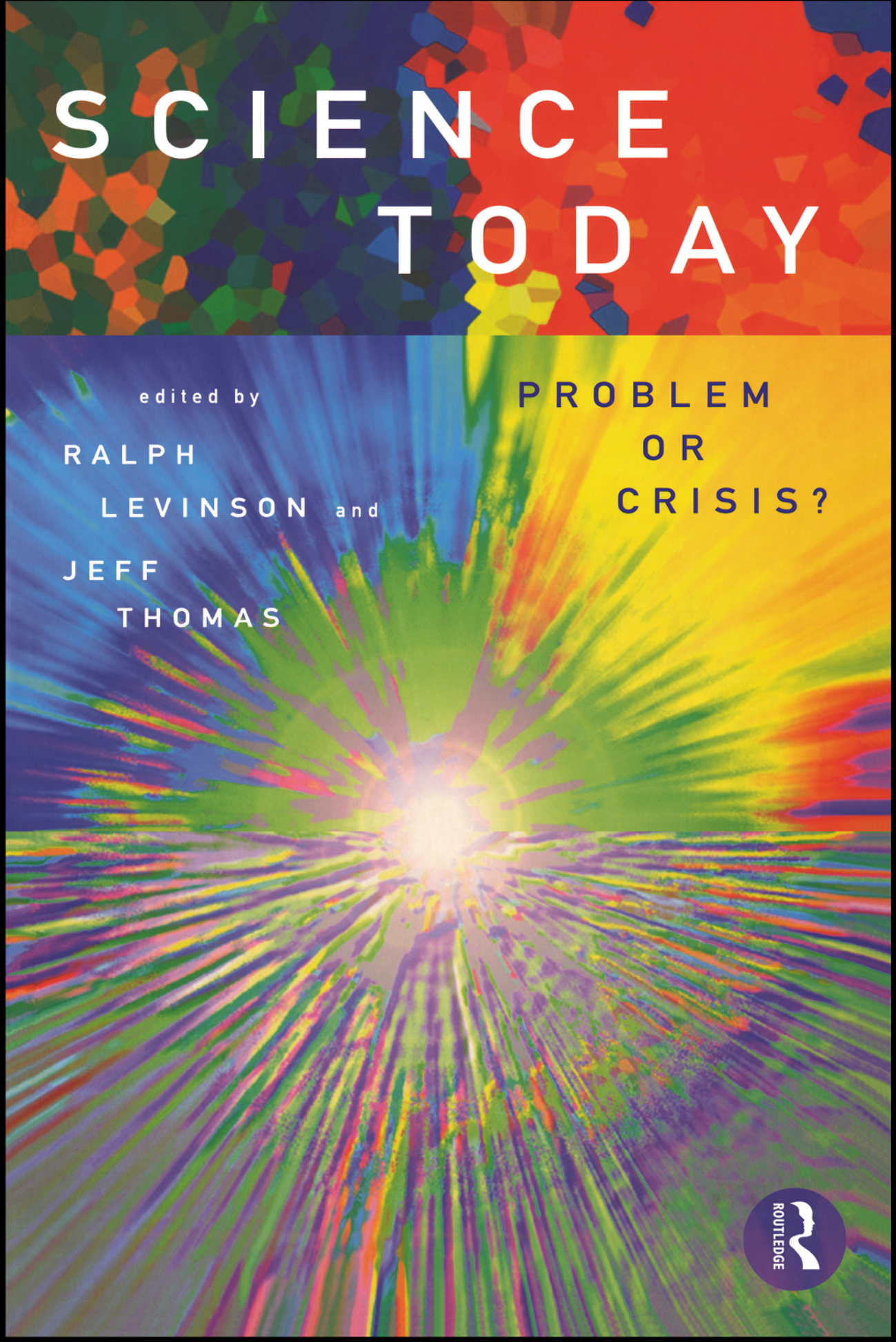

SCIENCE TODAY

In this comprehensive text, key figures in the fields of science and science education critically discuss the role of science in public policy, in the school and in broader public education. Their contributions form an original dialogue on science education and the general public awareness of science, tackling both formal and informal aspects of science learning.

Engaging with the socially contentious areas of this core curriculum subject, as well as the dichotomy between 'science for all' and 'training professional scientists', the authors of these articles uncover the prejudices which haunt the traditional view of science. They offer a range of detailed solutions. The editors argue that a better future for science must involve an open debate on its public role, and this can only happen by breaking down the barriers that divide scientists, schools and the public.

SCIENCE TODAY

Problem or crisis?

Edited by

Ralph Levinson and
Jeff Thomas
with a foreword by
JOHN DURANT

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FOREWORD

A century ago it would have been inconceivable to publish a book called *Science Today: Problem or Crisis*?. A the end of the nineteenth century, the newly industrialized world regarded science as an unalloyed blessing. If people perceived problems or crises, these were mostly to do with the scarcity of science. By 1950, science had moved to centre-stage industrially, economically, and socially; and for a brief period, it really seemed as if scientifically speaking almost anything was possible. Before long, however, new sorts of problems—problems not of scarcity, but of abundance— began to emerge. In the 'ban-the-bomb' movement of the late fifties and sixties, the student movement of the late sixties and seventies and the environmental movement of the seventies and eighties critical voices were raised about the place of science in the wider society; and today, after a century of extraordinary scientific progress, it is paradoxically true to say that science itself has become problematic.

Science Today addresses some of the key issues that we face at the end of the twentieth century as we confront both the obvious power and the obvious limitations of science. Many of these issues lie at the interface between science and the public, and they have to do not merely with the technical but also with the philosophical, moral, social and political import of scientific research. The movement for the public understanding of science has taken up the cause of closing the gap between scientists and so-called lay people; and in doing so, it has challenged teachers and educationalists to reassess the role of science education in relation to wider cultural concerns about science and technology. There are no easy answers here, and readers of this book will find no pat solutions. Rather, they will enounter contrasting and even conflicting interpretations of the way in which science should be dealt with in the processes of formal and informal education. If, as one of the authors suggests, we are living through a series of 'science wars', then *Science Today* is an informative and frequently provocative guide to some of the key areas of conflict. By avoiding some of the more arcane academic disputes and concentrating instead on the practical arena of teaching and learning, it offers some hope of a way forward in our understanding of the proper place of science in our culture.

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SCIENCE, PEOPLE AND SCHOOLS
An intrinsic conflict?

Ralph Levinson and Jeff Thomas

> I know all about elements, compounds and mixtures and that atoms have little circles and dots and how to use a Bunsen burner but I don't know what that has to do with anything.
>
> (15-year-old schoolgirl)

One of the major purposes of education, wrote the great critic, Raymond Williams (1961), is 'that of training the members of a group to the "social character"…by which the group lives'. At a general level, being socialized is an involvement in the problems and struggles of one's fellow human beings. If this is true of schools then, at the very least, school science should be preparing students for the scientific issues that occur in their lives. Few students at school today would recognize the science curriculum as preparing them to make decisions about such things as local sources of pollution or the ethical questions raised by modern genetics. A formal education in science leaves a small proportion of students with a sense of wonder and a wish to pursue the academic subject further in higher education. Others use it as a route to a variety of careers such as medicine, engineering and hairdressing. But the majority, like the school-girl and her atoms, are left with faint memories of meaningless symbols.

There are numerous critiques of the school science curriculum and, since the mid-1980s, of the expanding area of the public understanding of science, but there has been little discussion about the interrelationship between the curriculum and public understanding. It is this relationship between the formal science curriculum and people's lives—learning science as a socializing experience—that is at the core of this book.

Our aim is to ask new questions about science for all, for 5-year-olds and 75-year-olds. We all, however, face a dilemma because it is no easy matter to bridge the gap between formal science learning and our actions as social beings in a rapidly changing and uncertain world. Indeed, as we shall see in the book, it is a thoroughly complex and deeply political task to construct a formal curriculum that can address the small and large scientific questions of our lives. This book is directed at people with an interest in the role of education in general, as well as educators and practitioners within the world of science.

Here we describe some of the themes and ideas of the collection of original contributions in the book. Our belief is that a concern about science education raises very broad issues that take the reader far beyond the details of the school curriculum. We consider some of these ideas in what follows, touching on the common elements that run through the different parts of the book; each part also includes a brief introduction to guide the reader.

The Royal Society report (Bodmer 1985) recognized the potential of science education to influence public understanding. 'Public understanding of science has as its base the teaching of science in schools' (Section 1.2). It went on to give its rationale: 'better public understanding of science can be a major element in promoting national prosperity, in raising the quality of public and private decision-making and in enriching the life of the individual' (2.1). As Peter Fensham points out in Chapter 9, better public understanding of science—science for all—has been the aim of a number of countries. While this aim has been expressed through their science curricula, Fensham explains why it has not been realized so far. He goes on, however, to identify some promising leads. In a far-ranging discussion Edgar Jenkins (Chapter 10) teases out the issues and raises the question: 'What is science education for?' His analysis critically examines the prevalent notions of science in education as objective and unproblematic against reworking knowledge—knowledge-in-action—in the contexts of people's lives.

It is worth comparing Jenkins' analysis of knowledge-in-action with an article in the journal *Science and Public Affairs,* where Professor John Postgate (1995) proposes the view of science as a 'cultural experience'. Postgate argues that the sensational presentation of science in the media has not helped people to understand what science is really about—a way of thinking which 'enhances lives, and awareness, and even morality'. The media, according to Postgate, underestimate the viewer's intelligence and natural curiosity. There is nothing exceptionable in what Postgate is advocating but he perceives the understanding of science as a top-down approach—enlightenment delivered from the cognoscenti to the untutored, albeit an intelligent and curious untutored. He says:

> We have to face up to it that, in Britain…two generations have emerged into adulthood with little or no exposure to science In consequence the scientifically ignorant component of British society comprises not just the 'broad masses', to slip into old-fashioned politico-speak; it also includes the great majority of writers, journalists, broadcasters, clerics, politicians and administrators; even academics and teachers from the humanities. It encompasses the great majority of the people who make decisions, who educate children, who set trends and influence opinion. They have little idea of what science is or how it works; indeed most have little serious wish to know: the gulf between C.P.Snow's two cultures has never been wider. The long term solution, of course, is to educate the next generation to at least a minimum knowledge of science. This means educating the educators, too, as the planners of the National Curriculum have discovered. At least that task is in hand, and even elementary knowledge will bring about greater understanding of science and less fear of it. But in the shorter term we have to deal with this huge mass of adult ignoramuses who run our society. How? They are not fools, there is simply a gap in their knowledge. I see no way of bringing a clearer understanding of science to our sadly undereducated public than to present science as a cultural experience.
>
> (Postgate 1995)

Within his provocative analysis Postgate draws a vivid picture of the relationship of science and the scientist to society, the knowledge gap, the role of the media, and ideas of science as culture—themes which are reflected and contrasted in very different ways through the essays in this book.

Science as a cultural tool is the subject of Joan Solomon's Chapter 11. The 'culture' is not that of high science but relates to what is significant in people's lives. In the context of this chapter, looking at the differing notions of scientific culture across Europe, Solomon brings out her own significant pointers towards a more all-inclusive science education. Jeff Thomas (Chapter 12) challenges the meaning of the knowledge deficit model illustrated by the Postgate school of thought. But will greater understanding of science encourage a more positive response towards science as the Royal Society report hoped? Thomas questions what is meant by greater understanding. He provides evidence that becoming more informed about certain scientific issues does not necessarily bring about more positive attitudes; it is just as likely to go hand in hand with a more definite holding of pre-existing views.

What all these contributors do—Fensham, Jenkins, Solomon and Thomas—is to reformulate the problem, to question the old chestnut of delivering science to an ignorant and undifferentiated public. As a result their analysis is fresh, though the solutions they propose are challenging.

So what kind of education would enable these solutions to come about? Tam Dalyell (Chapter 5), who has pursued government policy-makers with scientific questions for many years, warns against expecting anybody other than experts to make decisions about technically complex matters. Given that the issues of the future may not even be anticipated and will involve complex science, Robin Millar addresses this intellectual conun drum in Chapter 7. He formulates ideas for students to gain active insight into technically difficult problems and to understand the issues raised by the media. In a similar vein in Chapter 6, Guy Claxton looks towards the year 2020—when all the young people today have learned science at school —and argues for appropriate attitudes and experiences in science. His conclusions unsettle the status quo but his logic is compelling.

Some scientists and educators advocate the teaching of science as a politically neutral act. Biotechnology, a development of the late twentieth century with huge research and development input, has strong connections with the science of genetics. Les Levidow points out in Chapter 8 that teaching about contemporary technologies can fall into the trap of supporting politically expedient and commercially profitable solutions in the guise of the public good. A reductionist approach to science, argues Levidow, makes genuine democratic participation difficult because it conceals the values that underlie the problems to be solved.

In contrast, Lewis Wolpert (Chapter 1) makes no apologies for separating the practice of science from the morality of its application. A distinguished scientist and an outstanding communicator, Wolpert applauds the explanatory power of science. 'Science', he writes in his opening sentence, 'is the best way to understand the world'. He elucidates what holds all scientific thinking together and is cautious about how much the lay public can be expected to understand. Chapters 2, 3 and 4 pick up a number of points from Wolpert's opening salvo, including his arguments about the neutrality of science and its unique nature. If it is desirable for the public to understand more about science then we need to understand a little about what science is, and this is the purpose of the first part of the book. Henry Bauer, Mary Midgley and Hilary Rose each discuss the multifaceted nature of science. There are a variety of types of science nestling under the label Science, argues Bauer. He describes the very different practices that take place in the disciplines of science. Explaining how science is held together by the diverse roles of its practitioners, he outlines what everyone should know about the way science works.

Mary Midgley explains how contemporary science came to be characterized by a particular philosophical approach whereas it is a confluence of many intellectual streams. She persuasively argues, on the one hand, against placing science on a level above all else and, on the other, against those, such as Bryan Appleyard, who warn of science as threatening our sense of place in the world.

Science has had an ambivalent press in the latter half of the twentieth century: Frankenstein and Einstein merge and separate, separate and merge. Not surprisingly the scientific community has responded defensively Within academe, the relationship between scientists and sociologists of science has at best been uneasy and, at worst, tempestuous. Hilary Rose contends that this polarization—those who see science as discovering the reality of nature against the relativism of those who dispute the unique status of science's claims, who may even perceive science as a kind of myth—is unproductive. She occupies distinct ground and looks for new alliances, less confrontational ways of thinking, within and without the scientific community.

So far, the contributions straddle the interface between the formal education system and the way people come to terms with science in our modern society dominated by technology and change. It is vital to explore this relationship. But people learn about science from many informal sources such as newspapers, books, radio, television, idle and purposive talk, museums and science centres. These do, after all, provide the background for the scientific issues that influence us. It is the media where we learn about the global questions such as acid rain, the problems of deforestation, the dwindling ozone layer, cures for ravaging diseases, the unknown effects of synthetic chemicals in the food chain and the perceived threat of biotechnology Graham Farmelo (Chapter 13) provides a critical overview of these informal sources. Scientists are more and more active with their message and Sue Pringle (Chapter 15) reports on the scientists' responses when engaging with the public. Finally, one arena where science arouses huge interest and excitement is a relatively recent phenomenon— the exploratory Richard Gregory (Chapter 14), the originator of the Bristol Exploratory and the moving force behind exploratories in Britain, describes their rationale and critically assesses how they can complement the formal role of schools.

The contributors present their ideas from different perspectives and occasionally take opposed views. Our stance is not to attack science or science education but to ask hard questions about something that is so important. The thinking in the book must withstand critical debate. The aim of the book is not consensus, rather it is an attempt to find a framework to solve new problems. We would like to thank the contributors for addressing the questions so energetically. The debate they stimulated should be seen in the context of science as a 'fascinating endeavour, capable of engaging men and women at their best, and enlarging, and enriching the human spirit with its discoveries' (Ziman 1984).

Part I

VIEWS AND CONFLICTS

INTRODUCTION

The first four contributions consist of diverse opinions about key aspects of science.

Lewis Wolpert describes what he sees as the defining features of science, but avoids a definition of its true nature. He points out that there are a variety of ways in which science is pursued but science knowledge has to be consistent across discipline boundaries.

Henry Bauer urges us to recognize the complexity of science. He argues that the different disciplines within science are of deep, tribal significance and culturally determined. Their existence means that generalizations are fraught with difficulty; there are limitless opportunities for confusion and alarm. What is so difficult to define has become such a rich area for dispute.

Mary Midgley and Hilary Rose both expand on the prevalent conflicts within and around science. From a philosophical perspective Mary Midgley notes diverse influences to which science has historically been subject. This provides a basis for her refutation of those who attempt to demonize science as a damaging monolithic force. As a feminist, Hilary Rose examines the conflict between sociologists and scientists, highlighting the sterility of the old arguments. She proposes new alliances for a more socially responsible concept of science.

These chapters pinpoint the contemporary meaning of science in ways that allow the educational implications to be considered later in the book.

1
IN PRAISE OF SCIENCE

Lewis Wolpert

Science is the best way to understand the world. By understand, I mean gain insight into the way all nature works in a causal and mechanistic sense. Science is the only way to understand motions in the heavens, the tides, the movement of terrestrial bodies, the chemical constituents of matter and the nature and evolution of living organisms. There is no other way to understand such objects and processes. That we remain ignorant about many aspects of human behaviour is not a failure of science but a reflection of human complexity. What science cannot do, as Tolstoy pointed out, is to tell us how to live, what is good or bad. It has nothing to contribute to moral and ethical issues; these can, however, arise in relation to the application of scientific ideas. In principle, if we understood more about how society works, it could help us design a just society once we made clear the ethical and moral principles that we want.

But what do I mean by science? I cannot be trapped or forced into a definition any more than I would be willing to define 'life'. Indeed science is in some sense as complex as 'life'. But it is not at all difficult to give some of its characteristics. It attempts to explain natural phenomena in terms of the underlying causes in as economical way as possible—preferably using mathematics. The ideas have to be self-consistent and correspond with reality. They must be tested. It is nice, but not essential, if the theories make predictions—but sciences with a large historical content like geology and evolutionary theory do extremely well. The self-consistency also implies that one branch of science must be consistent with all the others; biological theories cannot contradict chemistry.

In claiming, as I will, that science is a special form of knowledge, I fully realize that scholarly pursuits in the humanities, like history, resemble science, but the differences lie both in the subject matter and the techniques. Not only is history overwhelmingly more complicated, but also it is not subject to experimentation nor can it be easily linked to other sciences like psychology. Also unlike the humanities, ideas in science are value-free. Archimedes' law of floating bodies is simply true. A surprising aspect of science is that almost every important idea can be expressed in fewer than thirty words; how unlike the arts!

This all seems so simple and straightforward, yet attitudes towards science show both ambivalence and polarization. While there is much interest and admiration for science, there is also some fear and hostility. Science is perceived as materialist and dehumanizing, arrogant and dangerous. Reductionism is suspect and uncomfortable, sabotaging all the mystery and wonder of life. This was a theme taken up by D.H.Lawrence in the early twentieth century:

> The Universe is dead for us, and how is it to come alive again? 'Knowledge' has killed the sun, making it a ball of gas with spots; 'knowledge' has killed the moon—it is a dead little earth fretted with extinct craters as with smallpox…. The world of reason and science …this is the dry and sterile world the abstracted mind inhabits.

Others see its practitioners as a band of cold, competitive and unfeeling technicians wielding power without responsibility. The threats of nuclear war and the genetic manipulation of embryos loom large. Science is also blamed for polluting the environment. On the other hand there is hope, even expectation, that science can provide the solution to our many problems: the cure for cancer and other illnesses, cheap and environmentally friendly nuclear power. There also is considerable enthusiasm for popular science books and programmes which reveal the mysteries of the origin and workings of the universe —including the origins of human beings like ourselves. Science is intellectually exciting.

MISCONCEPTIONS AND COMMON SENSE

There are numerous misconceptions about science that range from thinking that there is some unique scientific method to conflating it with technology; misconceptions which include the idea that it is mainly about the accumulation of facts, uncreative, yet highly competitive. There is even a school of sociologists of science that argue that science is little more than another set of socially constructed myths with no particular validity. For example, in their book *The Golem,* Collins and Pinch (1993) state that scientific disputes are not settled by further experiments but by social negotiations. Collins has even written that the real world has played little role in the development of scientific ideas. These relativists wish to deny the superiority of