defined within the abdominal segments of the milkweed bug, *Oncopeltus*. On the basis of these findings, Lawrence and Morata (this volume) have developed the "compartment hypothesis" as a conceptual framework for approaching several important questions: for example, how genetic information becomes translated into a three-dimensional pattern and how size and form are controlled.

Some hope of understanding the nature of developmental events at the cellular and molecular level has been provided by the studies of germ cell determination and by studies, reviewed in this volume by Kalthoff, of anterior morphogenetic determinants in eggs of the chironomid *Smittia*. It is possible, by experimental intervention, to alter cytoplasmically located developmental information in the anterior egg region so that the normal segmental pattern of head, thorax, and anterior abdominal segments is replaced by an additional set of posterior segments arrayed in mirror-image symmetry. The most effective and reliable method for producing these double abdomen embryos is ultraviolet irradiation of a very small region at the anterior end of the egg prior to blastoderm formation. That the morphogenetic agents might be nucleic acid protein moieties was first suggested by the action spectrum for induction of the monster embryos and by the photoreversibility of the effects of ultraviolet irradiation. Now it has been shown that the application of ribonuclease to the anterior end by microinjection produces double abdomen embryos (Kandler-Singer and Kalthoff, *Proc. Natl. Acad. Sci. U.S.A.* **73**, 3739 [1976]). Thus it is speculated that in *Smittia*, and perhaps also in the germ cell determinants (Mahowald, *J. Exp. Zool.* **176**, 345 [1971]), cytoplasmic masked messengers, in the form of ribonucleic phosphate particles laid down during oogenesis, provide localized information controlling specific differentiative or determinative events.

Other chapters in this volume deal with rather diverse subjects. Sander provides a useful review of studies, mostly from German laboratories, of the wide variety of morphogenetic movements during early embryogenesis and lists commercially available films of embryonic development in a number of insect species. It is apparent that if we are to understand the bases of these interesting movements of both the yolk system and embryonic cells more detailed analyses at the cellular and subcellular levels are badly needed. There is an interesting and stimulating discussion by Shelton of the relation of the development of the compound eye, a structure almost crystalline in its organization, to a number of general developmental issues; included are some fascinating observations of differences in growth cone structure in different regions of the brain. Whittle surveys the kinds of developmental problems that can be analyzed by using mutants that affect a single structure (in this case the wing), an approach first used by Waddington in 1939. Wigglesworth reviews his extensive studies of juvenile hormone and cuticular pattern formation. His chapter is distinguished by an interesting discussion of the characteristics of determination at the cellular level in *Rhodnius*. In a final chapter that seems somewhat out of context with the rest of the volume, Ashburner and Richards present their recent studies of induced puffing in the polytene chromosomes of *Drosophila*.

The book is not comprehensive in its coverage, there is some unevenness in that some papers are broad general reviews and others are limited to the author's own studies, and there are some incorrect literature citations. There is also some overlap with articles published elsewhere. The subject has currently become so popular that it is in some danger of overexposure, particularly since the cast of authors reviewing the work remains much the same. Indeed, it is perhaps surprising that some of them have managed to find something new to say in this volume.

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Advances in Cell Biology

Cell Motility. Papers from a symposium. R. GOLDMAN, T. POLLARD, and J. ROSENBAUM, Eds. Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y., 1976. Three books, illus. Book A, Motility, Muscle and Non-Muscle Cells. xiv pp. + pp. 1–456 + index. Book B, Actin, Myosin and Associated Proteins. xiv pp. + pp. 457–840 + index. Book C, Microtubules and Related Proteins. xiv pp. + pp. 841–1374 + index. $75. Cold Spring Harbor Conferences on Cell Proliferation, vol. 3.

These three volumes effectively demonstrate the change in emphasis that has taken place in research on cell motility in recent years. Until about ten years ago, the main emphasis was on the role of microtubules because they were the major component of such motile organelles as cilia and flagella and because the discovery of cytoplasmic microtubules suggested that microtubules might have a more general role in cell motility as well. Particular interest was focused on trying to find the mechanism of chromosome movement in mitosis, a classical problem that seemed much closer to solution when microtubules were found to be the major fibrillar component of the spindle. Although an equally visible and impressive form of cell movement occurs in amoebas and similar cells, it was considered, for reasons now perhaps less clear, to be less likely to lead to a generalized model of cell motility, even though the involvement of the muscle proteins actin and myosin in amoeboid motion had already been suggested.

Since that time, the working out of the sliding mechanism of ciliary and flagellar movement has provided one of the more elegant examples of the effectiveness of a combined ultrastructural and biochemical attack on a problem in cell biology, and the mechanism of the assembly of cytoplasmic microtubules from the tubulin monomer has become both more clear and more complicated. Assembly of microtubules in vitro is now possible, and the process seems similar to that in cells, where rapid assembly and disassembly of microtubular structures are commonly observed.

While these studies of microtubules were progressing, our view of actin and myosin was changing and they were generally coming to be considered to be not specialized proteins of highly differentiated muscle, but proteins common to most eukaryotic cells. This change came about primarily as the result of two events—the convincing demonstration that "actinlike" and "myosinlike" proteins could be isolated from the amoeboid Myxomycetes by a modification of the methods that had been employed in studying muscle and the demonstration that the enzymatic myosin fragment heavy meromyosin could be used specifically to identify (and localize) actin in cells by electron microscopy. This latter technique was used to demonstrate that actin is present in most cell types, and, more recently, immunofluorescence has shown that other muscle proteins are also common in cells. These results have encouraged the biochemical preparation of muscle proteins from a variety of cell types, and the development of the field can be seen in the change in terminology from "actinlike" and "myosinlike" to "actin" and "myosin" and, more recently, in the study of slight differences in actin and myosin from different sources.

The papers presented at this sympo-

sium include examples of the increasing sophistication of the methods used to study such topics as the localization of actin and other proteins in cells, the components and conditions necessary for the assembly of microtubules in vitro, and the functions of cilia and flagella, as well as examples of the more tentative approaches to the larger areas of ignorance that remain. In the case of the functions of actin and myosin in cell motility, an overdependence on muscle models may have slowed progress in the past because the search for similarities to muscle sometimes prevented the emergence of new approaches. However, the large amount of actin found in cells and the high ratios of actin to myosin, together with the recently discovered interactions of actin with new proteins not represented in muscle, are now stimulating a reconsideration of the classical question regarding the existence of a cytoskeleton and, since force generated in the cell must be transmitted by some means to be effective, the possible interaction of such an actin-based structural framework with the contractile elements. Force generation and transmission in mitosis remain a mystery that the theories of each decade in turn appear to solve. It seemed at one time that the presence of microtubules in the spindle coupled with their undeniable motile function in cilia and flagella would eventually provide an explanation of chromosome movement. This has not happened—at least to general satisfaction—and actin and myosin are now being implicated in force production. Perhaps the discovery of an interaction between the mechanisms of force generation and transmission will finally put to rest this seemingly perpetual mystery.

A 1963 conference on primitive motile systems is generally considered to be the benchmark for research on cell motility in the 1960's, and the 1975 conference will very likely serve the same function for such research in the 1970's. The three-volume report on the conference is comprehensive in its coverage and includes papers on almost all aspects of current research activity. A comparison of the published results of this conference with those of the earlier one in terms of topics covered and number of pages might be used as a measure of the development of research on cell motility. One can only hope that the tripling of the price of the books is a measure of the increasing affluence of biologists.

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Astronomy Transformed. The Emergence of Radio Astronomy in Britain. DAVID O. EDGE and MICHAEL J. MULKAY. Wiley-Interscience, New York, 1976. xviii, 482 pp. $25. Science, Culture, and Society.

During World War II, in the course of radar research, the British physicist J. S. Hey detected radio emission from the sun, noticed radar echoes from meteor trails, and also observed that much of the cosmic noise on radar sets came from the Galaxy, including a high-intensity source in the direction of Cygnus. In the postwar years, radar studies of meteor trails formed the main initial enterprise of a new research program at the University of Manchester under Bernard Lovell. Radio emissions from the sun and, soon, from discrete sources outside the solar system captured the attention of a team under Martin Ryle at the Cavendish Laboratory and of another at the University of Sydney under J. L. Pawsey. By the early 1950's, the combined work of the three groups was gaining recognition within the British scientific community under the name "radio astronomy," and the field was rapidly acquiring such institutional manifestations of identity as a Royal Astronomical Society Committee on Radio Astronomy.

By late 1952, radio astronomers knew that the sky had a bright radio background against which could be discerned a large number of discrete radio sources. It seemed necessary now to map these discrete sources systematically and to catalog their principal physical characteristics, notably position, spectra, intensity, polarization, angular extent, and radio redshift. Through the next decade, the development of instruments occupied a major part of the respective radio astronomical research programs. At the University of Manchester's Jodrell Bank, the staff concentrated on the design and construction of the 250-foot dish, a multipurpose instrument able to accommodate the interests of both the observers of meteor trails and the students of radio phenomena. The Jodrell Bank group also developed long-baseline interferometer techniques to measure the position and angular extent of radio sources in our own and nearby galaxies.

At Cambridge, impressed by the optical identification of highly energetic radio sources, Ryle aimed to detect sources that might appear to be weak because they were an immense distance away. To gather enough incident energy, Ryle's group proposed to probe radio emissions over a large horizontal area, but with the ingenious twist of relying upon a small number of elements in a rectangular array. By measuring the amplitude and relative phase of the signals striking the elements and then using a Fourier transform on these data, it was possible to obtain the frequency distribution of the signals. This technique, eventually known as "aperture synthesis," was especially powerful when used in conjunction with the earth's rotation, which carried one element around the other over a 24-hour period.

In the 1950's, employing a four-element interferometer, the Cambridge group conducted its 2C and 3C surveys. The results for the distribution of sources in relation to distance contradicted the prevailing steady-state theory of the universe, and the Cambridge group began advancing the view of an evolutionary universe characterized by higher density of sources at extragalactic distances. But the 2C and 3C results failed to distinguish clearly between close and distant weak sources. In fact, at Sydney an independent discrete-source survey, made with a large array in the form of a cross to form a pencil beam, contradicted the 2C and 3C results. About 1958, despite general recognition that a majority of discrete sources must be extragalactic, radio astronomy was colored by acute dissension regarding source counts, source characteristics, and cosmological claims.

In part to resolve the dispute, the 4C survey was undertaken at Cambridge from 1958 to 1964. This relied on full aperture synthesis, reported on 5000 sources, and tended to confirm the central conclusion of the earlier Cambridge work that there was an excess of weaker sources at great distances. After 1961, a survey in Sydney with the new Parkes 210-foot dish ended the dissension with Cambridge, since the two surveys converged on virtually the same density-