Review: Science and Scientists: Where are We Going?
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Review by: Malcolm P. Griffin and Peter D. Taylor
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for reassembling the cell nucleus." Micrographs show very nucleus-like structures that form from *Xenopus* egg extracts and dismembranated sperm nuclei. N. Ringertz and his colleagues present striking illustrations of digitalized immunofluorescence micrographs of nuclei treated with antinuclear antibodies. As long as a source of different and specific antibodies is available, this approach will successfully map nuclear spatial organization. Functional organization will, I imagine, be more problematic. In a contribution entitled, "Cell surface carbohydrates: molecules in search of a function?," G. W. M. Cook offers a thoughtful and historical approach. He sees that, at least for cell-surface studies, cell biologists are slow to allow data to change their collective mind. When hypotheses alone stated that plasma membranes consist only of protein and lipid, journals were loathe to publish reports of membrane isolation if the fractions contained any carbohydrate. Now that carbohydrates are an incontestable part of plasma membranes, one hopes that the functions of these exquisitely specific molecules will come to the fore amid less resistance.

The excellent final chapter of the first section is on the biology and biochemistry of plant cells, by D. H. Northcote. The piece outlines many of the critical problems in plant cell biology, and shows how plants can be especially suited to solving many of them. The book might have been improved by the addition of one or two similar chapters on this long-neglected topic.

Two consecutive chapters on cell adhesion present an interesting contrast in outlooks. Gerisch dissects the biochemistry of slime-mold cell adhesion, using all the tools of carbohydrate chemistry, oligosaccharide synthesis inhibitors, and immunology. His assumptions are clearly stated, he never loses sight of the adhesive specificity phenomena that initiated these studies, and he pursues his problem into whatever new research areas are indicated. Garrod focuses on desmosomal adhesions in vertebrate tissues, and relies perhaps excessively on the assumed specificity of antibodies raised against desmosomal proteins. A number of his conclusions might be affected, for example, if gel electrophoretograms of desmosomal proteins separate classes of proteins with identical molecular weights. Polyclonal or monoclonal antibodies raised against these mixed antigens could be equally varied. Deductions concerning the qualitative and quantitative variation of desmosome fractions could be severely compromised.

There are four excellent chapters on gene activity and cells in development by Gurdon, Weatherall, Gardner, and Meinhardt. The latter two, especially, come to grips with the problem of gene products that must direct morphogenesis. These two articles illustrate also the fascinating difference in apparent rigidity of position effects in mice and *Drosophila.*

The book's final section—Cells and Disease—contains articles on DNA maintenance (Giannelli), oncogenes (Marshall), malignancy (Harris), and the molecular genetics of hemophilia (Brownlee). As Harris eloquently points out, malignancy refers to several phenomena that are, essentially, all morphological and morphogenetic. Therefore, one ruefully notes again the striking difference between the biochemical detail present in discussions of DNA repair or hemophilia, versus those in discussions of cellular invasion and metastases. It is possible, however, that oncogene research will be the most important route over the abyss that now separates genetics and biochemistry from morphogenesis. Marshall's chapter on oncogenes cogently describes current knowledge in this rapidly expanding field, and presents possible future research directions that could explain how cellular and viral genes act to transform cells. There can be no doubt that a clear picture of how genes cause invasiveness will be highly relevant as well to embryonic morphogenesis.

Developmental and cellular biologists should be indebted to the editors and authors of *Prospects in Cell Biology.* We should also look to the next twenty years with great anticipation.

SCIENCE AND SCIENTISTS: WHERE ARE WE GOING?

MALCOLM P. GRIFFIN
PETER D. TAYLOR
Department of Mathematics & Statistics, Queen's University, Kingston, Ontario, Canada K7L 3N6

SCIENCE AND BEYOND.
Edited by Steven Rose and Lisa Appignanesi. Published in association with The Institute of Contemporary Arts by Basil Blackwell, Oxford and New York. $24.95. viii + 211 p.; index. 1986.

We accepted without much hesitation the offer to review this book because it appeared to address issues with which we have recently become concerned, and we thought it might force us to come to grips with them. We found the issues disturb-

ingly elusive, but we were entertained through many hours of lunch-time jogging, discussing what scientists do, and what they might hope, even dare, to do at this crucial time in the history of our species. The book can be praised for having made us do that.

Science and Beyond is a series of essays exploring "themes of major conceptual controversy in science" which "raise matters of profound human concern" (p. 5). The book originated in lectures delivered by 14 leading scientists marking the twentieth anniversary of the Science Policy Foundation, a foundation set up to study science itself using the tools of sociology, economics and philosophy. The lectures were planned to encourage a pair of advocates of opposing positions to square off in debate over a major issue. Draft papers were circulated to those involved before the lectures. This two-sided debate is evident in the first half but not in the second half of the book and we would have appreciated an extension of it to the final chapters.

The essays are timely, well written, and worth reading for their individual insights. They are, broadly speaking, of two types: those which tackle a specific controversial issue within a discipline and those which attempt to make a broader sweep suggesting how science should be practiced. The essays of the first type usually succeed in their stated purpose, and leave the reader wiser, whereas those of the second type are more problematical: although they address issues of major concern they leave us dissatisfied.

Typical of the essays dealing with specific issues is the pair by John Maynard Smith and Brian Goodwin. The point at issue is that natural selection must take place within the context of certain possible laws of form. Do we concentrate on the history of selection or on the morphogenetic forms giving the matrix in which such selection must take place? The essays present two scholarly and well-written summaries by scientists well chosen to present two apparently opposing viewpoints.

A second pair of essays by Richard Dawkins and Patrick Bateson is less a debate than a dual review of some major issues in sociobiology and society's view of it. Dawkins, in his usual compelling style, defends sociobiology and the scientific method of reductionism (more of this later), and then dismisses effectively the non-issue of inevitable genetic determinism. He does not deny there are points of controversy with and within sociobiology, but insists that criticism is often misdirected. Bateson accepts Dawkins's view of sociobiology, but stresses that the competitive framework, in which Darwinism is generally viewed, obscures the important cooperative aspects of communities, which can in fact be engendered by the evolutionary process. Lichens, which are a symbiotic partnership of algae and fungi, provide a primitive and widespread example of such a cooperative community. Bateson argues that such cooperation extends to more complex organisms, and may be particularly important for human communities.

In a final section Bateson argues that the view of human communities that there is stability through strength, a view that has fueled and justified the recent arms race, is based on an impoverished competition model of human behavior. "Whatever the historical processes that favored warlike behavior in humans may have been, they did not look into the future. These processes operated in conditions which no longer apply" (p. 97).

The essays with a broader sweep seem to us more interesting, as much for their failures as their successes. The first pair, by James Watson and Stephen Rose, encapsulate two different views of how science functions in society. For James Watson science discovers "how the world works"– scientists are driven by curiosity about the unknown, and with the analysis of the human brain still before us there is plenty that is unknown. However, he sets the scientific endeavor in a context much wider than mere curiosity. We should "accept the situation that we alone, without any help from the heavens, must organize our futures to the best of our abilities" (p. 24). To allow for any other explanation than a scientific one for the phenomenon we observe is to surrender our freedom. "Our real problem is not [in] deciding on what forms of biology we stop or limit but . . . in acting rationally and compassionately on the basis of what we discover" (p. 25). Although he recognizes that these problems are difficult, on the whole, Watson is optimistic.

By contrast, Stephen Rose is much less happy with the relationship between science and society, and indeed the methodology of science itself. By calling our attention to the fact that in the UK and USA at least half the scientific research is funded by the military, he suggests that the view of the scientist as simply curious about how the world works is a little simplistic. He contrasts "the restless experimentation implied by the scientific method" (p. 27) as a way of knowing the universe with the "contemplative knowledge offered by alternative systems" (p. 27), and appeals for a less reductionistic and more holistic and human-centered science.

We share Rose's feeling of disquiet and believe that the issues he raises are important. We are disappointed at the book's failure to come to grips effectively with these issues, and to face, firstly, how profound the required changes are, and secondly, how such changes might be effected. We will say more about this shortly.

In another essay Alwyn Smith examines the contribution that science, as medicine and health service, has made to our level of health care over the

last century or so. Although there have been many improvements in our fight against disease, he claims that these are much less striking than is suggested by trends in mortality, concluding that "most of the changes occurred before any effective medical measures were available" (p. 142). He states that if health care were really a matter of concern, there are quite a number of seemingly simple things we could do to improve it: for example, "eating no more than is healthy, and distributing food according to need rather than profit" (p. 156). Smith is not overly optimistic about our ability to implement such solutions. We would have enjoyed reading a response to this interesting essay by some authority on community medicine holding a different viewpoint.

In the final two essays, Janet Sayers and Hilary Rose examine the place of women in science. They argue that there are two problems: first, that there are far too few women involved in science, and second, that the practice of science has been masculine and exploitative in nature. Their thesis is that a solution to the first problem has a good chance of bringing with it a solution to the second.

Sayers analyzes the evolving roles of men (involved in production) and women (involved in reproduction) during the last century and argues that science as we know it serves the former at the expense of the latter. She describes (p. 174, citing Jordanova) "a statue in the Paris medical faculty of a young woman, her breasts bare, her head slightly bowed beneath the veil she is taking off, which bears the inscription, 'Nature unveils herself before science.'" The image here is that the relationship of science to nature is one of laying bare, of exploitation, even of rape, and it is this attitude that is responsible for our current ills. A feminist science, being more socially oriented, would not be exploitive in this way.

Hilary Rose begins with a quotation from Virginia Woolf of which Sayers would approve, "It is obvious that the values of women differ from the values which have been made by the other sex . . . yet it is the masculine values which prevail" (p. 179), and proceeds to evaluate the present unequal treatment of women in science and to propose methods that would help give women "nothing less than half the labs."

Again, we would like to have seen an essay with an alternative viewpoint to that of these essays, not only to present another side, but to encourage Sayers and Rose to focus more closely on some of the issues we find confusing. For example, what constitutes "feminist science"? Is it less logical and more intuitive than traditional science? Is it less mechanistic and more statistical? Is it less physical and more social? Is it simply science done by women? Perhaps it is an attitude to science rather than science itself that is feminist. Possibly the expression "feminist science" is not a useful term to use at all.

We devote the remainder of this review to our response to the need for and the practice of a "new science" as it seems to be advocated by some of the authors. The general problems the book raises are important and perplexing, but they are also, as we have discovered, difficult to talk about; even our vocabulary seems to let us down. There would appear to be two reasons for seeking a new science, for attempting to go "beyond" science as it is currently practiced, one societal, the other epistemological. The societal motivation stems from the multitude of problems resulting from the application of technology, problems which threaten our health and perhaps even our survival as a species. It draws its strength from the impression that technological solutions appear to create more problems than they solve. The reason for going beyond our current science on the epistomological level is that there appear to be important phenomena in the world that the reductionist thinking of present-day science can hardly hope to penetrate.

These two reasons are closely related, of course, and when Steven Rose argues that there seems to be "a fundamental limit to the capacity of science, framed within the dominant paradigm in which most of us work, to give meaningful—let alone satisfying—answers to the great questions of human concern today" (p. 31), he has both these reasons in mind. But it is often important to distinguish them in order to face up to the question of just how profound are the changes sought. Are we to leave science altogether or, as several authors certainly suggest, remain scientists but inside a new paradigm? If so, how does this "new science" differ from the old? We are unable to extract from this book answers to these questions that we regard as satisfactory.

On the societal level, the concern is that the practice of science should be informed by a new and less impoverished view of human nature: less confrontational and more cooperative, less masculine and more feminine, less exploitive and more societal, less technological and more in sympathy with nature. The difficulties involved here are aptly illustrated by our earlier quote from Alwyn Smith. It seems to be simple to distribute food according to need rather than profit, but in political terms this is exceedingly difficult. The crucial time in the history of our species that we mention in the opening paragraph relates to our opportunities to turn around global pollution and nuclear armament in the near future. Many scientists have spoken both clearly and eloquently on these issues, and the coverage of popular science in magazines and on TV has ensured that this message is widely heard. The im-

pact of this knowledge on public policy, however, has appeared to be minimal. The longer the delay in changing public policy the more devastating become the problems we hand on to our children and grandchildren.

The essays suggest a number of routes by which such changes might be enabled. Steven Rose thinks that considerable progress would be made if all laboratories were organized to have community involvement in their direction and planning. This is an interesting idea, but we find the details perplexing and the potential pitfalls alarming. Janet Sayers and Hilary Rose believe that if "half the labs" are occupied by women, then the shift in priorities will follow. We agree that the changes in the role of women in science that they advocate are important and overdue and will probably have a salutary effect on the practice of science, but we don't believe that this will lead to a rapid change in the methodology of science. They also advocate changes in the curriculum: we must "open the syllabus towards a more human and social-centred approach . . . [which] means more than tacking a few obligatory culture lectures onto the slack parts of the week" (p. 194). We are in agreement with this, but suspect that much more radical curriculum changes are needed. If scientists are to be more adventurous in their choice of problems and methods of attack, they should be fostered in a much more imaginative curriculum than we currently give them, both at school and at university. The "new curriculum" must not simply provide new topics, even if they are human-centered. The necessary change is more in *style* than in content. Adventurous scientists should be encouraged to adventure in school. If scientists are to take seriously the consequences of their science they deserve to have been given some real choices in the classroom, and need to have been expected to live with their decisions.

On the epistomological level it is suggested that scientific knowledge is limited by our methodology. In considering the shortcomings of this methodology, the chief culprit mentioned is reductionism. Thus it seems to us that it would be helpful to contrast "new science" with reductionism. In its essence, as we understand it, reductionism seeks explanations in terms of underlying mechanisms, and tries to understand phenomena in terms of properties and interactions of building blocks at the lowest possible level. This seems to be a reasonable way to do science, and it has certainly proved powerful. Can we imagine alternative methods?

Here is an example which might help. A reductionist approach to the problem of cancer would look at the level of the cell or lower. It would not be likely to suggest meditation (visualizing the death of cancer cells) as a method of cure. [The announcement from the Sixth International Congress on Immunology that significant immunological reactions appear to accompany such meditation hit the press while we were writing this review.] Of course, once statistical evidence was obtained indicating success for a given method, reductionism could be employed as a tool to study possible mechanisms, and indeed it is the tool we as scientists would naturally use. But a science that, at the outset, would suggest the use of a meditative technique might qualify to be called a "new science."

It seems to us that the real problem with reductionism does not lie as much in the restrictions it places on methodology as in the way it restricts our readiness to study certain phenomena. We are unwilling to invest time and energy in the study of meditation largely because we have difficulty imagining appropriate mechanisms. We tackle the problems fitting easily into the "reductionist framework" and ignore those outside. We would like to see science making bolder and more adventurous choices of areas for study. At the beginning we will use our familiar reductionist methods in these new situations. We may find they are adequate. To the extent that they fail us, we will presumably be guided towards other methods that serve us better.