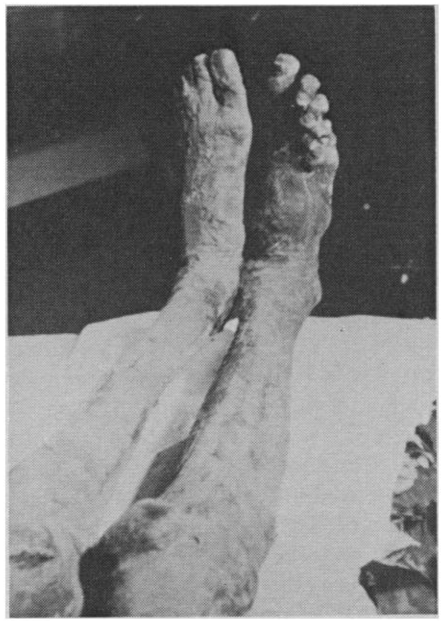

Fig. 2. Legs of Pum II. Histopathology showed that the swelling of the right leg was due to a noninfectious periostitis. The displacement of the toes is an effect of the wrapping. [Photograph by Nemo Warr, Detroit Institute of Arts]

One of the visceral packages housed spleen and a small portion of intestine. The spleen, with recognizable capsule and trabeculae, was normal. The intestinal tissue contained a single fragment of partially digested but recognizable meat (muscle) fiber with residual striations. Also present within this tissue was an *Ascaris* egg (typically *A. lumbricoides*).

A number of radiologically identified bony abnormalities were also found. Pum II had a transitional or sixth lumbar vertebral body. Several Harris lines were noted in both tibias and fibulas. Also, in the distal half of the right fibula, there was a nonneoplastic chronic osteoblastic periostitis (see Fig. 2). There was no excessive fibrosis in the soft tissue adjacent to the bone, which suggests that the periostitis was not infectious in nature. However, the etiology is unknown.

Electron microscopy studies were undertaken by Hufnagel (*21*). Small pieces of the rehydrated tissues were fixed in glutaraldehyde and postfixed with osmium tetroxide, after which they were dehydrated and embedded in a plastic resin. Ultrathin sections were prepared, and these were examined and photographed with the electron microscope at magnifications of 3,000 to 24,000 times.

The tissues examined were from several different portions of the body, including abdominal wall, aorta, and trachea. In all cases a wealth of structural detail was apparent. Masses of striated fibrous material resembling collagen were very common. Trilaminar membranes were also observed, as well as membranes arranged in multilayered myelin-like configurations. Rounded, dense bodies comparable in size to nuclei and mitochondria were also seen. Superficially, the structures were arranged in a way that suggested tissue organization. However, it was also apparent that the mummy's tissues had undergone extensive structural modification.

Protein and Lipid Extraction; Blood Group

Attempts were made by R.A.B. to extract, fractionate, and identify proteins and other macromolecular components in mummy tissues. The prime motivation for this was the possibility of detecting gamma globulins and the antibodies against infectious agents they may contain. Further, it might be possible to identify certain lipids, particularly neutral lipids, in an effort to determine the nutritional milieu of ancient disease states.

The methodology employed for the biochemical analysis of ancient tissues involves (i) rehydration of the mummified tissue samples, (ii) extraction and purification of macromolecular material, and (iii) analytical studies of the extracted material. The methods for rehydration of the mummified tissue and extraction of macromolecular material were evolved after considerable trial and error. Each tissue requires specific rehydration and extraction conditions depending on what type of tissue it is, its degree of preservation, and the desired macromolecular material.

To date, protein and lipid material have been extracted from four Egyptian mummies, including Pum II. The enriched protein material has been characterized by gel filtration, scanning spectrophotometry, amino acid assay, protein assay, sugar assays, and analytical polyacrylamide gel electrophoresis. The protein material contains high-molecular-weight substances (~ 130,000) although there is some reduction of heterogeneity. There appears to be preferential degradation of basic amino acid residues in the extracted proteins. However, some proteins with carbohydrate and lipid prosthetic groups remain stable and extractable as glycoprotein and proteolipid.

Greater heterogeneity appears to persist in lipid than in protein material. The total lipid extract was fractionated by thin-layer chromatography or further partitioned into gangliosidic, neutral lipid, phospholipid, and proteolipid fractions, which were separately analyzed by thin-layer chromatography and assayed for neutral hexose, sialic acid, and proteins. It appears that gangliosides and phospholipids undergo degradation. However, the neutral lipid fraction demonstrated a marked persistence of heterogeneity. Further, both the neutral lipid and total lipid fractions stained positive for cholesterol and sterol esters. Thus, our data indicate the persistence of macromolecular heterogeneity in mummified tissue. Full details of the procedures and findings are being published separately (*22*).

Hart and Kvas (*23*) used bone from Pum II as a source of blood group antigen, utilizing pulverized cancellous lumbar vertebral material. The procedure used was that described by Connolly and Harrison (*24*), but in this instance the technique was enhanced by employing the indirect Coombs test. The pulverized bone was absorbed onto group O human red cells and the antigen identified by using specific antiserums. Blood group B was detected with 70 percent accuracy.

Teeth, Nails, and Ears

No special studies of the teeth were made. After viewing the radiograms of the skull, Wesley (*25*) reported that there was (i) horizontal resorption of the alveolar crest of the interdental bone adjacent to the maxillary and mandibular teeth, most likely secondary to chronic periodontitis, and (ii) occlusal attrition and cervical erosion of the maxillary and mandibular central incisors with loss of contact between neighboring teeth.

There is evidence that hardness of the nail as measured by the Knoop hardness test reflects protein nutrition status (*26*). Robson (*27*) was to test the nail of Pum II, but this proved impractical, since the nail was so brittle that the paring broke into fragments when it was cut off.

Lynn and Benitez (*18*) removed the temporal bones and found considerable resin in the external auditory canal, middle ear cleft, and mastoid air cell system of the left temporal bone. The ossicles and ligaments were covered with resin but appeared to be intact. There was no evidence from the condition of the bone to suggest previous ear disease. After some of the resin was removed from the canal, a small attic perforation was noted in the posterosuperior region of the eardrum. The perforation was filled with resin, which indicates that it was probably the pathway by which resin entered the middle ear spaces. Relatively little resin was found in the right temporal bone. A small oval perforation with smooth and well-delineated margins was present in the postero-inferior region of the right eardrum. The shape and appearance of the perforation suggested that it may have been the result of antemortem acute otitis media. Ossicles and ligaments were present and looked normal.

Undecalcified sections of the temporal bone were studied by Benitez and Lynn (*28*). Roentgenologic studies with polytomography before the temporal bones were removed revealed no abnormalities of the auditory and vestibular apparatus in the inner ear. However, there was a definite increase in radiographic density throughout the left temporal bone as compared to the right.

The superior portions of the petrous bones were removed with an electric saw. Each specimen included the arcuate eminence and the arc of the superior semicircular canal. For histological control, a similar specimen was removed from a cadaver immediately after autopsy. Sections were cut in the horizontal plane, ground down by hand to a thickness of about 100 micrometers, and stained with the polychrome bone stain of Villanueva. There was excellent preservation of the Haversian systems. The vascular channels were clearly seen and were surprisingly similar in appearance to those of the fresh specimen used as control. Examined in polarized light, the bone matrix did not show abnormal amounts of collagen in sections from the left temporal bone of Pum II, compared to sections from the right temporal bone and from the control specimen. The lacunae contained osteocytes with well-preserved nuclei, which is remarkable for a tissue more than 2000 years old. A striking find was the identification of osteoid seams. This is the first time that an osteoid seam has been demonstrated and the osteon activity described in an Egyptian mummy. There was a low turnover type of bone but there was no evidence of bone metabolic disease. It was postulated that the increased radiological density of the left temporal bone was due to the greater amount of resin found in this bone than in the right one. It appears that the resin acted as a fixative, preserving the bone cells and related elements.

Estimation of Date

Several techniques are available for dating a mummy. First, carbon-14 dating was done by Stukenrath (*29*), using linen from the wrappings. The figure he obtained was 170 B.C. ± 70 years.

The amino acid racemization reaction can be used to estimate the age of organic material (*30*). Only L-amino acids are usually found in the proteins of living organisms, but over periods of time they undergo slow racemization, producing the nonprotein D-amino acids. Thus, the proportion of D- to L-amino acids in paleobiological material steadily increases with time. However, the racemization reaction is dependent on temperature, and some estimate of the temperature history of a paleobiological specimen must be available for accurate dating. Amino acid dating requires much smaller quantities of material than radiocarbon dating, and since amino acids racemize at different rates, a chosen amino acid can be used for dating such material in a specific age range which extends the applicability of this technique beyond that of radiocarbon dating. R.A.B. has recovered intact protein from Pum II and, in collaboration with Hochstim (*31*), is attempting to date the mummy by this technique. Tests show both D- and L-amino acids to be present, but the estimation of a date is hampered by lack of data on the temperatures of Egyptian tombs. Assistance on this point is requested.

The coffin can give valuable information for dating, but Strouhal (*1*) reports that about 10 percent of the 180 mummies he has examined in Czechoslovakia appear to be in coffins not originally used for them. Angel has measured Pum II and concludes that its size is consistent with the assumption that the coffin was used originally. However, photographs of the coffin taken by Angel were studied by Fischer (*32*), who describes it as Greco-Roman. He points specifically to the Apis bull carrying the dead man (see cover) as being a late motif, as well as to the slight garbling of the hieroglyphs and the absence of any name for the dead man. This last factor would suggest a "stock" coffin rather than a custom-made one.

An estimate based on cultural features was given by Strouhal. At first sight it appeared that the methods of mummification, such as packaging the organs, removing the brain, painting the nails with henna and the feet with white, and crossing the arms, indicated a mummy of the third Intermediate Period, perhaps about 700 B.C. However, later evidence showed that the organs were packed carelessly, so that three of the packages contained lung and one contained spleen and some intestine, instead of lungs, liver, intestines, and stomach being placed in separate packages. Also circumcision had not been performed. These facts indicated that the methods used were a debased form of those of an earlier period.

The linen wrappings were examined by Johnson (*33*), who gave an opinion that they were Ptolemaic. To sum up, all the evidence points to the Ptolemaic period, about 170 B.C.

Textiles and Metals

Mummy wrappings were usually made specially for the purpose, but in this case the inner ones appear to be a mixture of odd pieces of linen from a variety of sources. An unexpected find was a ball of cotton wrapped in a piece of linen; stuck to it was some claylike material. Cotton fibers were also discovered woven into the linen. The identification of cotton was confirmed by Fryxell (*34*). This is the earliest find to date of cotton in the European and Middle Eastern areas, although it was in use in India 2000 years earlier (*35*).

Tests were made to see if the concentrations of metals in bone from a vertebra could be estimated by using the neutron activation and atomic absorption techniques. It was feared that the overwhelming amount of calcium might interfere with the measurements of other metals present in only trace amounts. This proved to be the case in the neutron activation test; Gordus (*36*) reported that of the 20 metals sought, only the calcium could be measured.

Smith (*37*) tested for lead and mercury by using atomic absorption and found a lead concentration of 0.6 part per million (ppm) and a mercury concentration of 0.43 ppm (dry weight). According to Kehoe (*38*), the lead content of modern flat bone averages 6.55 ppm and that of long bone 18.0 ppm, so Pum II had only a fraction of the lead load of modern man. The mercury level in bone from Pum II, however, is about the same as that in modern bone, which ranges from 0.03 to 1.04 ppm with a mean of 0.45 ppm (*39*).

Similar results for mummy Pum I were obtained by T.A.R. using atomic absorption. His heavy metal values for soft tissue were (in parts per million): lead, 1.3; copper, 1.9; arsenic, 6.2; and mercury, 0.3. The values for long bone were: lead, 2.5; copper, 2.3; mercury, 0.1; and arsenic, none detected.

Discussion

Our purpose here is to draw attention to the valuable data that can be gathered from a well-preserved mummy and to provide guidelines for scientists undertaking such autopsies. No pretense is made that all possible tests were done in the case of Pum II. Undoubtedly, workers in other disciplines can suggest new lines of exploration, and these would be appreciated, either for the tissues of Pum II still in storage or for those obtained in other mummy autopsies planned for the future.

The study of Pum II is a continuing process, so that it may be a decade before the final report is completed. For example, Beck (*40*) is studying the chemistry of the resin and is able to report that pitch is not present. It was a practice in Ptolemaic times to mix pitch with resin. Strouhal (*1*) and his colleagues in Prague are attempting to date the resin and identify the trees and the country from which it came. This has led to efforts to collect resins from trees in eastern Mediterranean countries for comparative studies; it will take a year or more to collect the specimens.

Many of the findings reported here are not new, but it is justifiable to comment on some of them, for example those bearing on pollution and arterial disease.

Air pollution. Ancient human remains from widely separated locales have contained carbon deposits in the lungs (*41*) similar to those seen in Pum II. These deposits presumably resulted from inhaling smoke from fires, and probably occurred as soon as man made fires in confined spaces, such as huts, caves, or tents. Carbon itself causes very little damage to the lungs unless accompanied by other toxic substances, such as silica or plant fibers or pollens. Silica, on the other hand, is toxic and causes varying degrees of fibrosis in the lungs (*42*). The severity of the pulmonary fibrosis is related to the amount of silica inhaled and the duration of the exposure. Pulmonary silicosis is common in miners, quarry workers, and potters and may produce considerable morbidity and mortality. The hands of Pum II are not those of a manual worker, so his silicosis is more likely due to the inhaling of sand during the sandstorms common in Egypt. The silicosis is obvious; only the clinical effect on Pum II during life is uncertain.

Chemical pollution. Contamination of the atmosphere and oceans constitutes one of the most serious problems facing the world today. Study of this problem is handicapped by lack of adequate data on the concentrations of elements in the period before the industrial era commenced, and data for comparison with those of the present are sorely needed. Metal levels in human tissue such as bone are of value, but bones lying in the ground for thousands of years may have been subject to the leaching effects of rain and subsoil waters and may not be reliable witnesses of the past.

Bodies mummified naturally in dry areas in sand or caves, or artificially treated and preserved in tombs, are not subject to leaching and so are more fit for examination. There must be millions of such bodies in Egypt and Peru and small numbers in locations such as the Aleutian Islands, Canary Islands, New Guinea, and Australia. The efforts reported here by Smith and Gordus to measure metal concentrations in bone from Pum II were simply trials to see how successful such techniques might be. When satisfactory procedures have been established, a survey of ancient mummies would be practical.

Arterial disease. Atheroma and arteriosclerosis are prevalent today, occurring extensively in the young (*43*) as well as the aged. The etiologies of these conditions are unknown, although many factors have been associated with them (*44*). What is clear is that arterial disease was common, at least in the adult, in former times, for it has been reported from several countries (*8, 45*). Whatever the cause, it is an ancient one, and not something that has appeared recently, such as the stress and strain of modern life or modern diet.

Summary of New Finds

1) Silicosis. It is surprising that this has not been reported earlier.

2) Color changes after unwrapping. Pum II deepened in color significantly within 24 hours, and continued to do so for several weeks.

3) *Ascaris*. Ova of this helminth have been reported in vast numbers from seven countries in Europe (*46*), most recently from prehistoric salt mines in Austria (*47*), but this is the first report from Egypt. The human parasites pinworm (*Enterobius*), whipworm (*Trichuris*), and hookworm (*Ancylostoma*) have all been identified in pre-Columbian America and must have been carried there by man during the Ice Age. Roundworm (*Ascaris*) has been recovered only in the Old World and so may have evolved as a human parasite since the separation of the Americas after the Ice Age. A possible source of parasites would be the ascarids of pigs, which were domesticated about this time (*48*).

4) Cotton. This early find from Egypt raises many questions about trade route connections between Egypt and India before Christ as well as about the cultivation of cotton in Egypt.

5) Protein. The recovery of apparently intact protein of molecular weight corresponding to that of gamma globulin raises the possibility that bodies exceptionally well preserved (such as by freezing) may provide material with biologically active antibodies. Identification of such antibodies would be a major scientific finding.

6) Periostitis of the right tibia and fibula. No explanation has been found for this condition. The radiologists suggest some chronic condition such as varicose veins. The possibility of Guinea worm was entertained, but no positive evidence in support could be found.

7) Temporal bone. The perforation in the right eardrum is the earliest known, although since its discovery a similar one of equal antiquity has been reported from China (*45*). The preservation of the temporal bone was excellent.

8) Osteoid seam. An osteoid seam is a new unmineralized bone matrix which allows one to calculate the rate of bone remodeling. The activity of the osteoid seams will give evidence of the presence or absence of metabolic bone disease. This is significant because it means that in Pum II we found no evidence of metabolic bone disease in the temporal bones. It is remarkable that osteoid seams could be identified in the tissue of a 2000-year-old mummy.

The successful cooperation of so many scientists over the autopsy of Pum II led to the development of an informal Paleopathology Association. Although without funds, rules, or officers, the association had 200 members in 12 countries by 1 July 1974. The members communicate and cooperate through a quarterly newsletter (*49*). The autopsy of Pum II was just a beginning; the association is now looking for frozen human bodies and is even discussing frozen mammoths and the possibility of tackling large stony coprolites from the Reptilian age.

References and Notes

1. The autopsy was organized by a committee which consisted of the four authors and Eve Cockburn, editor of the *Paleopathology Newsletter*. Participating by invitation were J. L. Angel, physical anthropologist, Smithsonian Institution; P. K. Lewin, pediatrician, University of Toronto; P. D. Horne, technologist, Banting Institute, Toronto; E. Strouhal, Egyptologist, Náprstek Museum, Prague, Czechoslovakia; R. L. Henry, physiologist, and H. J. Normile, graduate student, Wayne State University School of Medicine, Detroit; and I. F. Burton, pediatrician and antiquarian, Detroit. After the autopsy, the temporal bones were removed and studied by G. E. Lynn, audiologist, Wayne State University, and J. T. Benitez, otologist, Beaumont Hospital, Royal Oak, Michigan. Especially helpful were A. T. Sandison, Department of Pathology, Western Infirmary, Glasgow, Scotland, and L. J. Bruce-Chwatt, London School of Hygiene and Tropical Medicine, London, England.
2. T. A. Cockburn, *Science* **181**, 470 (1973).
3. The loan was arranged through the courtesy of D. O'Connor of the Pennsylvania University Museum, hence the name of Pum II, this being the second mummy he has provided.
4. The television unit of Detroit Legal News made the recording; the director was H. V. Munce and the chief technician J. L. Walter. A half-hour version of the color videtape has been prepared for teaching purposes by Legal Tapes, Inc., 24293 Telegraph Road, Southfield, Michigan 48075.
5. Official photographers were N. Warr, Detroit Institute of Arts, and J. Levis, Mount Carmel Mercy Hospital, Detroit.
6. V. Podolak maintained the log of the autopsy and was responsible for recording all specimens.
7. This period is best reviewed in R. L. Moodie, *Paleopathology: An Introduction of the Study of Ancient Evidences of Disease* (Univ. of Illinois Press, Urbana, 1923).
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14. P. S. Gooch and L. Khalil, Commonwealth Institute of Helminthology, St. Albans, Hertfordshire, England.
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