namely, bat-guano caves (see *3*).

I have been carrying out research on a guano deposit 150 cm high situated in a small chamber (chamber C) of Carrai Bat Cave in northeastern New South Wales, Australia. Between 1000 and 3000 bent-winged bats, *Miniopterus schreibersii*, roost in chamber C from late January to June and again from October to early December (*4*). This guano heap has built up over many years of cyclical occupancy of chamber C by bats and supports a permanent community of organisms which comprises bacteria, fungi, protozoans, nematodes, mites, bettles, flies, moths, and spiders.

The temperature profile at three depths in this heap of guano, together with the air temperature of the chamber, was monitored with an automatic temperature recorder from 29 September to 31 October 1969. Bats arrived in chamber C in large numbers on 5 October, and from this date to 31 October the combined metabolic activity of the organisms inhabiting the heap increased the temperature of the surface layers of freshly fallen guano from 14.6° to 23.9°C. The temperature at about 5 cm and 15 cm below the surface of the heap increased from 14.9° to 16.6°C and from 16.1° to 19.1°C, respectively. The air temperature of the chamber increased from 13.9° to 15.3°C (30 cm above the top of the heap), while in the domed ceiling the temperature increased from 14.7° to 21.6°C (readings were taken at 10 a.m. when the bats were roosting in the chamber). These data reveal that the environmental variability associated with bat guano communities is high.

Nursery caves of the two species of cave-dwelling bats, *Tadarida brasiliensis mexicana* and *Miniopterus schreibersii*, are also known to exhibit a high degree of environmental variability. The presence of bats within these caves warms the air so that, over a period of a few months, temperatures rapidly increase, often by more than 10°C (*5*), giving an annual temperature range of at least 10°C. Major changes in the relative humidity and in the concentration of ammonia also occur in the atmosphere of these caves, together with changes in *p*H and in the moisture content of the guano deposits. The buildup of guano in nursery caves is immense, and a large biomass of organisms may be supported. These organisms are living in environments of high variability.

The environment of organisms inhabiting guano deposits in caves is highly variable, whereas there is low environmental variability associated with "the cave environment." Bat-guano caves are not constant-temperature laboratories in which ecological studies can be carried out on simple animal communities, but they are invaluable for the study of isolated animal communities (*6*).

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DDT Action and Adenosine Triphosphate–Related Systems

Hilton and O'Brien (*1*) interpreted our data (*2*) on DDT inhibition of a Na^+, K^+, Mg^{2+}-adenosine triphosphatase to mean that DDT inhibits only the energy-requiring "sodium-potassium pump," and gave an impression that this is what we claimed to be the mechanism of DDT action. This is not what we meant, and we wish to clarify the situation here.

What we found was that DDT inhibits a yet undefined Na^+, K^+, Mg^{2+}-adenosine triphosphatase which may or may not be involved in the process of "sodium-potassium pump." We agree with Hilton and O'Brien that, if DDT attacks only the sodium pump, the end result would be just a slow blocking of the nerve action, whereas what DDT does to the nervous system is opposite: quick excitation through inhibition of Na^+ and K^+ "gate" operation. What we actually suspect, therefore, is either (i) this portion of DDT-sensitive adenosine triphosphatase is not the "pump" enzyme (but rather an enzyme-protein involved in the processes of conductance changes) or (ii) the adenosine triphosphatase in question superficially resembles the actual DDT target; the relation would resemble that between cholinesterase and the acetylcholine receptor site in the nervous system. This is the very reason that we stated in the last sentence of our report (*2*) that "the involvement of an adenosine triphosphatase or an ATP-utilizing system, or both, in DDT poisoning is a likely possibility."

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Superheated Ice

The interesting experiment of Schubert and Lingenfelter (*1*) demonstrates metastable freezing of water to ice under a pressure low enough so that both the water and the ice are superheated with respect to the vapor phase. Contrary to the authors' statement, this phenomenon has been observed previously, in fact, under even more extreme and striking conditions.

Roedder (*2*) caused microscopic aqueous inclusions in minerals to freeze, eliminating the vapor phase as a result of the expansion on freezing, and he then allowed the ice thus formed to remelt. Under these conditions the vapor phase often fails to nucleate initially, and a great reduction in pressure then occurs when the ice melts. In this way Roedder (*2*) was able to heat ice, in metastable equilibrium with the aqueous liquid, to temperatures as high as +6.5°C and thus to create a negative pressure (hydrostatic tension) in the ice-liquid system as high as about 900 bars. Since the metastable melting could be reversed (*2*, p. 1414), Roedder evidently observed both the transformations $S_I \rightarrow L_I$ and $L_I \rightarrow S_I$, in the nomenclature of Schubert and Lingenfelter (*1*). Roedder does not specifically mention observation of the transformation $L_{II} \rightarrow S_I$ described by Schubert and Lingenfelter (*1*), but he was in a position to have observed this transformation, by simply cooling his inclusion 5a from the state shown in the upper half of frame D [figure 2 in (*2*)].

In this connection it should be pointed out that one does not really "observe" the transformation $L_{II} \rightarrow S_I$, except at the first instant of nucleation of the supercooled liquid phase (liquid phase L_{II} supercooled with respect to the solid S_I). As soon as the solid nucleus forms, the latent heat released warms the immediately adjacent liquid to the metastable melting temperature, whereupon the distinction between L_{II} and L_I for this liquid becomes lost. The subsequent freezing process can just as well be described as $L_I \rightarrow S_I$, rather than $L_{II} \rightarrow S_I$. The fact that the temperature observed by Schubert and Lingenfelter (*1*) did not rise immediately to essentially 0°C can be explained in one of two alternative ways: either (i) the thermocouple was located in such a position that it remained for several minutes within the still-supercooled liquid phase, at a distance from the ice-water interface; or (ii) the thermocouple was located so near the H_2O-$C_{12}H_{18}$ interface that it became imbedded almost instantaneously in ice, which continued to be cooled by the adjacent $C_{12}H_{18}$, the initial rise to 0°C being missed because it was such a short transient.

Attention should be called to the fact that the unqualified term "superheated ice" might suggest, as a converse of "supercooled water," the idea of ice superheated with respect to liquid water (*3*). In fact, Schubert and Lingenfelter lump together under the designation S_I both ice that is superheated with respect to water vapor but not liquid and ice superheated with respect to liquid water but not vapor [figure 1 in (*1*)]. Yet existing experimental information shows that there is a great difference between the feasibility of superheating ice into the stability field of liquid water (which is essentially impossible) and of superheating it into that part of the stability field of water vapor where its free energy is lower than that of the liquid (as was achieved by Roedder and by Schubert and Lingenfelter). The essential impossibility of superheating solids into the stability field of liquids is well known (*4*), and is usually explained by the statement that there is no energy barrier to nucleation of the liquid phase at the solid surface, which is already in a more or less disordered, liquid-like state (*4*). If this is true, then the only possibility for superheating the solid with respect to the liquid is by internal heating of a single crystal of the solid.

In fact, a superheating of ice with respect to water by about 0.3°C seems to have been achieved by Käss and Magun (*5*) in an experiment in which a crystal of ice was heated dielectrically until internal melting occurred. The conditions under which this superheating was achieved are of particular interest in relation to the experiments of Roedder and of Schubert and Lingenfelter, and in relation to the possibility of the superheating of solids generally. The internal melt figures in ice (Tyndall stars) always contain a bubble of water vapor, an indication that nucleation of the vapor phase is necessary for their formation.

Nucleation of the vapor phase here limits the extent to which the solid can be superheated. If the vapor phase did not nucleate, the newly formed water would be under a hydrostatic tension of about 1200 bars, owing to the decrease of volume on melting, and the melting point at -1200 bars would be about $+8$°C (estimated by extrapolating the freezing curve to negative pressures). Without vapor-phase nucleation, it should therefore be possible to heat an ice crystal internally to $+8$°C. This does not represent a superheating of the solid with respect to the liquid formed by internal melting without vapor nucleation, since liquid and solid are *in equilibrium* at $+8$°C in this case, but it does represent a superheating with respect to liquid plus vapor that could be formed internally at any reasonable pressure for the vapor. Since the superheating required to form Tyndall stars represents either the sum of the superheatings or the largest of the superheatings required for internal nucleation of both the vapor phase and the liquid phase simultaneously, and since we know from cavitation experiments and from the experiments of Roedder (*2*) and of Schubert and Lingenfelter (*1*) that nucleation of the vapor phase itself presents a significant barrier, there is no reason to see in the 0.3°C superheat achieved by Käss and Magun (*5*) any significant barrier to internal nucleation of the liquid phase. A possibility of making ice crystals sufficiently free of nuclei so that the theoretically allowed internal superheating to $+8$°C could be achieved depends on whether the Tyndall-star nuclei are removable impurities or inherent structural imperfections, a question that remains unsettled (*5, 6*).

If "ordinary" solids that melt with an increase of volume are internally heated, the appearance of internal melt would be accompanied by an increase in pressure and an increase in the internal melting point, so that, as in the case of ice, substantial internal heating above the external melting point should theoretically be possible. Here, however, there is no question of nucleation of the vapor phase and consequent appearance of internal melting at lower temperatures. We cannot regard the internal heating in this case as superheating with respect to the liquid, until this heating exceeds that required to form the liquid by confined internal melting. The pressures to be expected will generally be high (thousands of bars), much higher than the tensile strengths of crystals, so that one would expect the solids to shatter before the heating required for confined internal melting is achieved. From this point of view there seems to be little possibility of observing any true superheating of the solid with respect to the liquid, except perhaps for a solid that melts with essentially no change in volume.

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2. E. Roedder, *ibid.* **155**, 1413 (1967).
3. Although Schubert and Lingenfelter have properly qualified their use of the term "superheated ice" at most places in their paper, it is easy for readers to overlook this qualification; I became acutely aware of this when one of my colleagues rushed into my office shortly after the issue of *Science* was received.
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