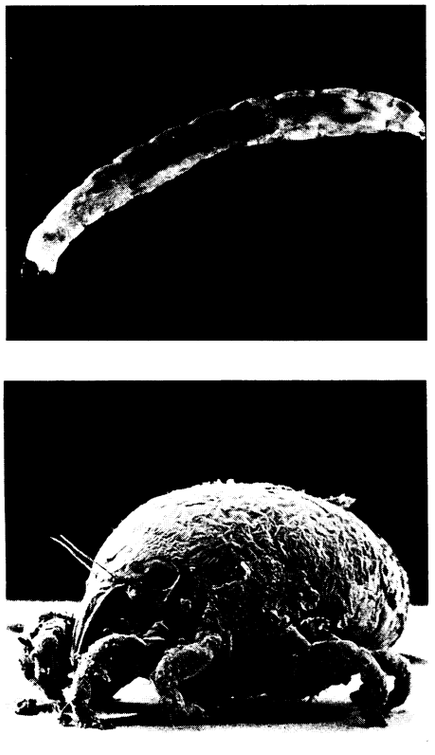
the biochemical and physiological adaptations that contribute to cold-hardiness. The synthesis of cryoprotectants is a prominent feature of overwintering strategies and contributes both to the prevention of injury in freeze-tolerant insects, by affecting the concentration of frozen material in the intracellular compartment and to the depression of the supercooling point and stabilization of the supercooled state in freeze-intolerant species. The relative costs (in terms of requirements for ATP, oxygen, and reducing equivalents) associated with the synthesis of various cryoprotectants (glycerol, sorbitol, trehalose) are well assessed in a chapter by Storey and Storey, and energetic arguments are developed to explain temporal patterns of cryoprotectant accumulation. The direct stimulation of cryoprotectant biosynthesis by low temperature (without neural or hormonal intervention), reflecting the temperature sensitivity of enzymes (such as glycogen phosphorylase phosphatase) that regulate glycogen metabolism, is also demonstrated. The importance of regulating the events of ice nucleation is emphasized in a contribution by Duman *et al.*, who review structure-function relationships in both the thermal hysteresis (antifreeze) proteins (which contribute to the stability of the supercooled state in freeze-intolerant species) and ice-nucleating proteins (which initiate extracellular ice formation at relatively high temperatures in freeze-tolerant species). Of particular interest are similarities between the surface membrane (phosphatidylinositol-anchored) ice nucleator of bacteria and a lipoprotein ice nucleator of the crane fly, *T. trivittata*.



Antarctic insects. *Top*, "Freezing-tolerant larva of *Belgica antarctica* (Diptera: Chironomidae) from the Antarctic peninsula (photograph by C. Gilbert). Body length is approximately 5 mm." *Bottom*, "Freezing susceptible tritonymph of *Alaskozetes antarcticus* (Acari, Cryptostigmata) from Signy Island. Body length is approximately 0.7 mm and its live weight is approximately 125 μg." [From Sømme and Block's chapter in *Insects at Low Temperature*]

The second section deals with the impact of low temperature on development and survival. Most notable in this section is the discussion by Denlinger *et al.* of cold shock. For example, although larvae of the flesh fly (*Sarcophaga*) can supercool to −23°C, they cannot survive for 15 minutes at −17°C; however, even a 10-minute exposure to 0°C permits more than 50 percent of the larvae to survive at −10°C (apparently owing to the rapid induction of cryoprotectant synthesis). The similarity between some aspects of the response to cold shock and the better-characterized heat-shock response is striking. Furthermore, exposure of larvae to 36°C protects against cold shock, suggesting common mechanisms of recovery from both heat and cold shock. Other contributions in this section simply catalogue the myriad effects of low temperature and the interacting effects of temperature and photoperiod on rates of development, morphogenesis, and the induction of cold-hardiness and diapause.

The third section of the book documents the diversity of ecological and physiological adaptations that permit survival in specific (including polar, alpine, and aquatic) environments. In particular, the contributions of Baust and Nishino and of Kukal provide thorough case histories of how specific insects (the goldenrod gall fly and the lepidopteran *G. groenlandica*, respectively) adapt to extreme environments and how many diverse elements (including the role of the gall, behavioral factors, and patterns of pigmentation) contribute to survival. Furthermore, the factors (cryoprotectant concentration and mix) presumed to be important in permitting formation of the recently discovered vitrified state (which is presumably advantageous because it limits the absolute amount of ice formation) in the goldenrod gall fly are examined in natural populations.

The final section deals with the practical applications of the study of insect cold-hardiness and cryopreservation to insects of either economic (honey bees, silk moths) or scientific concern (*Drosophila*). Of particular interest is the chapter by Steponkus *et al.* describing how theory-driven experimentation has resulted in recent success (20 to 33 percent survival) in the cryopreservation of *Drosophila* embryos by employing a vitrification protocol.

In summary, this volume draws together widely scattered and diverse data on the cold tolerance of insects. The treatment is generally current and topical, though the repetitious treatment of some topics and a heavy reliance on scientific names makes the volume difficult to read from cover to cover, it is an important resource for those interested in the thermal relations of insects.

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