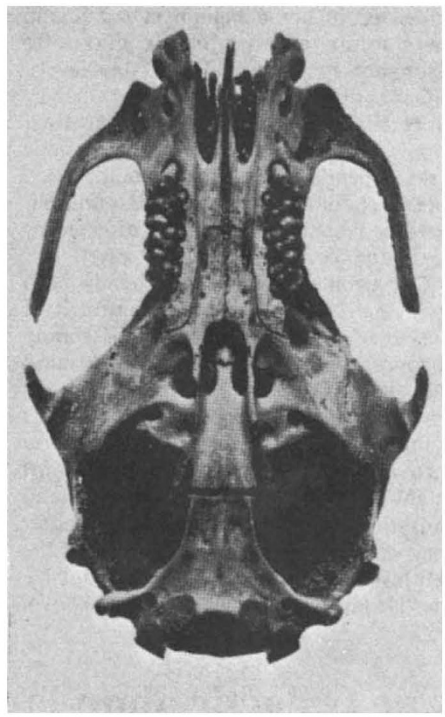
which the electrons are excited and Thiry *et al.* assume that excitation occurs into a free electron final state band. This procedure has previously been shown to give remarkably accurate results for the occupied states of some metals by Stohr *et al.* (*Phys. Rev. B* 17, 587; 1978). Eastman's group makes use of the calculated electron states and both groups obtain very good agreement with theoretical predictions of the band structure of copper. Electron mean free paths determined from the experiments confirm the well known surface sensitivity of photoelectron spectroscopy particularly for excitation wavelengths below about 500 Å. Thiry *et al.* observe excited 3d hole lifetimes in copper which are in good agreement with the estimates of Pendry and Titterington, and further show the great importance of having a high angular resolution in the experiments.

These experiments again underline the power of angle-resolved photoemission coupled to a synchrotron radiation source as an accurate probe of electron states in solids. Studies similar to those described for copper, above, have also been conducted on nickel (Eastman, Himpsel & Knapp *Phys. Rev. Lett.* **40**, 1514; 1978) and the ferromagnetic exchange splitting accurately established. Coupled to other variations of the photoemission technique such as photoelectron diffraction (see *News and Views*, **279**, 755; 1979), which enable the locations of atoms near a solid surface to be established, an active and rewarding future in this area is certain, particularly as new dedicated synchrotron radiation sources such as the one at Daresbury in the United Kingdom become operational. These new methods will lead to a greater understanding of metals, alloys, semiconductors and insulators and will undoubtedly be important in probing areas such as surface reactions, oxidation of solids, and corrosion. □

The black rat in Britain

THE finding by archaeologists of remains of *Rattus rattus* in a filled-in Roman well in York in the north of England, suggests that the black rat was present in Britain several centuries earlier than had previously been supposed. The finds, which are discussed by James Rackham of the University of Durham in the latest issue of *Antiquity* (**53**, 112; 1979), lend support to the idea that epidemics of plague occurred in Britain well before the infamous Black Death of the Middle Ages, and may even have been common in Roman times.

Historians have assumed that the black rat — to be distinguished from its close relative the brown or Norway rat, *Rattus norvegicus* — was not introduced into Britain until the Norman period, when returning Crusader ships brought it from the Near East. The many contemporary



Black rat skull found in a Roman well in York.

records of 'plague' in Anglo-Saxon Britain in the 6th and 7th centuries AD have been either ignored or explained away as outbreaks of smallpox or other virulent diseases.

There is no doubt that the high mortalities in the early centuries AD were often caused by a multitude of diseases, of which smallpox was certainly one. But it does not seem likely that Roman Britain would have completely escaped the plague epidemics that swept around the Mediterranean area and across Europe between the 1st and 6th centuries AD. The most serious of these pandemics — without doubt of bubonic plague — began in about AD 540 during Justinian's reign and spread from the Mediterranean up into central Gaul and Germany, and almost certainly would have reached the British Isles.

Plague usually spread from one coastal port to another because infected black rats would find their way on to and off ships. As there was extensive sea trading between Roman Britain and the rest of the Empire the introduction of rats into a British port could easily have happened. York was a thriving Roman administrative and trading centre. Like other large towns of the period, it was a port of call for supplies from many parts of Europe — indeed it is known to have had strong connections with Bordeaux and Rhineland. So it is not surprising that the black rat slipped into the town one day.

The rat remains recovered from the Roman well represent at least two individuals and include a well-preserved skull, a complete mandible with all its teeth, fragments of maxilla and premaxilla, and a cervical vertebra. The wall was timber-lined and was probably built in the late 2nd or early 3rd century and was then filled-in towards the end of the 4th century AD. During excavation careful checks were made to exclude the possibility that the rats had burrowed into the well after it had been sealed. This, and other evidence from Roman objects found in association with the rat remains and radiocarbon determinations suggest a 4th, or at the latest a 5th century date for the specimens.

These finds of the black rat in Roman Britain lend some support to John Wacher's controversial idea that plague led to the downfall of Romano-British towns in the 5th and 6th centuries AD at the time the Western Roman Empire was disintegrating. Wacher has suggested (*The Towns of Roman Britain*, Batsford 1974; *Roman Britain*, Dent 1978) that the depopulation of these towns was caused by epidemics striking an already threatened Romano-British culture. As economic decline set in, so the way was made easy for the conquering Anglo-Saxons and the start of the Dark Ages. S.B.

Quest for superfluid hydrogen

from P.V.E. McClintock

THE possibility of preparing monatomic hydrogen (H_1) at high densities seems to have come a stage closer with three papers published in recent issues of *Physical Review Letters*. Two separate research groups have simultaneously reported the first observations of magnetic resonance from H_1 held at liquid helium temperatures: Crampton, Greytak, Kleppner, Phillips, Smith and Weinrib of the Massachusetts Institute of Technology (*Phys. Rev. Lett.* **42**, 1039; 1979); and Hardy, Berlinsky and Whitehead of the University of British Columbia, Vancouver (*op. cit.*, 1042). On a slightly different tack, Guyer and Miller of the University of Massachusetts, Amherst, have calculated how H_1 may be expected to interact with a helium coating on the wall of its containing vessel (*op. cit.*, 1754).

The notion of monatomic hydrogen has been around for quite a long time. Hecht seems to have been the first to point out (*Physica* **25**, 1159; 1959) that H_1 at low temperatures and high densities might be expected to display quantum properties on a grand scale and, in particular, that it might undergo a superfluid transition rather like that of liquid ^{4}He. These possibilities rest on the observation that, although a pair of hydrogen atoms with oppositely directed electron spins attract each other and form a molecule of H_2, a pair of atoms with parallel electron spins (in a so-called triplet state) experience a repulsive interaction. This means that a gas of spin-aligned H_1 atoms could be cooled to very low temperatures, even at a high density, without ever condensing into a

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