in more senses than one—in the study of membranes just now concerns transformed cells in tissue culture, which as all the world knows show enhanced agglutinability by lectins. Noonan and Burger (*J. Biol. Chem.*, **248**, 4286; 1973), aside from showing that the phenomenon is not only (as has been suggested) the result of greater membrane fluidity, but also of a greater number of available binding sites, have demonstrated a precipitous change in the amount of concanavalin A bound at 15° C, which again is a manifestation of a bilayer phase transition.

For students of the tricks of bilayers, Michaelson, Horwitz and Klein (*Biochemistry*, **12**, 2637; 1973), have demonstrated a tendency of particular phospholipids to collect preferentially on the inside or outside surface of vesicles, according to their ionic nature, and McNamee and McConell (*ibid.*, 2951) have found that in electroplax membrane vesicles there is a continuous migration of phospholipids back and forth between the inner and outer surface on a time scale of a few minutes at 15° C.

LOCUSTS

# Pheromone Identified

from a Correspondent

PHASE transformation in locusts refers to the changes induced when solitary hoppers (juvenile locusts) become gregarious. The process is reversible in the instar stages because it is dependent upon the insect's population density. Gregaria hoppers are more active, need more food and are darker in colour than the solitaria hoppers (the latter are a green to fawn colour); and the gregaria adults assume longer wings and broader heads than their solitary counterparts. There is, however, one feature of the gregaria phase that can be measured more accurately than behavioural and physiological phenomena; during meiosis in the swarming adult male, the frequency of chiasmata (genetic crossing over) is increased as much as 30% over that of solitary males (Nolte, *Chromosoma*, **21**, 123; 1967).

Chemical communication plays a dominant part in the behaviour of locusts. In the desert locust, *Schistocerca gregaria*, olfactory information is important for food seeking, for synchronizing maturation, and for localizing oviposition. It was on this basis that Nolte (*Nature*, **200**, 660; 1963) postulated the liberation of a pheromone (a substance secreted to the outside of an individual and received by a second individual of the same species, in which it releases a specific action) by massed locusts that would trigger off gregarization processes. Nolte *et al.* (*Chromosoma*, **29**, 462; 1970) later found that the postulated pheromone was excreted in the faeces of solitary and gregarious hoppers (but not of the adults). The production of the pheromone was found to be related to the crop section of the alimentary tract and perception of such a stimulus appeared to be through the spiracles directly into the haemolymph.

Nolte *et al.* (*J. Insect Physiol.*, **19**, 1547; 1973) have now obtained evidence that this pheromone is 2-methoxy-5-ethylphenol, a derivative of guaiacol, which is a degradation product of the metabolism of the lignin of plants. They postulate that lignin is ingested in grass or shrubs and degraded in the crops of the larvae to guaiacol, some of which is excreted in the faeces, and the rest changed to the active pheromone (called "locustol") and also excreted.

The pheromone and some other substances were extracted by steam distillation and pentane extraction of hopper faeces. Gas chromatography of the pentane extract and preparative thin-layer chromatography of a more intensely purified extract disclosed two major and several minor components. Mass and nuclear magnetic resonance spectroscopy suggested that the two major substances are guaiacol (O-methoxyphenol) and 2-methoxy-5-ethylphenol, and this was confirmed by comparison of the effects of the two extracts and the two synthesized suspected compounds (and some of their isomers) on gregarization.

Four characteristics of gregarization in *Locusta migratoria migratorioides* were used in the identification of the pheromone: colour change during the various instars; chiasma frequencies during the first few days after becoming adult; adult morphometric ratios; and behavioural traits. Chiasma frequencies of the eight largest autosomes (the three shortest invariably exhibit one chiasma per pair) provided the most sensitive index of gregarization. Of the other criteria involved, pigmentation is influenced by other external factors (for example, humidity) as well as by chemicals, morphometric ratios are somewhat restrained under laboratory conditions and behaviour is difficult to standardize.

Considering these four criteria, locustol was shown to be the most active constituent of hopper faeces, although several other substances were shown to possess varying degrees of activity on one or more of the gregarization traits. Thus in a congregating group of hoppers gregarization will be triggered off by the accumulation of locustol in the atmosphere around the group. Previously, gregarization was found not to be so prominent a phenomenon in well ventilated laboratories. The ecological significance therefore in field conditions of a phenomenon that seems to depend on the build-up of a substance in a confined space has yet to be assessed.

SOLID STATE PHYSICS

# Energetic Phonons

from our Condensed Matter Correspondent

IN a recent issue of *Physical Review Letters* (**31**, 215; 1973) Welte and Eisenmenger of Stuttgart University report that they have succeeded in generating extremely energetic phonons, with frequencies $\nu$ in the region of 1 THz ($10^{12}$ Hz), by using superconducting aluminium tunnel diodes.

The thermal energy of a crystalline solid takes the form of quantized lattice vibrations, known as phonons. From the thermodynamic point of view, a simple solid may be regarded as an empty box containing a large number of phonons, each of energy $h\nu$, behaving very much like a gas of rapidly moving free particles. Phonons of low frequency and energy travel at the velocity of sound. Their velocity falls with increasing frequency until, at the so-called Debye cutoff frequency $\nu_D$, which is characteristic of the material, their velocity becomes zero. Phonons of frequency greater than $\nu_D$ are not a very meaningful concept since they would have wavelengths shorter than the interatomic spacing.

At high temperatures the mean free path $\lambda$ of the phonons is very short because phonon-phonon collisions are frequent. But at temperatures near 1 K, at which relatively few thermal phonons are present, $\lambda$ can become comparable with the dimensions of the specimen; this situation is analogous to the molecular flow regime of a low pressure gas. A high energy phonon introduced at one end of the specimen has, therefore, a high probability of continuing in a straight line until it strikes a boundary so that, by using a suitable phonon generator and detector, the passage of a pulse of phonons across the specimen can be investigated. Unfortunately, conventional techniques for generating phonons are either restricted to relatively low frequencies, much less than $\nu_D$, or produce phonons which are not monochromatic but spread over a wide range of frequencies.

While working with A. H. Dayem at the Bell Telephone Laboratories, however, Eisenmenger was able to report in an earlier paper that a superconducting

## Correction

As the result of editorial error, Professor J. Yvon, of the Commissariat à l'Energie Atomique (CEA) in Paris, was inadvertently described in the News and Views article "Molecular Motions" (*Nature*, **244**, 256; 1973) as coming from the University of Paris; so, too, was Dr P. Lallemand, of the École Normale Supérieur.