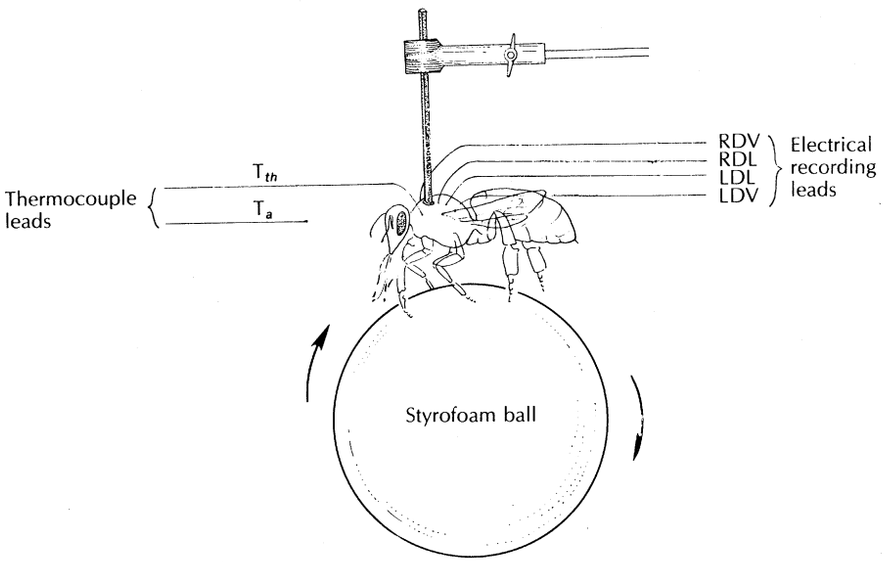
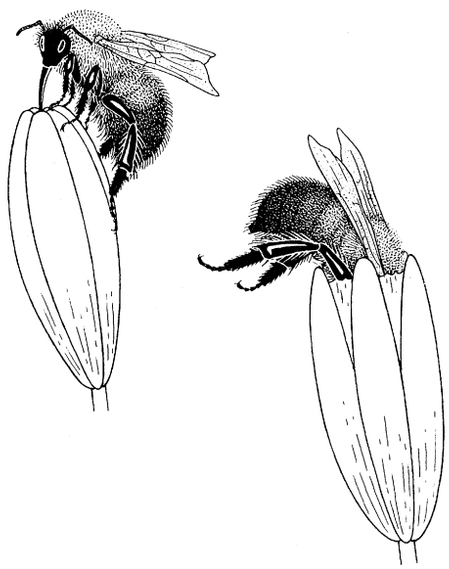


Approximate placement of wire leads inserted into the thorax of a bumblebee to measure thoracic temperature (T_{th}) and the action potentials from the right and left dorsoventral and right and left dorsolongitudinal muscles. T_a = air temperature. "We wanted to give our bee as many behavioral options 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

to the work of the Nieuwkoop group) by a partial transformation of the ectoderm through an interaction with endoderm cells. This mechanism is thoroughly epigenetic and somewhat later in its inception and is the mechanism elected by the salamanders and their allies among the Amphibia, and probably by the mammals as well. The primordial germ cells of these groups are not characterized by a germ plasm but contain cytoplasmic structures collectively termed "nuage" that have been suggested to be related to some elements of the germ plasm.

Because the Amphibia appear to employ both mechanisms, the monograph gives interesting consideration to the possibility that the class, and perhaps the entire subphylum Vertebrata, has a diphyletic origin. A problem with such interpretations lies in the rudimentary state of our knowledge of the origin of the primordial germ cells in the fish and reptiles. We have confidence in our understanding of critical events in amphibian and bird development, but the possibility cannot yet be excluded that similar variation in the history of the primordial germ cells occurs in the other vertebrate groups; the need for further research into this question is clearly signaled in the book. Moreover, the book limits its compass to the Chordata, and differences similar to those reviewed in it may also be found within the invertebrate groups. Such differences may represent divergences along the main lines of evolution of all principal animal groups.

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Reproductive Biology

The Spermatozoon. Maturation, Motility, Surface Properties and Comparative Aspects. Proceedings of a symposium, Boston and Woods Hole, Mass., May 1978. DON W. FAWCETT and J. MICHAEL BEDFORD, Eds. Urban and Schwarzenberg, Baltimore, 1979. xvi, 442 pp., illus. $49.

Spermatozoa are one of the most highly differentiated cell types. They are specialized to perform one short act: the fusion with an ovum, which restores the diploid genome and activates embryonic development. Until recently, our knowledge of the membrane ultrastructure and biochemistry of sperm has been scant. Most of the significant recent work on sperm physiology, biochemistry, and ultrastructure has been compiled in this very readable and beautifully illustrated volume. The book will be a major reference in reproductive biology for years to come.

The book is a collection of 40 papers presented at the third international symposium on the spermatozoon. The papers are divided into six major sections, on maturation, motility, surface properties, comparative aspects, isolation of germ cells, and quantitation of sperm motility. There are 333 figures, many of which are excellent high-resolution electron micrographs, illustrating the intricacies of sperm anatomy. In a paper on the basis of flagellar motility (P. Satir) the appearance of the dynein arms of the axoneme (p. 86) neatly demonstrates the value of the technique of reinforcement of the image of a periodically repeating structure. A companion paper devoted to the ultrastructure of the axoneme (R. W. Linck) presents beautiful negatively stained images showing the radial spoke triplets (p. 101). The distribution and patterning of intramembraneous particles on sperm flagellar membranes (D. S. Friend *et al.*), as visualized by freeze-fracture (pp. 160–165), are most impressive. A paper on the morphology of urodelian sperm (B. Picheral) presents one of the most extensive studies of amphibian sperm yet accomplished.

The quality of the art work in the book is consistently excellent. It is amply demonstrated in a paper on the evolution of the acrosome complex (B. Baccetti), where illustrations of such fantastic sperm as those belonging to the diplopod *Packyjulus* (p. 317) appear. The quality of the printing and the general layout, organization, and balance of content are all without fault. In fact, the only detracting feature is that the subject index is rather short.

Sperm-egg recognition, adhesion, and fusion are processes that must be mediated by macromolecular components on the cell membranes. Many laboratories are currently attempting to isolate these important molecules from both invertebrate and vertebrate spermatozoa. For this reason, the section on surface properties, the major section of the book, is timely and of considerable importance. Mammalian sperm taken from the testis or the caput portion of the epididymis are incapable of fertilization. Only those sperm that have passed from the caput to the caudal portion of the epididymis can fertilize eggs. G. L. Nicolson and R. Yanagimachi review their work demonstrating that as sperm pass from caput to caudal portions, the lectin binding specificity changes. This shows that new glycoproteins, which may be intimately involved in capacitation and the acrosome reaction, must appear on the sperm membrane during epididymal maturation. Another paper (C. F. Millette) describes the appearance of membrane antigens during mouse spermatogenesis. A third paper (M. G. O'Rand) is concerned with antigenic changes occurring during the still mysterious process of sperm capacitation.

The surprising finding that sperm membrane components persist on the surface of both sea urchin and hamster eggs as distinct patches is described, along with a novel method of labeling sperm using ^{125}I-labeled diiodofluorescein-isothiocyanate (C. A. Gabel *et al.*). A paper (G. B. Dooher) on the serological analysis of T/t antigens (surface antigens) on mouse sperm is also included. Useful methodology, such as the isolations of components of rat sperm (H. I. Calvin), the perforatorium of rat sperm (G. E. Olsen), and mitochondria from bovine sperm (V. Pallini), is presented.

This is a welcome and refreshing treatise. One hopes it may stimulate young investigators to enter this field of research.

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Books Received

Acoustic Tumors. William F. House and Charles M. Luetje, Eds. University Park Press, Baltimore, 1979. Two volumes. illus. Vol. 1, Diagnosis. xviii, 298 pp. $29.50. Vol. 2, Management. xvi, 280 pp. $19.50.

Additive and Cancellative Interacting Particle Systems.. David Griffeath. Springer-Verlag, New York, 1979. vi, 108 pp. Paper, $9. Lecture Notes in Mathematics, vol. 724.

Adjuvant Therapies and Markers of Post-Surgical Minimal Residual Disease II. Adjuvant Therapies of the Various Primary Tumors. Papers from a meeting, Paris, June 1978. G. Bonadonna, G. Mathé, and S. E. Salmon, Eds. Springer-Verlag, New York, 1979. xii, 468 pp., illus. $53.90. Recent Results in Cancer Research, 68.

Birth Defects Compendium. Daniel Bergsma, Ed. Published for the National Foundation—March of Dimes by Liss, New York, ed. 2, 1979. xxxviii, 1184 pp., illus. $50.

Biting Off the Bracelet. A Study of Children in Hospitals. Ann Hill Beuf. University of Pennsylvania Press, Philadelphia, 1979. x, 164 pp. $9.95.

Brain, Environment, and Social Psychology. J. K. Chadwick-Jones, Irmingard I. Lenzer, James A. Darley, and Kenneth A. Hill. University Park Press, Baltimore, 1979. xii, 202 pp., illus. Paper, $8.95.

Captivity and Behavior. Primates in Breeding Colonies, Laboratories, and Zoos. Papers from a symposium, Seattle, Wash., 1977. J.

(Continued on page 1495)