other gases were also effective in modifying surface energy anisotropy.

Professor P. Feltham (Brunel University) showed that stress relaxation provided a method for studying recovery at low temperatures, for example, at 20 K in nickel. In principle a single relaxation curve sometimes sufficed for determination of the magnitude of the energy barrier to dislocation movement. He illustrated this for the case of the Peierls barrier in α -iron. The method was potentially most useful in the design of alloys, but these potentialities had not as yet been generally recognized, he said.

BIRDS

Magnetism of Navigation

from our Animal Behaviour Correspondent

THE way in which migrating birds find their way continues to be a puzzle to zoologists. Until quite recently, however, it was thought possible to discount at least one theory—that birds made use of the Earth's magnetic field for navigational purposes. Experiments in which magnets were attached to the wings of homing pigeons and found not to interfere with their homing ability at all seemed to show that they could not possibly be using magnetism. Then, in a series of articles, W. Wiltschko (*Z. Tierpsychol.*, **25**, 537; 1968) claimed that European robins could be made to reorient their migratory activity with respect to a static artificial magnetic field, putting the magnetism theory once more firmly in the running.

S. T. Emlen (*Anim. Behav.*, **18**, 215; 1970), at Cornell University, on the other hand, has recently reported his failure to confirm these results with indigo buntings (*Passerina cyanea*). In the absence of visual cues, these birds seemed totally disoriented, and they also failed to learn that they could avoid a brief electric shock by responding to a change in the direction of the magnetic field in a classical conditioning experiment.

These negative results do not, of course, rule out the possibility that indigo buntings may be able to use magnetic cues, and should be viewed in the light of Wiltschko's claim that his birds only responded to changes in a magnetic field when the strength of the artificial field closely corresponded to that of the Earth's field. The robins did not orient to stronger fields. This intriguing problem is still open.

CELLULOLYTIC ACTIVITY

Municipal Refuse Composting

from our Microbiology Correspondent

ONE of the major limitations to the effectiveness of composting solid waste is the incomplete degradation of cellulosic materials, or the long period required for its removal. The results of a research programme carried out at the US Department of Health, Education and Welfare and East Tennessee State University on cellulolytic activity in municipal refuse composts are therefore interesting and timely. Stutzenberger and his colleagues (*Canad. J. Microbiol.*, **16**, 553; 1970) have studied the factors effecting cellulose decomposition in refuse dumps and defined precisely the kinetics of the process.

Municipal solid waste, after being ground, was mixed

with concentrated sewage sludge and piled into low ridges or windrows. The windrows, about 9 feet wide, 3 feet high and 150 to 250 feet long, were sampled during a seven week composting period for cellulolytic activity. Measurements of temperature indicated the course of the composting process. Thus the windrow heated up at a linear rate and usually exceeded 60° C by the end of the first week. A temperature gradient of 10° to 15° was quickly established in the windrow and maximum heat was developed in the middle of the fermenting refuse. The peak temperatures held for about two weeks and thereafter the windrows cooled gradually but even after the end of the experimental period the temperature was about 50° C.

Cellulase activity was measured using soluble carboxymethyl cellulose as the substrate and, although the resulting data clearly indicated the progress of cellulolysis, it seems a pity that a cellulosic substrate closer in physico-chemical properties to that encountered in solid waste was not used. Nevertheless, a consistent temperature optimum of 65° to 70° C for the cellulase activity of compost extracts was observed and this optimum was independent of the age of the windrow. Temperatures considerably greater than 60° C often develop in composts, and Stutzenberger accordingly tested the activity of compost extracts at 75° C. Although activity declined 70 per cent within three hours, the residual cellulase remained very stable for up to twenty-four hours at the hotter temperature. Experiments designed to follow the selection of thermostable cellulase producers were not carried out, but it is likely that such development would occur within a natural microflora. Specific cellulase activity, however, increased exponentially during the seven week composting period, while the total cellulase content decreased by half. The final product was described as having the appearance, texture and odour of soil.

Of the microorganisms responsible for cellulose decomposition in the windrow composts, *Aspergillus fumigatus* and a *Bacillus* species grew at 45°–50° C, and a third, not surprisingly an actinomyces, was more thermophilous and grew at 55°–60° C. The crucial question now is: what limits the extent of cellulose decomposition? Heat denaturation of the enzymes and product inhibition do not seem to be implicated to any large extent. The cause of compost termination is much more likely to be substrate heterogeneity, a condition which is also responsible for the decline of glucose production by enzymatic treatment of wood cellulose (*Nature*, **218**, 320; 1968), and the complexing of cellulose with other materials, such as lignin, which blocks its hydrolysis. The 40 per cent of undegraded cellulose remaining after composting could be reduced by more extensive physical and/or chemical pretreatment of the raw waste or by seeding the partially degraded material with lignicolous microbes. Alternatively, it might be used directly as a substrate in commercial mushroom farming as Block suggested (*Appl. Microbiol.*, **13**, 5; 1965).

SENSORY PATHWAYS

Active and Passive

from our Experimental Psychology Correspondent

FOR several generations the large tracts of fibres which ascend to the brain in the dorsal columns of the spinal