lems" can be solved. Certain American scientists, it is alleged, "make out that the unique scientific and technological potential at the command of the United States enables it to lay claim to the role of sole leader in the contemporary world." Rule by force is giving way to a diplomacy of power through technology. Chapter 6 reviews Soviet-American cooperation under the 1972 Soviet-American Agreement on the Protection of the Environment. Chapter 7 contains the well-known Soviet attack on the Club of Rome and the "limits to growth" theory. The book ends on the optimistic note that the scientific-technological revolution contains unlimited possibilities for the protection of the biosphere and the U.S.S.R. leads the countries of the world in showing the way.

The book represents no new departure from the official position that has held sway in the Soviet Union for most of the '70's, but it is the most concise presentation of this position available in English and will be of value to those who have not the time or interest to work their way through the more scholarly discussions of the same material available in English translations of Soviet periodicals or who have not the Russian at their command to search out the primary literature.

In being a good overview of official Soviet thinking *The Biosphere and Politics* has its merits and its demerits. On the one hand, as in most Soviet studies, criticism and insight into the problems of environmental regulation and abuse in the capitalist system proliferate, supported by more or less credible source references. There is no criticism of the Soviet system nor any discussion of the problems the Soviet Party and government have encountered in this area. Yet the Soviets have admitted that they do have serious environmental problems, to which the Soviet mass media and scholarly journals frequently call attention. For an appreciation of the less attractive side of Soviet environmental planning, the reader might supplement this book with Western studies such as Marshall Goldman's *The Spoils of Progress* or Malcolm Pryde's *Conservation in the Soviet Union*. Both these books address the issue of kinds of problems that are inherent in environmental management in a planned society.

One conclusion reached by both Western authors is the difficulty of enforcement. Although there are many regulatory laws on the books in the U.S.S.R. and many of these are stricter than similar legislation in the United States, there is no independent regulatory agency, such as the U.S. Environmental Protection Agency, to monitor their implementation. Anther finding suggests that there may be an advantage in separating business from government. Goldman and Pryde argue that the subordination of the economy to the government has developed an institutional preference in the Soviet system for economic development and increased production, which militates against an enterprise's being rewarded for sound environmental practices. Other problems found by those authors include the fact that natural resources are regarded as free, a point of view that encourages wastage of them, and the rivalries between central and regional administrative and economic bureaucracies.

On the positive side, Khozin's book sets forth the Soviet Union's record in international environmental cooperation, a record that compares favorably with that of the other highly industrialized nations. Indeed, the U.S.S.R. has probably participated more consistently in U.N. environmental programs and has made its voice heard more constructively in the international conventions on the Law of the Sea than it has in other international cooperative endeavors. Second, the U.S.-U.S.S.R. environmental agreement is reassuring evidence that both superpowers are aware of the seriousness of global environmental issues and of their joint responsibility in dealing with them.

Finally, the book presents an alternative and by no means wholly invalid interpretation of the current environmental crisis that Americans would do well to ponder. As defined in *The Biosphere and Politics*, international cooperation means cooperation between equal and sovereign nation states, not "global interdependence," which should alert us to the danger inherent in trying to solve global environmental problems by transgressing national sensitivities. And the Soviets' rejection of the "limits to growth" theory is a warning that the U.S.S.R. is unlikely to permit its own or the Third World's economic development to stand still for the sake of a cleaner world advocated by American "technological diplomacy." A clearer understanding of the Soviet position helps shape our own options in defining a global environmental strategy whose aims and methods must be shared by all nations if mankind is to survive.

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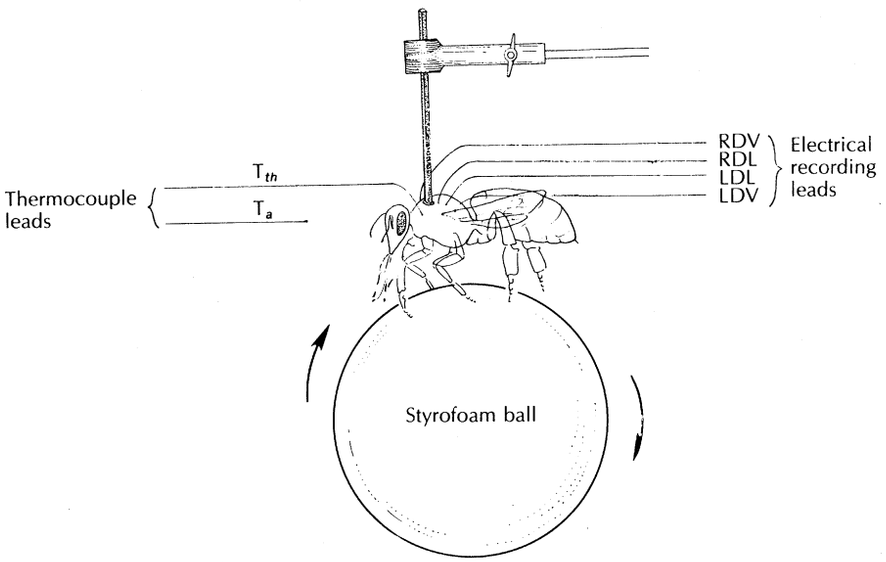
## Insect Strategies

**Bumblebee Economics.** BERND HEINRICH. Harvard University Press, Cambridge, Mass., 1979. x, 246 pp., illus. + plates. $17.50.

This small book (whose information content and provocative nature make it seem much larger) is a remarkable exercise in anthropomorphics, starting with the title, which does not refer to the cost of keeping bumblebees (although the reader will find a fascinating essay on how to do so in the appendix). It is the reader, not the author, who will introduce most of the human analogies. The bumblebee behavior described here has been shaped by 80 million years of evolution into forms that are familiar in the human marketplace.

The title refers to how bumblebees produce, distribute, and consume wealth. Bumblebee wealth, nectar and pollen, is produced by foraging at flowers and is consumed to propagate a new bumblebee colony next year. This economic system has its counterpart in flowering plants. Their wealth of nectar and pollen is used to pay bumblebees for pollinating other plants. Bumblebees and their kin use various tactics to wrest wealth in excess of costs from flowering plants, which have their own tactics for obtaining the services of bumblebees without paying excessively.

Heinrich organizes the complex coevolution of bumblebees and flowering plants first with a description of the annual cycle of a bumblebee colony followed by a presentation of experimental results that describe the energetic costs of foraging. Then he presents field observations and experiments of his own and others that illustrate how bees and flowers interact. The bumblebees he studied keep their flight muscles at a temperature of 30°C or more while flying, although they may fly at air temperatures of 0°C. A high metabolic rate and a hairy, insulated thorax are responsible for the large temperature difference. Insulation is adjusted by controlling the amount and timing of blood flow to the nearly naked abdomen. The queen bumblebee can produce heat at a high rate without flying and keeps her brood of eggs and larvae warm by incubating them. All this requires nectar for fuel plus fat and protein from pollen for the growing larvae. To bring home adequate supplies, the bees must juggle a number of variables: fuel aboard at takeoff, flight time to destination, flowers selected relative to nectar content and ease of gathering, air temperature, whether to hover or perch,

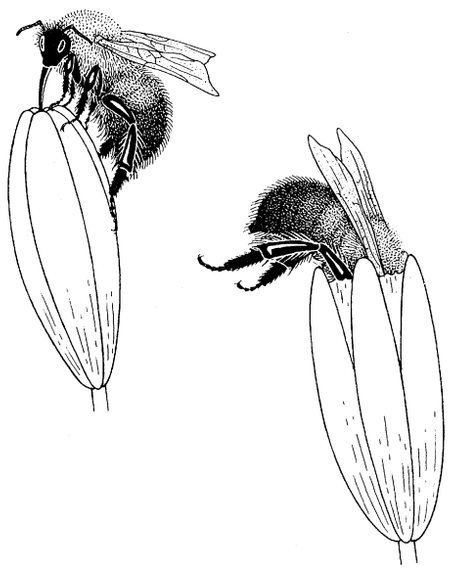



Approximate placement of wire leads inserted into the thorax of a bumblebee to measure thoracic temperature ($T_{th}$) and the action potentials from the right and left dorsoventral and right and left dorsolongitudinal muscles. $T_a$ = air temperature. "We wanted to give our bee as many behavioral options as possible, so that it could act 'normally.' In order for us to take measurements, the bee had to be fastened. . . . But we [gave] it the illusion that it had freedom. First, our bee was fixed in such a way that it could fly in place. (The illusion of flight movement . . . can be given by presenting the bee with a moving visual field. . . .) Also, the bee could walk as 'far' or as fast as it wanted. This illusion was created by letting it grasp a light styrofoam ball. As it walked on the ball, the ball rotated, and the bee, being dorsally attached, remained at the same spot—'on the ball,' that is. We controlled air temperature . . . by dipping the respirometer containing the bee into a temperature-controlled water bath." [From *Bumblebee Economics*]

whether to cool off or keep warm, and more.

The flowers advertise their nectar contents by their shape, color, arrangement, and odor. The author's observations on the last illustrate his straightforward and effective experimental technique. He covered a patch of clover flowers with bridal veil to exclude foraging bees, then lay back on the lawn with his eyes closed while a student held clover flowers for him to sniff. He could with 88 percent accuracy determine whether a flower had been visited by a bumblebee. Flowers may "cheat" by producing no nectar but looking like other flowers that do reward bees. Some orchid flowers resemble female insects closely and achieve cross-pollination by luring male insects into attempted copulation. On the other hand, bees may rob flowers by biting into the nectar cup rather than struggling through the pollen apparatus. Bees and plants have obviously reached a mutually satisfactory arrangement. One cannot help but admire a transport system where the fuel is nearly pure carbohydrate made on the spot from air, water, and sunshine.

Heinrich sets out to tie his research in with everyday experience so that both laypersons and professional biologists may share the fascinating continuity between physiology, behavior, and ecology. The overall aim of the book is to use the bumblebee as a model to explore biological energy costs and payoffs. All this Heinrich has achieved, with good science, pleasing style, and obvious linkages to the human condition.



"Bumblebees reach the copious nectar of closed gentian blossoms by prying apart the pleated corolla tube and crawling into the base of the flower." Although "few flowers are pollinated by one group of pollinators only, and bumblebees, in particular, visit almost anything, . . . a few kinds of flowers, because of their morphology, admit bumblebees to their pollen and nectar more readily than other foragers. . . . It is a curious fact that many of the flowers evolved to be pollinated specifically by bumblebees have hidden nectar or pollen. Apparently this . . . prevents other, non-pollinating insects from reaching the food rewards." The closed gentian is "an extreme example of a flower that is difficult," yet it is accessible to some individual bumblebees. [From *Bumblebee Economics*]

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## Developmental Differences

**Primordial Germ Cells in the Chordates.** Embryogenesis and Phylogenesis. PIETER D. NIEUWKOOP and LIEN A. SUTASURYA. Cambridge University Press, New York, 1979. xii, 188 pp., illus. $34.50. Developmental and Cell Biology.

In vertebrates the gonads originate in middle to late embryogenesis. At that time their constituent cells are already of two kinds: small cells that subsequently form the gonadal stroma, and large cells (the primordial germ cells) from which the eggs and sperm are subsequently elaborated. The two cell types represent distinct cell lines in that the small cells are located at the site of gonad rudiment formation whereas the primordial germ cells originate at some distance from the future gonadal sites and migrate into them. The primordial germ cells arise in early embryogenesis, and the events by which they originate comprise the central theme of Nieuwkoop and Sutasurya's monograph, which otherwise reviews the corpus of studies that underlies the statements made above.

The discussion is set against the more general background of the origin and development of the mesoderm, the embryological nature of which has drawn the experimental attention of Nieuwkoop and his collaborators over many years. The authors propound, on the basis of the mesodermal studies as well as other work, two principal mechanisms for the early segregation of primordial germ cells in the chordates. The first involves the compartmentalization of a group of endoderm cells. This is the mechanism adopted by the anurans (frogs and toads) and by the birds. In the anurans the cells are distinguished by the possession of a specialized cytoplasm (the germ plasm), which can be readily identified in the egg and which has been held to be responsible for their germinal character, but in birds the primordial germ cells apparently lack such a cytoplasm.

The second mechanism involves a compartmentalization of cells from the mesoderm, which itself arises (according