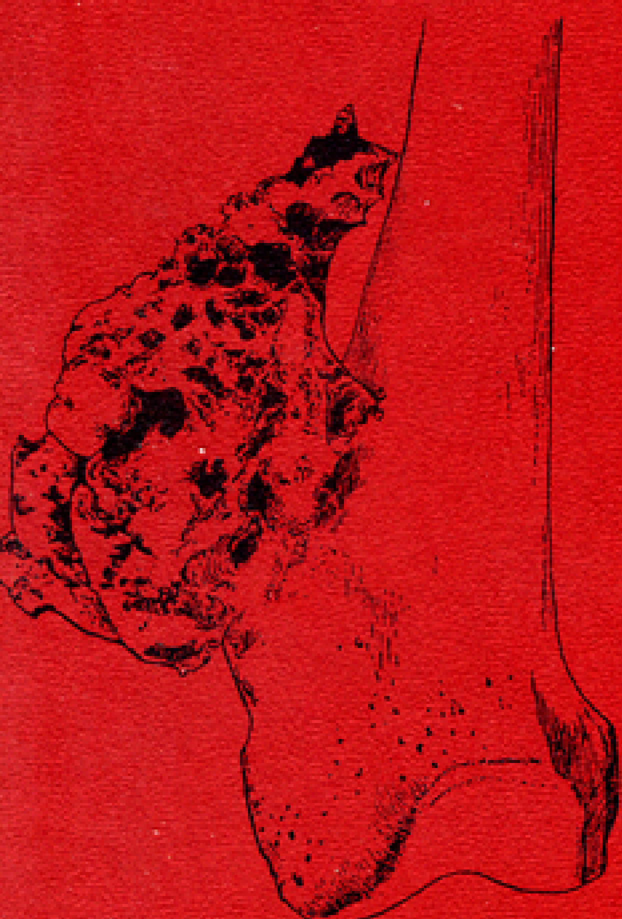
DISEASES IN ANTIQUITY

A Survey of the Diseases Injuries and Surgery of Early Populations



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With a Foreword by

WARREN R. DAWSON

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Foreword

THE TERM Palaeopathology was first suggested by the late Sir Marc Armand Ruffer (1859-1917) when he was professor of bacteriology at the Cairo Medical School, as a convenient label for the study of disease in ancient human remains.[1] He himself made many important contributions to the subject, and others before and after him have described many particular cases that came under their notice. Clear evidences of disease, dating from very remote periods, have been found in the skulls and other bones of some of the fossil hominids that flourished long before the emergence of *Homo sapiens*, or were contemporary with him. The Lower Pleistocene australopithecine group of southern Africa displays evidence of caries and enamel hypoplasia, and the *Homo erectus* specimens from China and Java showed clear evidence of trauma (perhaps as a result of group combat). However, perhaps the most famous diseased fossil specimen is the cranium of the Rhodesian Man, discovered in 1921, which was found to have been affected for a long period with chronic sepsis. The teeth displayed dental caries and alveolar abscesses leading to general oral sepsis. This Pleistocene African also had suppurative middle ear disease involving the mastoid process with an abscess which broke through the cortex at its base. In addition to this, the tibia showed signs of arthritic changes.[2]

Skulls and skeletons provide evidence only of diseases that leave their mark upon the bones: many affections that involve only the tissues are thus excluded from investigation. Most of the peoples of antiquity inhumed their dead; a smaller number used cremation (a method that robs the pathologist of most of his data); a still smaller number practised embalming. The resulting mummies, preserving more or less completely the soft tissues, have provided a vast field for research into the traces of disease. The dried and shrunken tissues of mummies can, by appropriate laboratory treatment, be rendered in a state that admits of histological investigation. Mummification was first practised in Egypt, but was adopted by other peoples and has remained in vogue until comparatively recent times over a wide geographical range.[3] Egypt and Nubia have provided by far the greatest contingent of material for the study of palaeopathology. This is

1. *J. Path. Bact., 18:* (1913) 149.

2. Macleod Yearsley in *Rhodesian Man and Associated Remains,* (British Museum, Natural History, 1928), pp. 59-63.

3. I have dealt with mummification in countries other than Egypt in a series of memoirs. Australia and America: *J. Roy Anthrop. Inst., 58:* (1928), 115-138, pls. 8-13; *Man,* 1928, 73-74, pl. E.; Canary Islands: *Proc. roy Soc. Med., 20:* (1927), 832-842; Torres Straits: *ibid.* 850-851; *Ann. Arch. Anthrop.* 11, (1924), 87-94, pls. 10-12.

mainly due to the fact that the late Sir Grafton Elliot Smith, F.R.S., while he was professor of anatomy in Cairo, was called upon to examine the remains in various degrees of completeness of some 30,000 skeletons and mummies brought to light by the excavations of archaeologists in Egypt, and during the Archaeological Survey of Nubia. The cemeteries and tombs from which these remains emanated, dating from Predynastic times, through the long period of the thirty historic dynasties, then through the Ptolemaic and Roman periods, down to early Christian times, cover a total span of over 4,000 years. Not only did he place on a scientific basis the definition of the technique of embalming and its variations of method from time to time, but he encountered in the course of his investigations numerous cases of pathological interest which he usually referred for investigation to his colleagues, for he was, as he himself often emphasized, an anatomist and not a pathologist.[4] There is no need here to summarise the pathological results obtained, as they have already been placed on record.[5]

The Archaeological Survey of Nubia has produced the largest mass of material from a single area hitherto brought together. The number of specimens of each period was large enough to provide data for statistical and general conclusions. Elliot Smith and such colleagues as Frederic Wood Jones and Douglas Derry, who assisted him, have ably recorded not only the data for the physical anthropologist, but also all the anatomical anomalies and pathological changes revealed by the thousands of skeletons and mummies brought to light by the excavations of the archaeologists. All the traces of disease and of wounds and fractures have been fully and interestingly recorded in their report, a large folio volume accompanied by forty-nine plates and numerous text-figures.[6]

Many Egyptian mummies were brought to England in the first few decades of the nineteenth century. Some of these were unwrapped and examined by the surgeons of the day—Sir Everard Home, Sir Benjamin Brodie, and others. As most of these mummies were destined to be museum specimens, the examinations of them had perforce to be limited to external observations so as to preserve the integrity of the specimens and consequently no dissection was permissible. A notable exception is provided by a mummy of the Persian period of Egypt (XXVII Dynasty, B.C. 525-402) which came into the hands of Augustus Bozzi Granville, F.R.S., in 1820. He made a thorough examination of the body, and not only completely dissected it, but also made numerous preparations which were exhibited at the Royal Society. This mummy had not been eviscerated and had not the customary incision in the left flank. Most of the viscera were *in situ;* all were present

4. References to such cases abound in his published works, notably in *The Royal Mummies,* Cairo, 1912; *Contributions to the study of Mummification* in *Mem. Inst. Eg.* Cairo, 1906, 5, 1-53, pls. 1-19.

5. Elliot Smith, G. and Dawson, W. R.: *Egyptian Mummies,* London, 1924, 154-162; Rowling, J. T.: *Proc. roy. Soc. Med.*: 54 (1961), 409-414.

6. *The Archaeological Survey of Nubia*: *Report on the Human Remains,* Cairo, 1910.

except the lower part of the intestines, the right kidney and the liver. These three organs had been removed by the embalmer *per anum* by incising and enlarging the orifice. The left kidney, with its capsule and ureter attached, as well as the uterus and its appendages, showed evidence of having been in a diseased state for some time previous to death. Granville's conclusions were that the woman died at the age of fifty to fifty-five years, and that the cause of her death was ovarian dropsy attended by structural derangement of the uterine system generally. I have mentioned this case because it is the first instance known to me of a detailed scientific and anatomical examination of a mummy. Granville's paper[7] deserves to be read in its entirety, and it compares honourably with many later and more superficial publications. His preparations from the viscera were examined by several well-known contemporary anatomists—Matthew Baillie, Wilson, Carpue and Joshua Brookes—who confirmed his conclusions. Dr. Granville may be truly considered a worthy pioneer of palaeopathology.

The improvements in scientific technique since Granville's time, particularly in histology, have provided later investigators with improved and more accurate facilities for research. Thus Ruffer was enabled to make investigations that considerably advanced the science of palaeopathology: he investigated cases of calculi, arterial disease, lesions of the lungs and kidneys, and bilharzia infection, of which he found ova in the tissues of mummies. His contributions, published in various scientific journals between 1910 and 1914, have been conveniently collected into a volume, edited posthumously by Roy L. Moodie.[8]

Radiology in more recent years has been a valuable aid to research in palaeopathology. The first mummy to be X-rayed was that of the Pharaoh Tuthmosis IV (XVIII Dynasty, *c.* 1413-1405, B.C.) in 1904. At that time the only apparatus in Cairo was that in a private nursing-home (a primitive one by modern standards), and Elliot Smith described to me very amusingly how he, assisted by Howard Carter, conveyed the rigid Pharaoh in a cab for the purpose. The result was interesting, because the condition of the epiphyses enabled Elliot Smith to estimate with some precision the age of the king at the time of his death. During 1931, a large series of Egyptian and Peruvian mummies in the Field Museum of Chicago have been radiographed, and the results published.[9] During 1963 and 1964, over sixty mummies in the British Museum, as well as a number of others in various museums, have been radiographed (as part of a new survey of material in Europe.) Among these, cases of pathological interest have been found.

I have confined this sketch mainly to Egypt, because it is the material

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7. *Phil. Trans.: 115,* (1825), 269-319, pls. 18-23.

8. *Studies in the Palaeopathology of Egypt,* Chicago, 1921.

9. Roy L. Moodie: *Roentgenologic Studies of Egyptian and Peruvian Mummies.* Chicago, Field Museum of Natural History. Anthropological Series, Vol. 3, 1931.

from that country that I have principally studied, and because it has been my good fortune to be closely associated with Elliot Smith for many years until the time of his death in 1937, and with the recent radiological investigations. The bibliography of palaeopathology is already extensive and it is rapidly growing. Throughout the world contributions have been made by a wide variety of specialists, and one of the important features of this book is the demonstration of the interest of anatomists, pathologists, surgeons, radiologists, biologists and medical historians in this fascinating study of disease through space and time. There is clearly much which can be contributed by these various disciplines, although it is to be hoped that the continuing efforts by all such workers will eventually establish palaeopathology as a subject *per se,* a subject worthy of academic standing and just as acceptable from the point of view of specialist employment and research grants as serology and cytogenetics are today. Although mummified remains are relatively uncommon, human skeletal material continues to appear at a steady rate from the numerous excavations undertaken every year in different parts of the world. This ensures an ever broadening knowledge of ancient disease, and with continually growing numbers of diseased specimens, we can look forward to more exact statistical comparisons of pathological data in the future. With further discoveries, present conclusions and theories on ancient disease will, of course, have to be modified, just as recent work reported in this book has to some extent modified the findings of those dealing with human remains during the first three decades of this century. This is both inevitable and desirable.

Although no work of this size can hope to present a fully comprehensive survey of this broad subject, this book nevertheless goes a considerable way to satisfying this need. It is to be welcomed as the first reference work for some time which has considered such a wide variety of topics in such detail, and is certainly the first symposium to benefit from such a large number of specialist contributors.

WARREN R. DAWSON

Editorial Prolegomenon: The Present and Future

THIS BOOK originates from a feeling among students of early disease, that the time has come for some form of palaeopathological stock-taking and pooling of recently collected data. Although during the early part of this century and continuing into the 1930's there was much interest shown in the medical biology of ancient populations, the past three decades have seen but small advances. Admittedly there has been a number of introductory works considering ancient disease, and it is customary for general works on medical history to include a section on disease in antiquity. But there was clearly a need for something beyond this elementary level—and by far the best way of achieving this end and at the same time guaranteeing a comprehensive and mature coverage of the subject, was to gather a series of specialist contributions. This is what we have attempted, and although we do not pretend that it has been possible to get complete coverage of this broad and complex field of study, most of the major topics have received attention. Some of these subjects are controversial, and in some cases diagnosis has of necessity been highly speculative, but this is to be expected and although we hope the subject has been generally approached with a critical outlook, it would have been wrong at times not to enter into hypothesis and speculation.

Although the majority of contributions to this volume have been written specifically for this work, there seemed every advantage in including a few "classic" papers. This has double value in not only adding to the content of this work and perhaps helping to bridge some gaps in the coverage, but also it is a pleasure to include contributions by earlier authors who would not otherwise be represented in this volume.

Some studies on the various undeveloped aboriginal populations of today have a bearing on the study of the health of earlier peoples, and because of this they have not been neglected here. Such studies have had, of course, to be limited in a book of this size, and some aspects of modern primitive groups—for example their mental health—have had to be left out entirely.

A prime reason for this symposium is to stimulate yet further interest in the fascinating problem of human disease viewed through time. There is certainly evidence that there is a healthier outlook to such studies on the part of museums and other institutions in which human material is preserved. Not only is access to such material becoming easier, but curators are more prepared than ever before to permit specimens to be submitted to new techniques, and to be moved and manipulated for X-raying. There is also some evidence that specialists in rather esoteric lines of medicine and biology are becoming increasingly interested in the temporal dimensions of disease. Improved techniques in radiology are being brought to bear on exploring the internal contents of mummy packs and the pathological changes taking place within bones. It is possible that slab radiographs of bones might also be informative. Improved histological techniques and staining methods including histochemistry are permitting a much more detailed study of preserved ancient soft tissues. Palaeobiochemistry, initiated before World War II by serological investigations on ancient mummy and skeletal tissue, has extended in the last decade to amino-acid determinations on the nitrogenous residues to be found in some prehistoric bones. One wonders if tissue antigens, other than those of blood groups, might eventually be identifiable and, if so, whether anything could ever be found out about immune diseases? Although excavated human remains will probably never be ideal for electron microscopy, which demands rapid and excellent fixation, some results can be hoped for, and indeed the study of early hair—to give an example—has revealed information on the melanin granules by this means.

There is great need at the present time for a reappraisal of the ancient classical medical writers. Far too much literature on early writers is itself becoming rather dated, and we have need of more studies along the lines of the recent collaboration between Chadwick and Mann (1950) on the medical works of Hippocrates. One would, for instance, like to see re-examined in this way the remainder of *Corpus Hippocraticorum* and the works of such writers as Galen, Celsus, Paulus, Aretaeus and Soranus of Ephesus.

Two serious deterrents to the progress of palaeopathology seem worthy of special mention here, and one can only feel a little puzzled that no attempt has been made in the past to rectify these matters. First and foremost is the generally miserable nature of comparative collections of recent bone pathology. Admittedly, radiographic data is more plentiful, but this does not exclude the urgent need for microscopic and macroscopic data on bone pathology, which is also well catalogued with accurate case histories. Already the conquest of antibiotics has rendered some forms of bone reaction very uncommon, at least in fairly advanced societies, and clearly it is now or never even in the case of undeveloped societies (for they will not remain thus for much longer). In some instances, as for example in yaws and leprosy, there is still every hope of obtaining worthwhile comparative specimens, and thus the needs of the palaeopathologist here need emphasizing. Specialists working on such diseases in the living cannot be expected to know the value of amputation material and autopsy specimens to the study of ancient disease.

The second deterrent we refer to is that of the distribution of specimens showing evidence of disease, and of skeletal collections which it would be worth while examining (or re-examining) for evidence of pathological change. Taking the British Isles as an example, there are dozens of museums which contain skeletal material excavated from local sites, dated to between Neolithic and Medieval times; to visit all these museums is both costly and time consuming. In the same way, visiting collections in other parts of Europe presents the same difficulty, but on a more expensive scale. Clearly the problem will be no different in other parts of the world. The only workable answer we can see to this is to have two or three major study centres where, not only will original palaeopathological material be easily available for research, but where casts of specimens in less accessible museums may be referred to. Also, in association with these original and cast specimens will be X-rays of the bone disease, and wherever possible sections of the involved region. This may seem rather ambitious, but is the only reasonable answer to the wide scattering of important specimens. The same type of centralization is of course needed for data on mummies and naturally preserved bodies, where at least duplicate X-rays and perhaps tissue samples could be made available. At the British Museum (Natural History) a move has already been made to collect together for research purposes not only original specimens (including some of the famous diseased Nubian specimens, until recently at the Royal College of Surgeons), but also X-rays and casts of specimens in other museums. The results so far are very promising, and there has been good cooperation with other museums so far approached.

Finally, mention might be made of some of the more archaeological aspects of this discipline. Directors of excavations are becoming increasingly aware that the study of early human disease is not only of value to the human biologist and medical historian, but that some diseases could affect and mould the activities and development of early societies. Moreover, the early town or city consisted not only of streets, mansions, cottages and temples, but also of drains, cesspools, wells and other sources of drinking water (not alway clean), and perhaps even carelessly discarded food waste. These latter details are not only useful supporting evidence, but could at times even directly contribute to the study of disease. Thus, for example, during recent excavations at Roman Fishbourne and Medieval Winchester, structures were revealed which may have been cesspools or latrine pits. Careful analyses of the soils from such structures may in some instances reveal evidence of intestinal parasites (particularly in water-logged or highly desiccated conditions).

There is also a need for further systematic excavations specifically with a view to finding pathological changes in skeletons. In Europe, the question of the antiquity, frequency and distribution of leprosy and syphilis can only be answered by purposeful searching for these diseases. Professor Møller-Christensen has set a high standard in this respect, not only in his detailed studies of leper skeletons, but also in his careful research into the location and distribution of Danish leprosaria, and in directing so ably the excavation of some of these sites. Similar records and sites are available in other parts of Europe, and clearly this opportunity should not be missed (and indeed, especially at this time when so much town and city redevelopment is covering, perhaps for all time, Medieval foundations and original street layout). In some regions it is possible that the history of syphilis might be investigated along similar lines. To give but one instance, it is recorded in *The History and Antiquities of the County of Surrey* by Manning and Bray (1814) that "stews" in a certain part of Southwark were in evidence as early as 1162, being suppressed by Henry VIII in 1546. Also, they state that prostitutes living in such stews were not permitted Christian burial, but were interred at a special site called The Single Woman's Burial Ground. Clearly historical evidence of this nature demands careful consideration, followed by excavation whenever a suitable site can be fixed in relation to recent plans.

We have perhaps digressed somewhat in parts of this editorial preface. It is to be hoped, however, that in so doing we have helped to underline not only present developments and problems, but also future possibilities in the challenging multi-disciplined field of palaeopathology.*

DON BROTHWELL
A. T. SANDISON

**Addendum*: Since going to press, D. A. Rokhlin has published *Diseases of Ancient Man* (1965, In Russian, Publishing House 'Nauka', Moscow) and an American symposium *Human Palaeopathology* (Saul Jarcho, Editor. Yale University Press, 1966) have become available for reference. Although too late to bring their findings into contributions here, it would nevertheless seem worth mentioning them at this point.

EDITORIAL ACKNOWLEDGMENTS

ALTHOUGH the acknowledgments of individual contributions are given separately at the end of the relevant papers, we should like to take this opportunity of thanking various individuals and institutions who have helped us during the compilation and preparation of this book.

Miss Mary Scott Ross and Mrs. Irene Copeland have given patient secretarial assistance. Mr. George Kerr has similarly helped with photographic needs; and Miss Theya Molleson and Miss Rosemary Powers with certain illustrations and other work.

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In the painful matter of proof checking, and in the preparation of an index, we have been helped by Patricia Brothwell.

In the case of contributions to this book which have already been published elsewhere, full details of the original place of publication are given in the list of contents to the volume. We would, however, like to take this opportunity to thank the editors of the *American Anthropologist, Journal of Pathology and Bacteriology, Bulletin of the History of Medicine, Archives of Pathology, Chinese Medical Journal,* and *British Medical Journal.* Also to the Executive Managing Editor of the American Medical Association, and the Periodicals Manager of The Johns Hopkins Press. In the case of the now extinct *Annals of Medical History,* we should like at least to acknowledge the important part this journal played in the furtherance of palaeopathology during the first three decades of this century.

Finally, we wish to thank Macmillan of London for permitting us to use parts of the Jones book on malaria in early Greece and Rome: and to Dr. E. A. Underwood and Oxford University Press for permitting republication of the Dawson paper.

D.B.
A.T.S.

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*Contributions marked with an asterisk are in our opinion some of the "classics" in the field of palaeopathology (Eds).

DISEASES IN ANTIQUITY

SECTION I

INTRODUCTORY STUDIES

Chapter 1

Pseudopathology

CALVIN WELLS

It is no trespass, I hope, on editorial privilege to point out that this volume is designed to be much more than a collection of essays in the form of a reference book. It is also calculated to attract new workers to the field of palaeopathology and to inspire a livelier awareness of the ancient evidences of disease and of what they reveal about early patterns of living. But the interpretation of archaic pathology is often a task of extreme complexity. Pitfalls abound for the unwary. Precipitate judgments and hasty conclusions are the surest road to errors of diagnosis and interpretation. As R. L. Moodie (1928) once wrote: "It sometimes takes years of painstaking comparison to be sure a diagnosis of an ancient lesion is correct." A corollary of this is, as I have said elsewhere (Wells, 1964) that "in palaeopathology the best opinions are usually tentative opinions." One of the commonest sources of error is to be misled into diagnosing abnormality where none exists. Experienced clinicians and archaeologists alike often fail to recognize the many conditions which can mimic disease and overlook the changes, artifacts and simulations which their material may present. Innumerable examples of this "pseudopathology" could be quoted. The purpose of this chapter is to alert workers in this field to the existence of these pitfalls and to describe a few of the types most commonly encountered.

Inorganic Agents: Mechanical

The vast majority of skeletal remains are inhumations recovered from a great diversity of burial places. It is important, therefore, to know how bones can be affected by the soil that covers them and to what extent pathological states can be imitated.

Mechanical forces are very common and usually exert themselves in one of two ways: (a) by simple pressure on the bone or (b) by erosion of its cortex. Pressure may result in various deformations. When the skull is affected it is easily mistaken for deliberate moulding (Fig. 1). As long ago as 1853 Akerman described a deformed skull with tilted sphenoid wings from an Anglo-Saxon cemetery at Harnham, near Salisbury. Davis (1862) strongly urged that this was artificially contrived but Dingwell (1931) refuted the suggestion and regarded it as post-mortem warping. Lagotala (1922) noted a similar appearance of deliberate artificial moulding in a group of eleven crania from a dolmen at Guiry. These, too, were almost certainly the result of soil pressure and few long series of skulls are found that do not have examples of this kind. If only a single specimen is found it may sometimes be difficult to decide whether it shows intentional deformation or merely post-mortem warping, but usually the diagnosis is helped by the fact that where ethnic head

FIGURE 1. An Anglo-Saxon calvarium from Thorpe St. Catherine, Norfolk. It is a strongly planoccipital skull and highly brachy-cranial. (Cranial Index 95.2). This is entirely the result of soil pressure. In life it was probably dolichocephalic with a well-rounded occiput and tuber occipitale. The destruction of the alveolus around the first molar tooth is due to soil erosion, not disease. Author's collection. Photograph Hallam Ashley.

moulding occurs it will be applied to many or all of the skulls in a cemetery, as at Pecos Pueblo (Hooton, 1930). Moreover, posthumous deformation is usually much more asymmetrical than that produced during life and tends not to fall into any of the recognized standard types: it is difficult to see, for instance, how it can produce conical forms. But unintentional obliquity from cradle decubitus is sometimes simulated by posthumous plagiocrany.

Skulls on which the weight of earth has led to much lateral compression may resemble a naturally occurring anomaly: scaphocephaly. This is easy to exclude if the sagittal suture is unfused but more care is needed when the parietals have united. In true scaphocephaly compensatory elongation is present together with other changes in cranial architecture. In young children the thin, ununited bones of the cranial vault often bulge outward as a result of pressure from soil which has seeped inside the skull. This may mimic hydrocephaly but careful inspection of the whole vault and base should suffice to show the real nature of the condition. In some cases of true hydrocephaly the sella turcica is enlarged but this does not occur under conditions of mechanical post-mortem pressure.

In many soils, especially where drainage is poor and acid conditions lead to decalcification, the long bones may become warped by earth pressure. This has commonly led to a diagnosis of rickets. It can be excluded by the absence of such typical features as expanded metaphyses (including ribs), an S-shaped tibial curve, and cranial bossing. It should be remembered, too, that under appropiate conditions these simulations of rickets may be very common whereas the disease itself is rare before late Mediaeval times. Unequal subsidence from the infilling of the grave may fracture various bones. Ribs are especially vulnerable but mid-shaft breaks in the tibia and fibula are also common. If these accidents occur soon after burial it may be impossible to distinguish them from fractures inflicted shortly before death. Exceptionally, an ante-mortem blood stain may still be visible on bones long after burial. Wood Jones (1908) found many such cases in his Nubian material and one has been described in a Scottish stone cist (Waterston, 1927). When present this distinguishes ante-mortem from post-inhumation injury. Pressure may sometimes be minutely localized by the action of a small flint or similar rock. If the teeth are affected they may suffer a post-mortem chipping not unlike an ethnic mutilation. Jackson (1914) quotes a neolithic tooth

FIGURE 2. An Anglo-Saxon calvarium from Caister-on-Sea, Norfolk. The frontal bone shows two "lesions:" a small healed depressed fracture above the right orbit and a circinate erosion above the glabella. The latter is due to soil erosion but a thin deposit of mineral salts over exposed diploë and around the margin of the "lesion" above the left orbit gives an appearance of osteitic reaction and early proliferation of new bone. Castle Museum, Norwich. Acc. No. 343.957. Photograph Ministry of Public Building and Works.

"filing" from Belas Knapp long barrow that was possibly due to this kind of injury.

Inorganic Agents: Chemical

So far I have discussed the purely mechanical effects of soil pressure but other forms of pseudopathology result from chemical erosion, though the two agents are often combined. When the compact cortex of long bones is lightly affected by solution processes a "grained" appearance may be produced that closely resembles periostitis. On the cranial vault and in the orbit a more pitted effect should not be mistaken for cribra parietalis or orbitalia. Chemical osteolysis which bites more deeply into the bone can imitate osteitis and even osteomyelitis if it erodes through to the marrow cavity. Absence of osseous reaction, which is found in all but the most rapidly lethal osteomyelitis, will avert misdiagnosis. A more patchy and circinate type of erosion on skull or limb bones has not infrequently been assessed as syphilitic gummatous ulceration or yaws (Fig. 2).

Bodies buried in chalk, such as the many Bronze Age round barrow interments of Wiltshire and Dorset, typically have very light, friable bones. In the absence of enough comparative material to establish that this is a chemical change it is easy to suppose that the condition is due to an intra-vitam osteoporosis. Leprosy, frostbite, syringomyelia and other forms of peripheral gangrene are sometimes diagnosed as a result of finding eroded metacarpals, metatarsals and phalanges. All these diseases have precise pathological changes, a knowledge of which will prevent these mistakes being made.

Even tiny areas of cortical destruction may simulate specific lesions. Two common examples are the erosion of the postero-lateral surface of the mastoid process (Fig. 3) or a thin layer of the maxilla to expose the root of the canine tooth. The first may be mistaken for a discharging fistula of mastoiditis, the second for a paradontal abscess. When much of the jaw is involved in this erosive change it may simulate chronic alveolar infection or scurvy, especially if associated with loss of teeth. Occasionally an appearance of dental caries is given by a combination of postmortem chipping and chemical erosion but in general the teeth are by far the most stable elements in the dead skeleton. If a narrow zone of anterior alveolus is eroded

FIGURE 3. An Anglo-Saxon skull from Thorpe St. Catherine, Norfolk. The left mastoid process has three "fistulae" on the postero-inferior surface. Destruction of septa within the bone has taken place. These openings are strongly suggestive of discharging sinuses in chronic mastoiditis but there is no doubt that in fact they are due to physico-chemical erosion. This process has also attacked the adjacent part of the occipital bone. Castle Museum, Norwich. Acc. No. 15.953/41.

with posthumous loss of incisors, it may at times be necessary to consider the possibility of accidental loss or ritual ablation during life.

In many fully fossilized specimens a peculiar chemical change known as pyrites disintegration may be found. It is common in Jurassic remains such as ammonites and belemnites, also in ichthyosaurs from the Kimmeridge clay in which it may resemble the changes produced by chronic periostitis and other lesions. It may sometimes be detected by the strongly sulphurous smell which emanates from it.

In addition to pressure and chemical erosion on interred bones further pseudo-pathological changes may be produced by physico-chemical deposition. This takes many forms, but films of precipitated carbonates are common and when found on teeth may be mistaken for tartar (which, indeed, they chemically resemble) although their shape and distribution are quite different from the deposits formed in a living mouth. Sometimes these accretions may be coloured brown by ferruginous infiltration or greenish from copper salts and other matter. They can then be mistaken for the similarly coloured deposits which are a frequent result of coca or betel chewing (Leigh, 1937).

Fine alluvium may percolate into the maxillary antrum or other sinuses and, adhering to the floor, produce a granular appearance suggestive of chronic sinusitis. Post-mortem damage to these cavities often permits a view of their interior and workers should beware of diagnosing antral infection in these circumstances. In fossilized material, especially when it is coated with a smooth mineral deposit or embedded in a closely investing matrix, an illusion of congenital or pathological synostosis is sometimes given. This can be most deceiving in the small bones of hands and feet, and in the vertebrae. Careful laboratory preparation of the specimen usually reveals the true situation without difficulty. Sometimes radiography is the simplest way of recognizing the condition.

Miscellaneous Agents

Physical factors other than soil action can play a part in pseudopathological changes. Fluctuations of temperature, particularly alternate freezing and thawing, are important; wind and rain likewise. In Eskimo graves, many of which are simple stone cists, the body is exposed to the vagaries of a harsh climate. Under these conditions various factors combine to demineralize teeth as well as bones. Shrinkage, especially of the dentine, takes place, and when the tooth dries out the enamel may flake off to give the effect of functional attrition or ante-mortem dental fracture (Pedersen, 1949). A peculiar perforation of the skull is common in Eskimo skulls. It is usually bilateral in the occipital squama and might be mistaken for congenital lacunae, trephination, or other anomaly (Pales *et al.*, 1952). It appears to be due to a combination of physicochemical causes including humidity, high winds and the weight of the skull itself.

Living Agents: Bacteria and Moulds

Bacteria are known to invade bone and to set up changes which may be mistaken for disease. Renault (1896) long ago thought that he could detect fossilized micro-organisms in his material and, although it was partly a post-mortem putrefaction process which he observed, later workers (Moodie, 1923) have left little doubt that bacteria can be recognized from exceedingly archaic times—some would say from pre-Cambrian deposits. Their effect on human skeletons is variable. Periostitis may be mimicked and there is some reason to believe that they play a part in producing an extensive destruction of the vertebral bodies which must not be confused with a tuberculous or pyogenic infection. When the sternum is attacked an appearance of congenital perforation may result.

Fungi, too, have been noted as ancient pathogens—at least as far back as the Eocene. But they are also important agents of pseudopathological change. Their mode of action seems to be that the fungal mycelia penetrate the bone and live on its organic matter, producing acids which dissolve the mineral content. Solution channels (*canaux de forage*) are produced (Morgenthaler *et al.*, 1957) and may appear in the guise of osteoporotic lesions. The essential nature of this process was recognized by Wedl (1864) and was further studied by Roux (1887) and by Schaffer, (1889) who named them "*Bohrkanäle.* Sognnaes (1950) has made a special study of this process as it affects teeth by invasion of the dentine and cementum. The large irregular channels which result should not be confused with intra-vitam decay.

Higher Plants

Plant roots often entwine themselves around bones and score the compact surface. These roots may be of any size from hair-line upwards. Typically they form a fine reticulate mesh on the cortex (Wells, 1963) which may be mistaken for minute vascular channels indicative of a hyperaemic condition such as periostitis (Fig. 4). Larger rootlets, up to 2 or 3 mm in diameter, have been mistaken for anomalous blood vessels. Either of these conditions, if present at all, tends to affect many bones of a skeleton or many bodies in a cemetery. It is common to find roots growing through cranial or other foramina. As the root enlarges it may split the bone and

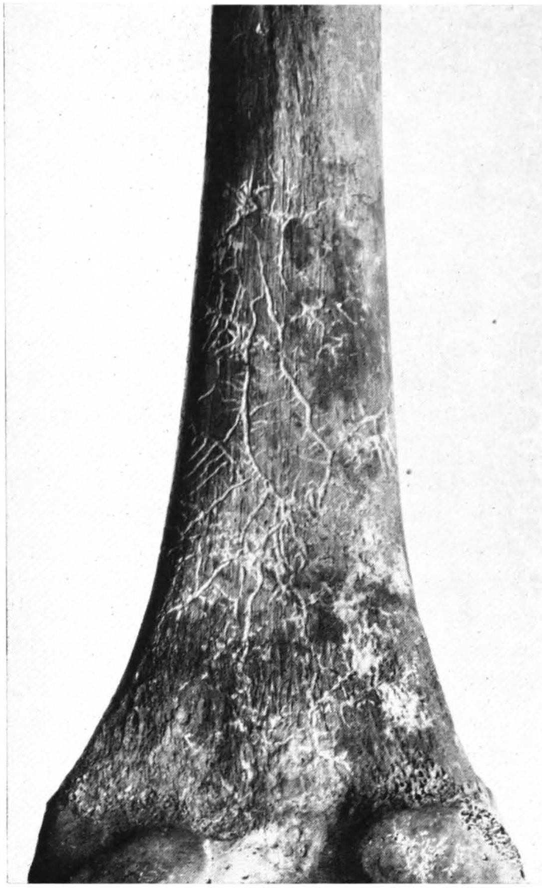

FIGURE 4. The distal end of an Anglo-Saxon femur from Burgh Castle, Suffolk. Two post-mortem appearances are seen: (a) thin, reticulate and branching lines which are the result of a web of roots eroding the cortex of the bone; (b) a fine longitudinal striation of parallel lines due to soil erosion which emphasizes the natural striated texture of the femur. Neither condition should be mistaken for the effects of periostitis or other hyperaemic conditions. Author's collection. Photograph Hallam Ashley.

make it look as though it had sustained an ante-mortem fracture. Misdiagnosis is likely here if the root has long since died and left no trace other than a soil stain from its carbonized remains. Fine roots may also encircle the necks of teeth and set up chemical solution of the dental tissue which has been interpreted as the effect of using tooth picks. (This is not to be confused with a somewhat similar chemical solution occurring in the living mouth.) (Hartweg, 1945; Brothwell, 1963) The pseudopathology noted above as affecting Eskimo teeth seems to be aggravated by contact with the decaying mosses which commonly invade the burial cairns.

In some soils, for example certain fine well drained gravels, matted collections of root fibrils can invade the medulla and decay into a deep black mass which stains most of the bone. This can readily be mistaken for an inefficient cremation or even for ante-mortem burning, the more so as it is often associated with an unusual brittleness of the cortex. A similar appearance can occur in peat burials. In these cases tannins seem to augment the effect.

Animal Agents

Animals of many different sizes attack exposed or interred bones and produce curious imitations of disease. Lortet (1907) noted an ancient skull from Roda in Upper Egypt with serpiginous ulceration of the left parietal and other areas. He claimed that it was syphilitic but it seems likely that the appearance was due to post-mortem gnawing by beetles (Gangolphe, 1913) since it is well recognized that various coleoptera attack recently buried remains. Fouquet (1897) spoke of these creatures as *les travailleurs de la mort*. Negro and other African crania are very often found with marks due to gnawing by rats and similar rodents. Porcupines are said to be vigorous offenders. The commonest area to be attacked is the upper margin of the eye sockets (Fig. 5). The result may be mistaken for ante-mortem injury or osteitis. Pales (1952) has reported a trephined Gallo-Roman skull in which the margin of the hole had been retouched by *un grignotage de souris*