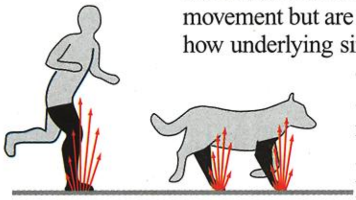
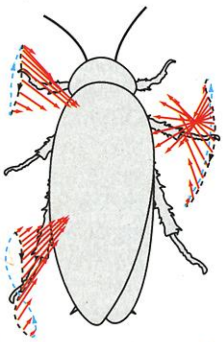
INTRODUCTION

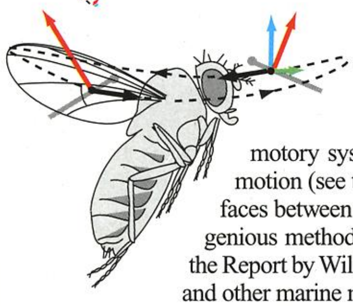
On the Move

From the trafficking of intracellular cargoes to the flight of the wandering albatross, movement is one of life's central attributes. All organisms have a three-dimensional spatial context that is both internal and external; directed, organized motion, which creates as well as operates within this context, has been a prime target of natural selection from the dawn of evolutionary time. This special issue examines the principles of movement as expressed at scales ranging from the subcellular to that of individual organisms, and in robots as well as in living creatures.

At the root of all existence lies movement at the subcellular and molecular levels. Recent studies of molecular motors such as the proteins myosin and kinesin, which are not only responsible for muscle movement but are also involved in processes such as cell division and membrane transport, have revealed how underlying similarities at the molecular structural level can generate a diversity of functional properties and mechanisms of converting chemical to mechanical energy. These findings are reviewed on page 88 by Vale and Milligan. These molecular analogs to motors are not the only way of controlling and organizing the movement of material within cells. As reviewed by Mahadevan and Matsudaira (p. 95), much has been learned about the polymeric analogs to other mechanical systems, especially springs and ratchets. Such systems mediate another sizable cross section of cellular activities, including fertilization, which can be governed by the dynamics of actin filaments in some instances.







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Of course, whole cells move too, with profound consequences for a host of physiologic processes, including development, when cells traverse the embryo to find their correct places. In a News story (p. 86), Gretchen Vogel reports that developmental biologists, long focused on genetic signals rather than cell movements, are at last catching glimpses of the molecules that prompt cells to move or stay still at crucial moments in development.

At the level of the individual animal, the wealth of solutions to the problem of getting from point A to point B—swimming, running, jumping, flying, diving—has been keenly explored by natural historians and biomechanicists for centuries. Yet the past decade has been a particularly vigorous period for biomechanics, propelled not only by an unprecedented harnessing of computing power and the runaway development of robotics, but also by a growing appreciation of the feedbacks between animal sensory and locomotory systems and of the parallels between different types of locomotion (see the Review by Dickinson *et al.*, p. 100). Studies at the interfaces between behavior, physiology, and motion, employing ever more ingenious methods, are also yielding remarkable new insights. For example, the Report by Williams (p. 133) reveals the stop-and-start behavior of dolphins and other marine mammals, including the world's largest animal, the enigmatic blue whale. A related News story (p. 83) by Elizabeth Pennisi discusses these findings, which are among the most dramatic of a series of recent discoveries concerning the diverse advantages gained by moving intermittently.

Mechanical creatures may also help illuminate the principles of motion, as reported in the News story by Gary Taubes (p. 80). As biologists learn from a new generation of robotic lobsters, moths, flies, and fish, roboticists are deliberately modeling their creations on natural principles. Not since the bird's wing gave us the airfoil has the application of natural knowledge in this area looked so promising.

The study of motion is one of those rare and challenging disciplines that draws together the biological, the chemical, and the physical, and it holds endless fascination for the pure and applied scientist alike. We can predict many fruitful collaborations in the future and expect many surprises.

–LISA CHONG, ELIZABETH CULOTTA, AND ANDREW SUGDEN

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