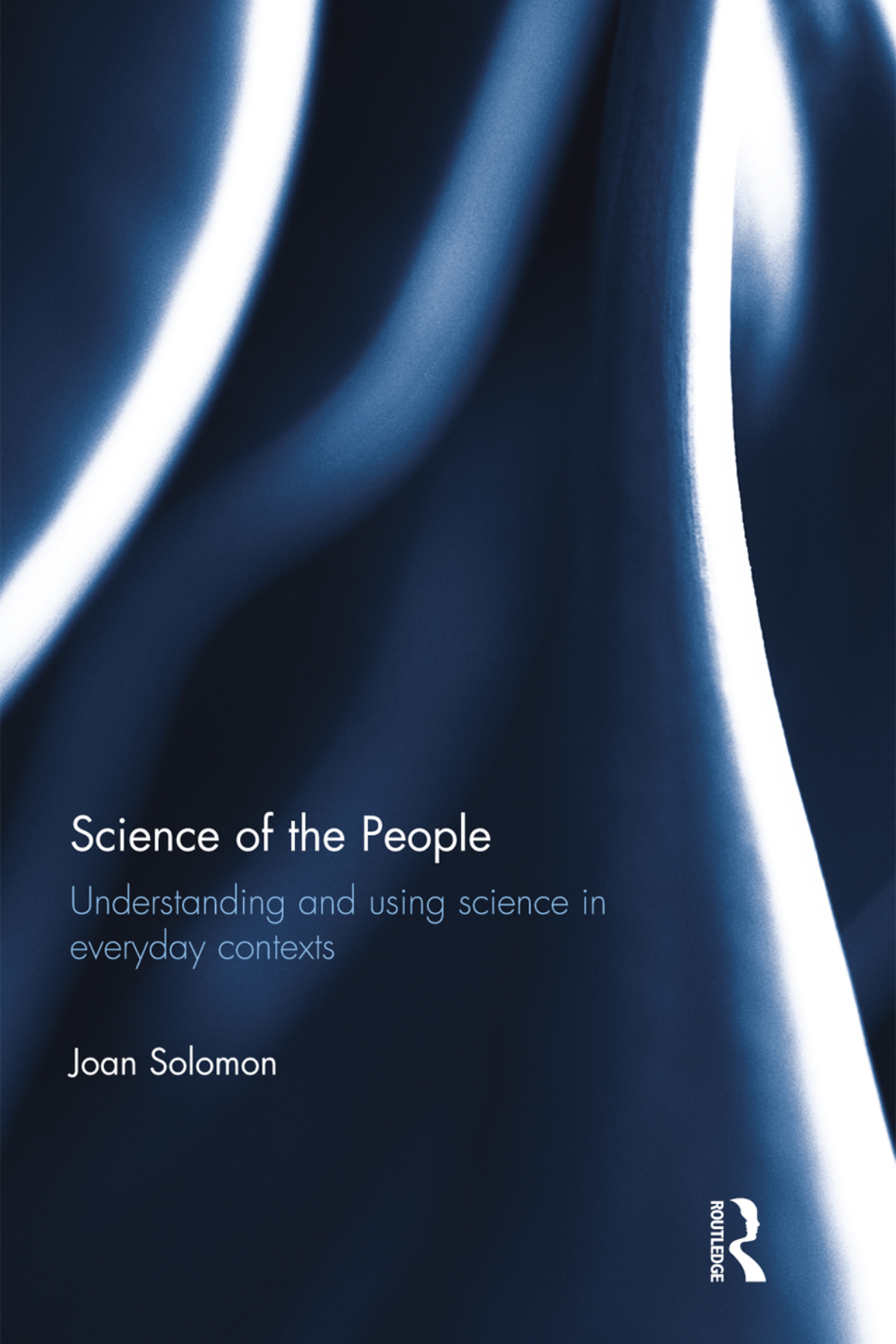
Science of the People
Understanding and using science in everyday contexts
Joan Solomon
ROUTLEDGE

Science of the People

How do people understand science? How do they feel about science, how do they relate to it, what do they hope from it and what do they fear about it? *Science of the People: Understanding and using science in everyday contexts* helps answer these questions as the result of painstaking interviewing by Professor Joan Solomon of all and sundry in a fairly typical small town. The result is a unique overview of how a very wide range of adults, united only by local geography, relate to science. Many of the findings run contrary to what is widely believed about how science is learnt and about how people view it. Chapters include:

- Publics for science?
- Scientific literacy
- Ethics and action
- Interpretation and change.

Joan Solomon, who sadly died before this book could be published, enjoyed an international reputation in science education. After a long career teaching science in secondary schools she moved into the university sector and ended up holding chairs of science education at the Open University, King's College London and the University of Plymouth. She was a world leader in her subject and inspired classroom teachers and wrote a number of very influential papers with some of them. She produced many important books, booklets and other resources to help science teachers and educators get to grips with the history and philosophy of science and the teaching of energy, amongst other topics.

This book is essential reading for those involved in science education and educational policy.

Joan Solomon was Professor at the Open University, King's College London and the University of Plymouth.

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Routledge
Taylor & Francis Group
LONDON AND NEW YORK

First published 2013
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Simultaneously published in the USA and Canada
by Routledge
711 Third Avenue, New York, NY 10017

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
Solomon, Joan, 1932–
Science of the people : understanding and using science in everyday contexts / Joan Solomon.
pages cm
1. Science--Social aspects. 2. Science--Philosophy.
3. Empiricism. 4. Science--Study and teaching--Public opinion. I. Title.
Q175.5.S6755 2013 500--dc23
2012024225

ISBN: 978–0–415–64478–5 (hbk)
ISBN: 978–0–203–07918–8 (ebk)

Typeset in Galliard
by Bookcraft Ltd, Stroud, Gloucestershire

As Joan Solomon's daughter I wanted to get this book published after my mother died. I owe an enormous debt of gratitude to Michael Reiss, Professor of Science Education at the Institute of Education, London, who edited this book, declining any payment for so doing, who lent his advice and help at every turn and without whom it would not have been published.

Bess Solomon

Contents

Preface

People making science

This book is about demotic science, that is, the science 'of the people', in somewhat the same way as democracy is about being ruled 'by the people': but there are substantial differences. People often define democracy simply and memorably as 'one person – one vote'. That is based on a profound sense of the equality of individuals: but it is easy to see that there may well be a great difference when it comes to people's scientific knowledge which cannot be defined by any voting mechanism. The demotic science of people is that science that they believe they know, and use in discussion. It is not defined by books. So I shall not even comment on whether or not it is 'correct' knowledge. At worst it may strike us as eccentric but then we might find ourselves saying 'Oh yes, but how very like her/him to say that!' So although demotic science varies from one person to another it will be a kind of knowledge that friends might recognise as being both about science and likely to be appealing to you, whom they know so well. If this recognition is as important as it sounds from this introduction, then demotic science may have some rather curious connections with such people's personal dispositions. They may be 'wearing' it in conversation as we might wear a jersey or a flower in the lapel when walking down the road. It was this kind of demotic science that I set out to investigate in the study for this book.

We should not expect changeable demotic knowledge to be simply the result of formal scientific education, providing us with knowledge which varies from excellent to downright nonsense. It may have been formal at first if it was taught that way at school or college, but afterwards what it leaves in our brains is only pieces of synaptic trails, traces of half-remembered bits of learning. This may, on the one hand, become hopelessly faint unless directly awoken by new ideas which link easily with pieces remembered from earlier times, or it may grow and change more smoothly, reflecting our underlying interests during the better part of our whole adult lifetime.

There are interesting ways in which demotic science and democracy already seem to be coming closer together. Modern democratic countries are far too large for each citizen to take a deep interest in every aspect of government as they might possibly have done in the ancient Greek city states. But at least each person gets the same one-shot vote in every election or referendum. Would the

same sort of finality be reached in conversation? One of the trickiest parts of this concerns the way new fragments of demotic science may become needed to cope with new situations. Their talk and their reactions may reflect somewhat frightening demands for new skills at work and they may be frightened by the need for new learning. It is easy to name some of these areas of positive interest – care for the environment would be one, medical advances might well be another. Either of these two may be newsworthy enough to support people as they go through the learning needed to support a personal interest in these two areas. Will people be keen or reluctant to search for new qualifications? Will the remnants of old knowledge in the mind conflict with the new, or can both be made more attractive in terms of different people's characters and dispositions?

If all goes well, the new knowledge links up with the old and gets built into a total network which may be called 'the civil society'. This is a new kind of democracy – one in which single-interest groups, including those associated with science of one kind or another, play an important part. When a country's groups come together the result is a movement of stunning power as we have seen in the Velvet or Orange revolutions in central and eastern Europe. Ernest Gellner (1994) wrote about civil society in this way:

> Civil Society is that set of diverse non-governmental institutions which is strong enough to counterbalance the state and, while not preventing it from fulfilling its role of keeper of the peace and arbitrator between major interests, which can nevertheless prevent it from dominating and atomising the rest of society.
>
> (Gellner 1994: 5)

The social anthropologist, Alan MacFarlane, saw this dangerous fragmentation as the result of a kind of 'rootlessness' which is specifically English, making us short on the construction of strong natural communities. Instead, he writes, we have only 'partial communities – groups of friends, co-workers, and neighbours' (MacFarlane 2005: 213), but possibly to a greater extent than most other nations. This capacity to make informal interest groupings is very useful and we shall see, in almost every page of this book, that it can indeed be used for the investigation of demotic science. These groups of people may be seen forming the usual companions in the pub, in the school playground, when mothers collect their children after school, in the office where adults work, and almost anywhere in the immediate neighbourhood. Then there are groups which are connected with the environment – such as Friends of the Earth or Greenpeace – and there are increasing numbers of others which have such direct connections with science. All opportunities for relaxed discussion help us develop yet more of this strange slippery material – demotic knowledge.

So the people in our cities, towns and villages could be expected to have variable amounts of uncertain scientific knowledge due in part to having reached rather different levels of formal education when younger, and also to having added different amounts of further knowledge during their adult lives. How did they do that? Studies of the knowledge of science, which people could summon

up in a spot test (for example, Durrant *et al.* 1992) showed very uncertain achievement scores, but always positive correlations between people's highest levels of achievement in their own formal science education and their scores when adult. That was not surprising: let's assume that the clever ones learn more, and more quickly. But to find that unknowledgeable adults were somehow learning science without any external help does sound a little odd. A more detailed exploration of these results might find what might have been called the 'advancement of learning' (Francis Bacon 1605). Is that due to a process of chatting about science which had been 'on the news'? We may well have had some questions to ask about how the learning came about, and its value.

Risk and politics

Several different kinds of public knowledge about science, some very close to demotic science, exist. In the days when scientific education was rarer than it is today there was general encouragement to become more learned, and more qualified, in science. At times, especially in the nineteenth century, the incentive was simple enjoyment (see Chapter 4). Then, in the following century, we find the first economic and political justification for more public learning of science. As the world moved towards a nuclear age with understanding of radiation in both war and peace becoming more urgent, public anxiety increased manifoldly. Voices emerged in the universities arguing for teaching the public about science so that they could better understand 'scientific risk'. One of the leaders in this way of thinking, in the aftermath of the Second World War, was Bill Williams of Leeds University who, with his friends, hired a railway carriage, furnished it with educational pamphlets on the likely outcomes of radiation from nuclear fission and had it taken, on procession as it were, across several of the towns in central England where lectures were given.

Ulrich Beck's *The Risk Society* (1984) was probably responsible for spreading this educational approach to science across most of the democratic countries of western Europe. In Britain the movement was called SISCON (Science In a Social CONtext) and later Science, Technology, and Society (STS). Like many educational projects, it spread downwards from the universities (cf. Williams above) to the schools (Lewis 1981; Solomon 1982). Once the link had been made between public risk (considered as weak emotional rhetoric) and scientific knowledge (better understanding of governmental reassurances!), a new reason for increasing the public understanding of science emerged. This was no simple effort to spread demotic science. Rather it was, by its own admission, a barefaced effort to recruit and monitor public backing for the government's spending of more money from general taxation to support scientific research. The Cold War between the USSR and 'the West' was fought out from a bastion manned (with full gender implications) by politicians and scientists who rarely understood each other.

The risks to which the public may have been exposed did seem to have multiplied, but science as an optional subject for study in the schools and universities continued to diminish sharply from the 1960s to the present day. As Sturgis and

Allum (2004) wrote in their general review of movements for *Science and Society*, the general 'climate of skepticism' about the desirability of scientific progress was still widely blamed on the public's lack of knowledge about science. This became known, widely and somewhat carelessly, as the 'deficit model' of people's understanding of science:

> The public's doubts about the value of scientific progress or fears about new or unfamiliar innovations, such as genetically modified organisms or microwave ovens, are due to the ignorance of the science behind them. Lacking a proper understanding of the relevant facts, people fall back on mystical beliefs and irrational fears of the unknown. If one accepts this hypothesis, the obvious implication for science policy is that public information campaigns should be instigated to remedy the public's disenchantment with science.
>
> (Sturgis and Allum 2004: 57)

Science into politics

But could such top-down information campaigns really 're-enchant' the public? It did not seem likely. In Chapter 1 this is explored further using the metaphor of learning to play tennis. But the attitude towards people who do not know enough orthodox science to satisfy the scientists is still thought to be the root problem of all public disagreements. Other more brutal metaphors like 'lancing the boil of public anxiety' are still used in this generally cavalier approach to those who do not understand risk (Chapter 10) by those who think they do. It has been argued that two different and crucial factors are missing in this understanding of risk. These concern, respectively, the nature of science and the nature of democratic politics. Both of these, if they exist at all in such a decontextual sense, are the most arcane and difficult aspects of knowledge. They are thought by some (such as Hempel) to be able to lift any discourse about science and politics to a much higher plane whose other inhabitants – mathematics, theology, logic, and so on – are also described in abstract and symbolic ways. (Dean Swift lampooned Newton, and science generally, for this very fault in the fourth of *Gulliver's Travels*.)

Back now to our quasi-historical account. When the wholesale testing of adults and schoolchildren during the 1990s showed how little correct science they knew (Durant *et al.* 1992; Harvard 1996) the whole situation became a scandal. No longer did the schools and universities feel that they should respond helpfully in the cause for citizen understanding, as in the case of 'science shops' staffed by graduates on the university campus (Yearley 1995). Profoundly weakened by reduced funding in the universities, and public criticism of teaching in the schools, few if any attempted to offer STS courses which might have encouraged opportunities to criticise and influence new science programmes in the media. Interest in demotic science where people discussed, constructively as well as destructively, what they thought about topics adjacent to science, became very muted.

Starting the research

In 2000 when research on which this book was based first became an object of local discussion within the Open University, I anticipated that the people of 'Market Town' (the name given to the place where the fieldwork was undertaken) would be bound to have different interests and so have collected different but relevant pieces of scientific knowledge. I thought that they might make and remake their construction of science by wondering about it, talking about it or being scandalised by it, but always giving precedence to the science that was of value to their own interests. The problem, as I saw it then, was that the resulting science might not be a single edifice these people had built for themselves. Fragments do not build an edifice and untaught ideas lack authority, so they are likely to be of changeable nature and size. Researchers who have studied what they called 'the public understanding of science' or 'scientific literacy' seemed only to be thinking about the emergence of a unitary edifice of correct science to be found like gold in the bottom of a crucible under a crust of crude misconceptions which were hiding it from the world. A fluid protean body of knowledge would be even less likely to form a sturdy edifice. So it must be wrong to think of a demotic science as if it was likely to be the same from one person to another. No edifice depending only on spoken thought can go on existing in a state of perfection like the smile on an archaic sculpture. Unless written down, which demotic science rarely is, it will keep on changing, from one issue to another and from one day to the next.

Our formal science or natural philosophy is the result of centuries of intellectual combat with the forces of curiosity. However, science in any market town is bound to be, at the same time, both unfinished and also unfinishable. It is always being formed and reformed during each and every conversation that the citizens of this little town – hardly bigger in its population than a very large village but town-like in its layout – have with one another.

Market Town is a real place, its inhabitants are ordinary people, and yet now that I know some of them, they have become quite distinct each one from the other. Their everyday muddling together of snippets from school science, breakfast-table science and controversial political science, remakes it into something more creatively personal and lively – ever changing, faster and faster. 'Too fast', as the older people often complain. Sometimes those who are experts in their own eyes are sure that they know about 'real science', and admit to shouting at the morning radio and quarrelling with the news-reader – 'You've got it wrong again!'. Others just marvel passively at television images of beautiful wildlife or mineral changes of state, in fast or slow motion, all of which confront them with the mortal danger that our ways of living are bringing to all life forms, including us.

Undoubtedly there is a lot of science around us, but is it much more than there has ever been before? There is more in our lives that we might now attribute to science than there was before. Once science was rare, esoteric and easily recognised although rarely understood, the possession of which separated the few who knew it from the many who did not. But nowadays everything we touch or do, from gardening to cooking, athletics to babycare has also been touched by

science. The question is not so much how much science we know, as how much of what we know and prize we can recognise as part of a debt we owe to science, gratefully or not.

Through stories and by other means

So the two of us went out into the town in different seasons of the year, and talked with people who had, of course, different interests, different work and different hobbies. They were asked about what interests they had in science. If we were right in believing that the growth and spread of science is in the hands or mouths of 'unscientific' people living ordinary lives (as some might see them), then they would be able to understand our questions, answer them, and go on to talk about their very favourite topic which was, of course, the sort of people they thought themselves to be. The sort of growth and change which remodels science in people's thought and emotions is bound to be both social and inter-subjective, as John Ziman (2000) wrote. It will depend upon the close presence of others who live out their lives next to us, crowded almost elbow to elbow. It would be bound to have affected many aspects of their social life in what Charlie Chaplin, a full century ago, had already called our *Modern Times*.

Before the interviewing began, while we were still talking in the grounds of the local branch of the Open University about how to carry out the project, we had thought that the main problem might be the reticence of people. Would they talk openly to us about their thoughts on science, a subject about which they believed themselves to be largely ignorant? Consider it from their point of view. If, as we sometimes believe, the main aim of conversation is to see ourselves in a better light, making new friends or maintaining old ones, then our interviewing process would have nothing at all to offer them once the last question had been asked. On the contrary, it might be expected to bring only embarrassment at their own ignorance, and the experience of yet another researcher putting them at the sharp end of the interview, and leaving just as soon as they got to the end of the last question on the schedule. But what that left out was the intimate relationship that always exists when we tell stories to others, and also to ourselves. This is a subject that literary critics, psychologists and sociologists have all written about, from E. M. Forster to Mikhail Bakhtin. The most consensual and surprising view of this is that the telling of the story, even if it is not responded to, quickly turns into a dialogue, because the other person is implicitly entering into it by listening and then asking more questions. Dialogues become self-maintaining. The interviewer will listen with apparent interest to almost any story, and the responses given ask for yet more stories, rather like the nursery call to 'Tell me another!'

People, interests and problems

This book is certainly not a moral text. It does not preach that understanding science is either especially worthy in its own right or even especially good for you. It is also possible to see this book as casting doubt on the economists' view

that our country's wealth and health depend upon a rigorous science education. Surely rigour is at the very heart of science? Isn't that why we teach it? As I listen to these sorts of remarks I often think with a shudder of the possible horrors of 'rigorous music' or 'rigorous art' and wonder why our science, which by its nature is supposed to be so very creative, has finished up carrying this burden of 'rigour' on its back.

The interviewees included a few of the scientists living in the town in the same way as it included the many who were not. There were practising scientists and technologists, retired school or university scientists and other science graduates who were enthusiastically working, or looking for work, in science education. The rest, the large majority, were not very knowledgeable about science in the usual sense. Some of them had loved science ever since childhood, while others cringed at the mere thought of it – especially physics and chemistry! The interviewees, all of them adults hidden in the text by pseudonyms and other adopted procedures to hide their identities, were a very interesting set of people. I am most grateful to them for their time and cooperation, without which this research could never even have been started.

But before we launch into the main text, which will use stories as well as excerpts from the interview transcripts to illustrate the views of the people in Market Town, I want to write about some serious problems. How should we have chosen whom to interview? We need to catch a sufficient number of people to 'represent' the whole town in some way. Towns have populations running from a few thousand, to a few hundreds of thousands. After that the town begins to feel more like a metropolis or at least a city. When a group-size is given in terms of hundreds or thousands no one person can possibly know all the others. Is that a social group? Should we round up and interview every person in each of some small groups of people, about six or seven in each possible group perhaps, who have common interests? Then the results might show how, and if, what their lives had in common might produce similar stories and statements about science. Because we believed that ideas about science grew stronger or changed when people talked together about them – and we have stuck to this view throughout the study – the groups might be farmers, shopkeepers, engineers, teachers and so on. (Actually, none of these particular group titles turned out to be very useful, but the conscientious reader will soon find out what groups we actually used once they reach Chapter 5.)

I worried a lot about the selection process. Had we got enough to make sure that the characteristics people share in their friendship or working groups are fairly represented? Do people have only one predominant interest, or many? Why are we selecting this or that interest in such a god-like way? What about the multitude of characteristics we haven't even thought about? I can describe an actual dilemma we lived through in our early days. Market Town has a large, old but well maintained church. One can imagine that it is usually the same crowd of people who attend it on Sundays. So why not go to the vicar and ask him to select some people for us to interview? We did. But wait a minute, what about including a sprinkling of Nonconformist places of worship? And when the vicar kindly came back to us with his list of Anglicans who might agree to

be interviewed, they were all aged over sixty, bar one. If it was really the case that most church-goers were old, we clearly could not manufacture any younger ones, but was it?

As time went on we began to see that those recommended interviewees were also rather too well-heeled to fairly 'represent' the whole population in terms of their wealth and standing. We had been invited into their homes and were rather overwhelmed by their beautiful surroundings as well as their courtesy. We tried knocking on other more modest doors in a rather random way. This produced a lot of silent and presumably empty houses during working hours, and when the busy people did get home they were often too preoccupied to stop for a twenty-minute interview, they pointed out that they were cooking, or putting babies in the bath. It was never going to be easy to find 'average subjects' to answer our questions, thus eliminating bias in the sample, and we worried about it. Big marketing companies who specialise in questionnaire studies often use random samples extracted from the telephone directory. Random selection from a very large base, you might expect, means fair. Even our youngest primary pupils learn about using 'fair tests' in science. But there is much more to be said on this subject, which will be found illustrated and argued through in Chapter 4.

Networks and encounters

Age would certainly not be evenly distributed in our samples, from farmers to young mothers. Should we have concentrated on being knowledgeable about religion rather than age? Understanding religion did turn out to be the basic objective of the busy Alpha Group whose members, we now saw, figured prominently on the vicar's list. What was the rationale for our selection process? After much worrying we had to return to the first simple feeling that the 'groupiness' of these people arose from them talking to each other, rather than it arising elsewhere and then encouraging talk. We tried asking each person that we interviewed to recommend another person to us. This was better, but it did not always work well because people's information seemed to dry up. (Or did they have a guilty conscience about involving their busy friends in troublesome interviews?) But it did help us to focus on deep long-lived friendships and also on rarer types of encounter. Both would turn out to be valuable.

The ideas for the shaping of this book owe a great deal to Manuel Castells' impressive trilogy, *The Rise of the Network Society* (1995). This took for granted the braid of political and cultural threads which might be found in any local network. Castells wrote about the violence behind individuals' choice of culture, the passion for escaping from collective identity which is subsumed into political and environmental movements, the frightening immensity of global industry, the local power embedded in institutions and organisations, the new science of complexity and, of course, the Internet. It seemed possible, even probable, that our townful of people was settling into new ways of living, which meant that individuals who had previously been almost unknown to the likes of each other were now getting linked up in new friendship nets as well as becoming more diverse in their opinions. We could dip into an urban relocation and see how

some groups might talk more to each other because they were now living in new estates in the town for reasons that may have started by being no more than financial, but as time passed had spread wider to include house maintenance, mortgages and local services – all these were talked about. The people made neighbourly contacts and, to use a pejorative word, they 'gossiped' together. How else could they find a place in the groups which could open local society to them? So new threads of interests and new snippets of knowledge emerged as they talked about what they held in common (for example, having young children or working at the same kind of jobs).

Small world

The next stage was exciting and distinctly enjoyable. It involved reading a book called *Small World* (Buchanan 2002) which addressed, in wonderfully easy language, the question of how new complexity thinking could be applied to the composition of networks held together by social encounters.

We exclaim with surprise 'It's a small world!' whenever we find that someone we met far away from home on a bus is our neighbour's mother, or when a distant friend's uncle we sometimes see writes us a postcard that mentions our daughter's most recent best friend at school. How did he know? That is curious, we think, the odds seem to be stacked against it. We may each, on average, have no more than fifty friends, but we expect the majority to be living close to us, not in Outer Mongolia. At greater distances we rightly expect that there will be fewer of our friends on the ground. But if we throw into the pot what these distant friends tell us, it may more than compensate for the rarity of the times that they supply any information. This is one of the curious results we obtained when applying what is called graph theory to the movement of knowledge in social people-nets. Although the discovery of the importance of weak links to faraway sources of information, even when compared with the strong links to well-known closer friends, seems curious under the circumstances, it would be worth remembering. Fortunately for us all kinds of friendship seem to flourish in our Market Town. The everyday friends respond to what they expect, or even know, you to be feeling because you and they talk so frequently together, whilst distant ones will be telling you more unexpected and illuminating news. It might well catch your attention better. In only two cases in our Market Town study did we interview, separately, a husband and a wife. In both cases they supplied rather dull information which both already knew and had been rinsed through rather thoroughly in private discussion. The conclusion may be that communications from friends who have weak socials links into the network are likely to have stronger effects than we might have expected. It is known to *Small World* experts as 'the strength of weak ties'.

Complexity theory provided a theoretical look at networks from the other side of the coin to that presented by Manuel Castells. I had read about how wire networks carrying electric currents, neural cells in our working brains, ecological networks of living components and metrological networks affecting our weather may have certain strange characteristics in common. All of them have a

basic net through which we might say that 'social energy' flowed, and all of them made sudden changes (called emergences), rather like our own *Gestalt* changes in perception when looking at a puzzle picture which jumps from being about one thing to another without any conscious help from us. So network theory should also be applicable to the *Small World* nets of information which were fuelled, you might say, by talking with friends. What travelled in that kind of net was not physical energy but local information (although I was quite aware from my undergraduate physics days that flows of energy were equivalent to changes of information, and from order to disorder). Because network theory considers a multiplicity of paths for flow, this would also be true for the *Small World* nets. They too would be both complex and unpredictable. The sudden and unpredictable 'emergence' of a new pattern in the network flow would lead not to disorder but to order (rather like the sudden change of opinion we might observe when some new piece of information either reconfigures or clinches the argument). I began to feel a little more comfortable, even rather more certain, about how the information bits and pieces of demotic science could be trapped and used by our *Small World* friendship nets. There is still a long way further to go – which makes the journey all the more exciting.

Many thanks

The small original project was funded by the Wellcome Trust, for which I sincerely thank them and hope that they find the substance of this book to be of value. Reading it will not, I fear, directly solve any practical problems, but it should be of real help in understanding their nature. None of the steps that the Wellcome Trust has set itself and often achieved, for increasing the understanding and enjoyment of science amongst the people of this country, can hope to succeed in any direct and functional way unless there is an understanding of the nature of demotic science, together with an appreciation of how it comes about. To my friends who commented usefully on the text, and for the patient encouragement from my husband John Ziman, more loving thanks are due.

Foreword

I first met Joan Solomon in about 1990 when she came to give a lecture at the University of Cambridge Department of Education where I was then working. I already knew some of her writing and it soon became clear to me that there wasn't a science educator I knew with whom it was intellectually more enjoyable to talk about science education. Joan over-ran with ideas and was always happy to congratulate you when she felt you were right and contradict you when she felt you were wrong. I remember when I gave a talk at the 1992 Association for Science Education Annual Meeting in Sheffield, titled 'How should science teachers teach the relationship between science and religion?', Joan stood up at the end of the talk and told us all that she had come intending to disagree with what I had said but had found herself agreeing with all of it.

We kept in touch over the years, mainly through meeting at conferences or when I examined one of her PhD students, and she raised the possibility of our writing together but, sadly, nothing ever came of that. At a distance I followed her illustrious career, with chairs of science education at the Open University, King's College London and the University of Plymouth. This is not the place for a full account of all Joan achieved but she was a world leader in the field of what is sometimes called STS (Science, Technology and Society) education studies. She inspired classroom teachers and wrote a number of very influential papers with some of them. She produced many important books, booklets and other resources to help science teachers and science educators get to grips with the history and philosophy of science and the teaching of energy, amongst other topics. She was one of that small group of people I knew where it was always worth reading what she had written.

Joan died in 2009 and I was very greatly honoured in 2010 to give the Open University Joan Solomon memorial lecture. Here I met her daughter, Bess Solomon, and we kept in touch. Bess subsequently sent me the manuscript of a book that Joan had been working on before she died and I encouraged Bess to contact Anna Clarkson at Routledge. Bess did so and the result, thanks to Bess and Anna, is this volume.

This is a wonderful book. It explores using detailed interviewing and rigorous analysis what the citizens of a fairly typical small town in England understand by science. In common with all Joan's writing, the book is therefore deeply respectful of people from all walks of life, both so-called 'experts' and so-called

'non-experts'. Both Joan and her husband John Ziman were sometimes frustrated at the tendency of all too many scientists to have a rather simplified model of science and of science communication. In this book we see the benefits of a careful anthropological approach to uncovering what people understand by science, how they feel about it, how they relate to it and what their hopes and fears about it are.

Science of the People: Understanding and using science in everyday contexts remains as timely today as when Joan Solomon began to write it. Fortunately, she had written virtually all of it before she stopped working on it and so all that has been needed is a certain amount of editing. Reading through the manuscript I was exceptionally impressed both at Joan's erudition – her reading is so wonderfully broad – and at her ability to write fluently first time (it was obvious from trivial mistakes of spelling, punctuation and grammar that large swathes of the typescript had never been read by her a second time).

One mystery is the source of the extract on p. 49, which Joan attributed to Feldman (2000). Despite thorough investigation, we cannot identify this work, but would like to include it in a future edition.

Somewhat to my surprise, and despite help from present and former colleagues at the Open University (Laura Colucci-Gray, Richard Holliman, Jeff Thomas, Liz Whitelegg) and the Wellcome Trust (Peter Finegold, Tony Woods), I have been unable to find out who was the person, funded by a grant from the Wellcome Trust, with whom Joan undertook the interviews. Some of my letters to various possibilities were returned 'not known at this address' so if anyone does know who this person was please let me know. I'll end with a quotation from an e-mail Jeff Thomas sent me on 29 December 2011:

> Maybe in your editing Michael this will have to remain the stuff of an unsolved academic mystery. After an initial feeling of frustration that I couldn't track down Joan's fellow-traveller, I ended up feeling it was all rather fitting and symbolic – true to Joan's tradition of nurturing fledgling researchers and 'bringing them on' through her own example, and leaving in her wake so many research trails and so much academic inspiration – all told (as this example shows) more numerous than even the best of her friends are ever likely to know.

Michael J. Reiss
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1 An approach to awareness

> Once back on the highroad he came again upon the noise and turmoil of his times. A troop of peasants were running excitedly with pails and pitchforks in hand to put out a fire. A large isolated farm had been set burning by one of those Anabaptists who were cropping up everywhere, mingling their hatred of the rich and powerful, with a special form of love of God.
>
> (Yourcenar 1976: 40)

It may seem odd to begin the first chapter, in what I claimed in the preface to be an empirical study, with an excerpt from fiction. Worse still, the contents seem to be more about religion than science. It is set in Europe some five centuries ago when the Anabaptists were the religious fundamentalists and global terrorists of their times. The title of this book by Margaret Yourcenar, *The Abyss*, describes a deep rift that appeared in those days between the excitement of new science, and a vigorous hostility towards change. We are told that the author, a historian, spent many years researching the background of her novel. The traditional kind of demotic science always has the advantage of fitting in with the common and comforting proverbs which everyone knows and uses in daily life. In most general ways demotic science is still like that today. Those points alone might justify the use of fiction in this non-fictional book. But the main reason for its use is that it is fiction. The essential recognition of truth which justifies fiction may come from another time and another setting, and so provides a kind of evaluation. So if we can read into this excerpt both the illegal actions which were carried out by those striving to make a point about social justice, and also link 'the turmoil of his times' to changing schemes of thought as well as violence, and to deep changes in the nature of religion, which we have again today, then it has performed its introductory task.

The short extract barely refers to the main character of the story, Dr Zeno. This book is about the public's awareness of controversy and disorder, like that of the Anabaptist fire-raisers who actually did attack and burn farms, barns and churches in the locality of our real Market Town. The thoughts of modern citizens, about science now, are the main constituents of this book. In the novel a great variety of working people were encountered by the philosophical doctor as he travelled on foot through Flanders. Is he the interviewer of his times, as

we two were today? The narrative chronicles Zeno's thoughts and fears as he observed people at work. It was charcoal makers who gave him the night's casual hospitality off the highroad, mentioned in the excerpt, as also did some unemployed weavers a little earlier in the story. They had recently been made redundant by new technology. So he moved not so much through or in people's lives, as across them, haphazardly, in real time or by memory recall. Dr Zeno was much influenced by Vesalius's recent anatomical work which flouted the forbidden dissection of the human body that was considered so horrifyingly unethical in the fifteenth century. It was a time which, like our own, seemed full of horror at the way science was usurping God's power. In the same way, some people in our modern Market Town speak of scientists as 'playing God'. Everything was changing then, as it is changing now. Zeno pursued his reflections on the science of the times, from the fire of alchemy, to the animation of the components of the *Anima Mundi* for making remedies through the living spirit of the Earth. And that might correspond to the Gaia theory of our own days.

Naming the problem

Just ten or twenty years ago our main subject might have been called the 'public understanding of science' or 'scientific literacy', but during the early 1990s someone, somewhere in the European Commission, put down the phrase 'Public Awareness of Science' in place of these and, for a while, it appeared on all their project documents. Much later there was an educational paper by Stocklmayer and Gilbert (1997) claiming that they had just coined the same term for themselves, as well they might have done, and presented it at a conference in Australia. This kind of multiple but independent emergence of new ideas, or even just new names, is quite common in technology where it becomes more awkward by the need to patent inventions. This controversy over priority is the best evidence we could have for a change in ambience surrounding what could be called 'the local culture' (Geertz 1992). The new name-tag, 'awareness', slips quite easily into the whole business of science and the public. It stops us from indulging in nit-picking arguments about what should be considered as the uniquely correct understanding of science. The old name was about 'understanding', and was always in danger of making the whole project sound like administering yet more school tests. 'Awareness' is a broader word than understanding and is used for the gradual awakening of consciousness. It can exist at different levels, running from acutely aware to barely aware. Just a few people in this study told us that they always turned to the page on medicine, astronomy or wildlife in their favourite newspaper. That is a high and determined level of awareness. Many more people confessed to only listening while preparing the supper, and of not having enough hands to turn the radio off without stopping cooking. So they typically become aware only of snippets about science.

The salience of such awareness depends upon the sensitivity to remembered experience and/or a busy imagination. At a stroke this renaming alters the whole field of study from being entirely scientific to being almost equally humanistic. It becomes, if you like, more akin to 'the noise and turmoil of the times'. The

powerfully mental abstractions of science, represented in our times by the paralysed body of Stephen Hawking, are at a very far remove from most people's understanding. But all of us are aware of the changes in our lives. The abstract theories of space and time seem more like theology or the metaphysics of the medieval times than like science.

Paintings of work

This study of a townful of people could be approached as if it were a picture painted by the Flemish artist Pieter Brueghel who lived at the time in which Yourcenar's famous novel was set. He often painted a great diversity of busy people scattered across his canvases in the way that the originals were scattered over natural landscapes during the different seasons of the year. In effect the observer of these paintings sees the common work-practices, including the knowledge of skilful techniques, in use during the different seasons of the year.

That is an example of the kind of workaday knowledge which is at a far remove from abstract scientific knowledge. It gives us pointers to daily knowledge and seasonal change. The predecessors of those living today in Market Town knew about tilling the land in a way that was almost entirely tacit, and dependent on their understanding of unspoken messages from the soil and the weather and a range of physical skills copied from parents, rather than from reading and teaching. With very little verbal explanation such messages were learned through the senses and transmitted via the hand-fork and the long levers of the plough, as well as by simple proverbs of the 'Red sky at night …' variety. There may seem to be little science there. Tim Ingold (2000), in his splendidly insightful book on how we perceive the environment, pointed out that scientific activity is 'grounded in the simple poetics of dwelling', where that last word evokes skilful living in an environment. Skilful enough, that is, to work and live there. The similar notion of a 'poetic-scape' has been used by Anne Primavesi (2000) in a book about the nature of *Sacred Gaia* – an account of how we might become aware of our planet's co-evolution with emerging life forms. This awareness fits nicely into the seasonal knowledge of farming.

The lives of people everywhere, now as then, are various and busy in the five dimensions of time, space and knowledge. In Yourcenar's novel, the bulk of the characters were as ignorant of the details of the alchemical and medical science of their times as most of the people of Market Town are today about details of modern genetics, the physics of nuclear energy, or the new nanotechnology. During both periods a proportion of the people did achieve some sort of 'awareness' of contemporary religion and its troubles, as of science and its startling technologies. But many more did not.

Knowledge through time and space

'Market Town' suggests that the urban location might also be relevant to its inhabitants' awareness of science. This is not because those who lived in one town might, on average, be more knowledgeable than those in another, but

that awareness is likely to map in some general way onto the various essential kinds of employment, of voluntary associations and friendship groups, through their activities and discussions. Our Market Town has a central market square with shops, a weekly market day, both new and old housing estates, a small but busy industrial 'park', and a recent road loop disconnecting it from the heavy through-traffic. Market Town seems quieter now because the stream of lorries going between Southtown, Northtown and the more remote capital city in the world beyond by-passes its lanes and homes.

Before the French Enlightenment, which glorified a logical kind of knowledge abstract enough to be applied in an over-arching fashion to almost any situation, and even before the earlier Scientific Renaissance, which delighted in experimental knowledge, there had been a long period of unthinking belief in the uniform nature of knowledge across all space and time too. When the sun was overhead at one place it was midday there, and it made little sense to ask if it was 12 o'clock anywhere else 'at that moment'. Mechanical clocks with their ticking escapement had been invented in the fourteenth century and they might, in principle, have been carried from one place to another showing that the sun's orientation at 12.00 midday did not agree everywhere along its path, but that would have been enormously difficult! Jules Verne's novel, *Around the World in Eighty Days*, had its climax in a taxi chase across London once it had been established that Phileas Fogg's watch was recording a time 24 hours in advance of the time-pieces of other gentlemen staying at home. Neither Fogg's servant nor the taxi driver understood this but, in the way that awareness of science so often precedes its understanding, they accepted its operation with wonderment, but without question. Time was not a constant aspect of wide space: it did not coincide with sun-time in any other locality but it took too long to check on that, carrying a ticking mechanism with them as they moved from one place to another. That was quite enough for people who neither travelled much nor corresponded with friends far away. Similarly, until the railways came to our Market Town along a slow branch line in the mid-nineteenth century, there was little sense in connecting time-in-use there with that in distant London. The railways took note of this and effectively disguised it in their timetables. Nothing happened quickly enough for the slight differences from sun-time in the different towns for it to matter much. The railway timetable imposed its time, 'London Railway-time', quite smoothly on a compliant and rather bemused population.

As for the flow of information, the situation was still not very different in terms of space and time then from how it had been in medieval times, although now faster. Letters or books posted in Market Town to be carried by train were handed in by the postmaster and remained under the eye of a railway guard during the entire journey. The letters were always in the awareness of a person and also within a moving location, rather than being 'beamed', as they say in science fiction, through space-time. So the movement of news remained essentially just as it had been when carried by a rider on a galloping horse. It seemed, as Giddens (1990) wrote, that knowledge was still embedded in 'social place' rather than 'empty space', as was fitting for those having people-centred ways of being.

For time, space and information to be linked together, but without the agency of people, another revolution was needed. Now the human carriers of information would be left far behind by impersonal uni-speed electromagnetic waves. The reception of information could be astounding in terms of moving images on the screen designed to attract attention, or it could just be a brief impoverished text-message on a mobile phone. These carrier waves moved without the continual overview of people. Even a partial elimination of the human carrier went a long way towards producing what Anthony Giddens called 'empty disembedded space time' that was 'distantiated' from people. There is only partial distantiation in the case of the telephone's contribution to the 'space of flows' (Castells 1996) in electronic space-time. Phones, old or new, static or mobile, unite people through the intimacy of a voice that evokes the presence of a friend, almost as surely as the presence of the train-guard had done 150 years before, through embodied oral communication. What kind of knowledge is most accurately communicated from one mind to another in these different ways is more difficult to guess, but will become an essential part of our empirical study.

So, in addition to the tacit knowledge of lived work-centred technology – now the new computer technology – today's public awareness of scientific knowledge may also be the result of communication of these two general types. One will be the result of talking with people using all the empathic skills they and we have developed since birth. The other will be built upon impersonal electronic communication which is 'distantiated' from people. How these three kinds of communication – non-verbal skills at work, talking with people, and the reception of electronic communication – are then brought together to construct a coherent picture of the world is fundamental to the exploration of public science in Market Town. It will form the hard core of this book.

'Communication tennis'

Studies similar to this one often focus on the transmission of knowledge from a science source to the receiver's mind as if the information were a simple given, like a hard, resistant object. But even in school and college the act of understanding what is being taught always changes it in more or less subtle ways. Perhaps that is inevitable. Learning is an active process in which we are taking in knowledge in many ways and which include a cognitive comparison between it and earlier learnt knowledge, and metaphorical comparisons with a horde of remembered life stories, both fiction and remembered. So the learning process almost always muddies, or equally enriches, the received knowledge and makes it diverse, elusive, uncertified and usually disconnected. About any scientific topic, there are a thousand ways of being incorrect, although demotic and unorthodox, but usually only one way of being correct in an orthodox sense at that present time. So correct science from 'those who know' may run the risk of being dull and repetitive, whereas 'public awareness science' often seems protean, new and surprising, even if it may be rather shocking to the scientific expert!

What happens, I guessed as we began this study, was that the modern people of our cities, towns and countryside pick up bits of scientific flotsam and jetsam,

make up a little more, and remember some from school. Then out of this they put together for themselves a comfortable personal package of 'science' that fits into their own way of living and that of their friends and family. These home-made collections might change as and when new topics hit the headlines, but they might also change due to mutations of personal interests. There might be a sudden awareness (that word again!) that there was a connection between the newly received science and other knowledge already established in the mind. Once, during some interview work, we found a young man working in a public house on the central square in Market Town, who was smarting from a failure to gain entry to university. He talked readily enough, including a boast that he had not only read all of Stephen Hawking's very difficult book, *A Brief History of Time*, but, as he added, 'You are looking at someone who understands it all!' We guessed this acted as a salve to hurt pride.

The communication of scientific knowledge is far from being a simple process like hitting a tennis ball across a net. Let us suppose that the scientist has a ball; s/he throws it up in the air and then strikes it very hard across the net in the general direction of the other player. But this 'other' may have never played the game before and so, understandably, fails even to see the ball, let alone get a racket to it. Those watching are sympathetic to the beginner and shout crossly to the server 'Hit it more gently! Then s/he will get it'. So the scientist changes the service of the ball to a simple underarm scoop so that the receiver manages to hit it. S/he (let's say 'Lesley' instead) looks relieved. But what is this? Now the server looks cross and throws down the racket. 'Hitting it like that is just not tennis! It has got to be served hard, and over-arm, according to the rules of the game.' The argument goes on. However, if you watch carefully a little later you may see Lesley somewhat nonchalantly bouncing the ball about by hitting it with the other (wrong) end of the racket, rather like in rounders or baseball, and is getting quite skilled at this. Some others come along and before you can say 'knife' they have joined in this new game or made up another. Of course the ball soon gets worn down from being hit by the hard handle and no longer 'bounces true', but Lesley's players don't seem to notice this. Soon it becomes quite impossible to recognise this ball as the pristine spherical one our scientist first lobbed across the net in such a kind if rather patronising fashion. The local sports authorities become concerned about this debacle and plan to build free Centres for Tennis Coaching, but not many people come to them. They don't fancy being defeated by fast balls that they cannot even see, and everyone gets thoroughly irritated.

That metaphorical account tells us that the communication of knowledge is not at all straightforward, even when attempted by an accredited expert. It is sometimes asserted that scientists would be the last people able to explain things to the public in a way that they would understand. They are 'too brainy', it is argued, or they are 'nerds' and even likely to be afflicted with some measure of autism, the mind-blindness which disables the essential faculty of empathy by which they can see how well others understand them. Familiarity with scientists easily dispels the majority of such ideas.

During the 1990s I, amongst others, ran a scheme whereby physics undergraduates from the local university spent time helping to teach children in some of the difficult local schools. A detailed national curriculum which included science as one of its three core subjects had been imposed from government. It was to be taught by the country's almost completely untrained force of teachers. The gifted undergraduates whom I taught enjoyed the experience hugely and in subsequent years this made my task of fitting students to the schools almost impossible. The students tried to explain phenomena in simple everyday language, as they remembered it from their own youth. This involved a shift of gear not unlike what bilingual people experience as they change language. But children's language is not like that of university physics. Large-scale investigations of Australian university students' methods of learning have shown that being bilingual is the best of all predictors of success in what researchers call 'deep learning' which takes place when students reflect on how different ideas seem to fit together. It is as if those who are used to accepting the shifts of meaning between words with (almost) the same meaning in two different languages learn more effectively. Such snippets of educational research findings seem to offer at least a glimmer of explanation for why a few gifted scientists can move quite easily into the everyday mode of explanation, once they sense that the Lesleys are having trouble. They are, we might say, fluently bilingual between scientific and everyday demotic thinking. It might be that the less able scientists might be less good explainers (other things being, as they never are, equal).

Phenomenology – a theory of awareness

The second question to be asked was how the Lesleys 'learn' from scientists in such informal circumstances. In the analogy of the tennis game it was suggested that the knowledge being communicated – the ball – was difficult to see and even more difficult to hit. That translates into a type of science that would be hard to understand. At least two scientists, Lewis Wolpert (1993) in the UK and Morris Shamos (1995) in the USA, have pointed out how difficult, even 'unnatural', scientific knowledge must seem to the non-scientific public. From this they drew deeply pessimistic and unhelpful conclusions about the possibilities of the public understanding any science at all from an occasional lecture, and even less from the entertaining but thin informal sources usually provided. In the sense of learning some complete conceptual scheme they may be right – it is very difficult for an older brain to install a network of neural trails while the older ('wrong') ideas remain in place. The same applies in some measure to almost every discipline. In the next chapter we will revisit the unequal situation when scientists teach the public.

But awareness is not like that. It requires little or no internal structure, just a frail and single hook remaining from some previous interaction so that our awareness can be hung upon it for the time being. The first effort to construct a theory about our general awareness of phenomena was the work of Edmund Husserl at the beginning of the twentieth century. He had been, in turn, a mathematician and a philosopher, but his new theory of 'phenomenology' was, as he himself

claimed, 'descriptive psychology'. At that time psychology, the new science of the mind, was just emerging out of old and venerable schools of philosophy. It was built on the huge success of Darwin's work and the high reputation of recent science. Psychology was the science of the mind in much the same rather restricted sense as botany is the science of plants, and chemistry is of materials. But Husserl's psychology (Bell 1990) had daringly set out to explore the intentions of the mind, rather than carrying out simple behavioural experiments like those of Pavlov with his dogs. But philosophy was still focused on exploring knowledge for its logical content. Thinking, in the sense that Descartes had used the word, was still considered as the central proof of existence and was to be judged by its logical structure and not by anything as vague as wordless awareness. This new discipline of psychological thinking would reflect on consciousness and might include experiences from personal history. It was an inward-looking study.

Husserl began with the elusive notion of consciousness about which he could only say that it was connected with the 'stream of consciousness' within ourselves whose eddies could turn into awareness of some phenomena happening around us. We are aware, for example, of the noise in a restaurant, and of background music. Those are raw perceptual experiences; Husserl's own splendid example was becoming aware of an itch which may only be strong when we find ourselves already scratching at it. At a higher level he thought we might become conscious of the music which we could recognise and name, music that we might even have made a special journey to hear. In Husserl's words we have now performed a 'mental act', bringing our intentions and intuitions into the picture. This is a more intense kind of awareness; we might also call it more conscious. In this way the consciousness we study becomes more solidly familiar. The old embargo on thinking about our consciousness seemed to be loosening. New books were emerging, and an academic journal, *Journal of Consciousness Studies*, is now flourishing.

Phenomenology looked, at this point, as though it might be just what was needed for thinking about the public awareness of science. However, it was seriously defective in at least two linked respects – it was hopelessly individualistic and so worryingly subjective (at least to Husserl). A single person's consciousness of some of his or her own mental acts, intentions and intuitions seemed a possible beginning – but where were the other people to discuss it with? When Husserl turned his attention to everyday linguistic meanings he encountered more serious hurdles. His theory was entirely internalist, tacit and solipsistic, leaving no way to communicate with others about what they were conscious of in the world around them and how this agreed with their consciousness. What use would there be for a multitude of mental meanings and descriptions from a whole range of single, isolated persons, when what was needed were language links for exchanging their ideas with others and recognising their points of agreement? The problem, as Husserl saw it, was that if phenomenology was to be descriptive psychology, and a branch of science, it should be built out of objective knowledge – not 'subjective feelings' – so that it could be taught and written about in an authoritative way. But he knew, he thought, that awareness could not be objective. He tried to deal with this by simply asserting that we and others live in the same world. 'We have a world pre-given … existing for us and to which we together belong, the world

is a world for all' (Husserl, quoted in Bell 1990: 228). However, he could not expand on this assertion so the 'awareness problem' resurfaced every time people described to each other the same happening but in different ways.

The great achievement of Alfred Schutz, a pupil of Husserl, was to see that what was needed was a new concept of intersubjectivity which, unlike the rather rigid consensual intersubjectivity of scientists about science, was fluid, protean and interpersonal. Experiences could be shown to be similar if other people recognised the meanings from their own subjective experiences. It was still about conscious awareness but the linguistic sharing of it now became central to its description and recognition:

> it is thus in the we-relation that the intersubjectivity of the life-world is developed and continually confirmed. The life-world is not my private world nor your private world nor yours and mine added together, but rather the world of our common experience … a breaking off, or even just a radical restriction in the continual confirmation of this … has grave consequences.
> (Schutz and Luckmann 1973: 68)

So when we hear someone continually asking, rather urgently, for confirmation, 'you know what I mean?' we see that the 'grave consequences' which Schutz had mentioned might include doubts about the capacity to make and transmit any recognisable meanings about our awareness of the world. That way madness, which is akin to that induced by brain-washing, lies.

Talking about awareness

In life-world discussion between people in Market Town we may expect to find that justification is based on such generalisations as 'everyone knows that!' or helpful analogies 'it is like when …' which often does make it easier to be recognised by another. During research carried out for the old Economic and Social Research Council (ESRC) on how 17-year-olds discussed science-based social issues, the difference between scientific or mathematical knowledge and agreed common awareness was often striking (see Solomon 1993).

Comments on a media discussion between the Director of British Nuclear Fuels and the Chairman of Friends of the Earth yielded many examples of how these two ways of thinking and talking can easily get muddled. Often the young people offered the old motto – 'it all depends on the circumstance' to justify some illogicality. If your friends are really trying to share your meanings and confirm them, the old familiar sayings like 'nine times out of ten' will be more valuable than logical mathematical knowledge because they too exist in the demotic world of simple awareness (see Chapter 10).

Both Husserl and Schutz used phrases that had been utterly foreign to philosophy before their time. 'Awareness' was one and 'taken-for-grantedness' was another. At a leap the search for understanding and meaning had taken up phrases that would, under the old philosophical rules, have been rejected as showing irretrievably sloppy thinking. One of these was 'paramount reality' which might

translate into the subjective assertion 'It seems obvious to me that …'. From this perspective the people in Market Town, some of whom lacked any substantial education in science at all, would still be able to talk about their ideas. They were aware of science at some low level, and could talk about some aspects of it by using their own experiences (and images from television) couched in ready-to-use common words, along with suitable emotional overtones. In some circumstances they might speak as persuasively in interview as they would with friends. So if we researchers were in doubt about why they took the stance they did, we could search through the transcript to find some explanation, half-hidden in their small talk. (We will take up the problem of if and how we might be able to interpret what was being said – an ambitious claim – in Chapter 7.)

To summarise, awareness is triggered by some perceptual and/or affective interruption in the stream of consciousness, which may itself be at either a low or a high level. It is sharpened if there has been previous experience of a similar sort, even if only at second hand via television. We may then struggle to explain it to some other people. If they can confirm the experience by reference to a logically similar one of their own, it will help the idea to grow, even though there is no strict sense in which they can be compared. Awareness may reach a level where it can be stabilised and possibly even be built upon by talking with others under favourable affective and cognitive conditions. We shall assume therefore, right at the start of this study, that the public awareness of science is of this general species. People will take on an idea which seems important to them and then try to awaken a similar idea in their friends by discussion of a general sociable kind. (This will be further extended at the start of Chapter 6 when we are trying to interpret ideas arising from the interviews.)

Finally, we can use this whole epistemological excursion to explain the later stages of the 'communication tennis' game which was rather mischievously left without any resolution. You may remember that when the scientist had left the court the Lesleys gathered together to try out games with new rules. The goal was to discuss the idea that they think they have received – to 'pat' the ball to each other – not so much to verify its meaning as to justify it in the sense that Schutz would have recognised. No longer were the logical proofs of science required. So long as the players agreed with each other as to what their words meant, and how such a meaning could be extended in recognisable ways, its message could be socially agreed and confirmed. But not for long. The meanings we use are essentially protean, which is invaluable when anyone introduces a new idea and others attempt to catch it. But there is no umpire present to monitor the process. No wonder then that if the talk goes on for any length of time the very shape of the idea/ball becomes distorted and almost completely unrecognisable to the scientist who first hit it across the net.

Personal discovery and play

Husserl's phenomenology of 'mental acts' was useful as an approach to awareness. It included learning and remembering, and showed some signs of emerging from an exclusively affective or perceptive domain. Thus, individuals living in any

Market Town might be expected first to become aware of science in terms of new experiences or words used in media presentations. These might be about some technology that was barely understood and had never yet been used by the recipient, but eventually they would be. Recent discoveries in medicine or astronomy which carried memorable headline labels like 'designer babies' or 'black holes' might well be recognised, in the sense that we are aware of having heard of them before, although never understood in a strictly scientific sense. We might dip a little further into this awareness through intentional acts of imagination along with the free play of intuition. The whole process would then become coloured with emotions in some way. This might be exciting, feeling proud, frightened, worried or uncomfortably at odds with their own previously held beliefs.

Awareness, in this rich sense, provides the conditions under which discoveries can be made. It begins with knowledge learned by our own activities, in much the same way as young animals learn the skills of hunting prey through games. Arthur Koestler called this 'ludic learning' and Robin Hodgkin (2003) took up the same idea again to illustrate the role of space and danger in play. It was from animal learning that the Russian psychologist Lev Vygotsky was first drawn to study young children solving practical problems. Nearly half a century later, Jerome Bruner in his book *Play: Its Role in Evolution and Development* reported some similar research on 3–5-year-old children. He made the following points about play:

1 The process is more important than the ends it achieves.
2 The risk of failure is lessened by this de-emphasising of the ends.
3 There is less frustration because of this precedence of process over outcome if things go wrong.
4 There is freedom to notice seemingly irrelevant details.
5 Play is voluntary and self-initiated.

Several of these five aspects of discovery learning show how easily this kind of free play might enhance awareness. Because there is no pressure to learn, and no particular goal, perceptual awareness, like the working antennae of an insect, is free to receive and store what Bruner called 'seemingly irrelevant details'.

There are only a few Interactive Science Centres where the above criteria are met and, as far as I am aware, only two pieces of published research about such activity. The first was carried out with primary pupils in a small research centre within one of the schools in Market Town. This was only used by primary pupils living in a small bunch of villages. In the Centre there were no labels, no writing, no task, but just an encouragement to 'make discoveries' in small groups. The researchers reported that the first part of the investigation involved both getting used to the equipment, and 'playing around' with it. In about half the cases one of the children's awareness was suddenly interrupted by some unexpected happening. There was a shout of something like 'Oh look at that!' or 'Do it again!' The stream of low-level consciousness was broken and the shock gave the group of youngsters a focus for their curiosity and an urge to carry out what Husserl would have described as 'intentional action'.

In one recorded incident, when a pencil was illuminated by red, blue and green lights, a child saw that it cast a yellow shadow, amongst others. This was so unlike the shadows he expected that his consciousness was thoroughly ruptured. 'That's crazy', he almost shouted (Brooke and Solomon 1998).

Data from the other piece of research were taken from an interview study of adult visitors to the Australian National Science and Technology Centre in Canberra undertaken by Stocklmayer and Gilbert (2002). In this case the researchers were looking for a trigger to awaken the visitors' interest from a previous personal incident. The researchers called this linkage a 'Reminder'. The authors also make reference to another way for the visitors to make the link, this time by using an analogy in words. They considered that this did not, by itself, construct clear and helpful links and only rarely succeeded in bringing about the new awareness that the Centre's designers had intended.

Relying on incidents like the above is an uncertain way of bringing science to the public. The models are strictly personal and there seem to be grounds for a suggestion that a method which relied more on our empathic social gifts might have been more efficient. This will be useful when we find out what science the groups in Market Town discuss.

The knowledge of towns

In the sixteenth century, towns of the modest size of our Market Town were sharply differentiated from villages. This, as Max Weber pointed out, was because they usually had a marketplace, a law court, a varied population which included professionals and craftspeople, and sometimes also a grammar school. Not only was there a church, which even the smallest village would have also had, but within the next two centuries there were also to be a great variety of different Nonconformist places of worship. The important market was mainly an agricultural one, but then wealth in any small inland town would mostly consist in agricultural produce as it did in the wealthy 'wool towns' of the Cotswolds. But our Market Town was famous for its pig production. Itinerant traders in ancillary items came to the market from further afield, as they still do today, and judges on assizes paraded into the law courts at regular intervals during the year. English towns of those days not only contained more variously skilled workers than did the surrounding villages, but they also had a population mixture which included those with more education, those who had travelled and some who were skilled in debate and controversy. First the Reformation and then the Civil War, when our Market Town was so staunchly royalist that even the presence of Oliver Cromwell himself could not subdue it, required oral literacy. The war ensured that there would be much to be discussed, often with passion, as there still is today.

In order for there to be discussion, the town's inhabitants, or at least a proportion of them, had to be in the habit of talking freely together. To whom did they talk? Who would be likely to set up movements like Friends of the Earth or Greenpeace? What did a 'community' or a 'neighbourhood' really mean in terms of discussing new ideas? By the time this study was ready to begin, the method had already been asking useful questions like:

- Did the mix of people in the towns lead to middle-class domination?
- Does the distribution of the social classes in a town conform to geographical patterns?
- Is the town a community with a culture of its own, or is it part of a social network?

These questions could have practical importance to the study of scientific awareness in our Market Town. For example, should we interview by areas within the town assuming them to be uniform communities in terms of interests, class and education? Or should we assume that each person is linked by network with others, who may live in different parts of the town or even further afield in a neighbouring town, but share their interests?

During the last sixty years the above three questions have been partially answered through studies of towns or different parts of cities. The review of this body of research by Pahl in 1970 drew on a great variety of previous research projects in relation to social class. There were middle-class people who had settled in working-class villages and working-class people on new estates, but in the end Pahl concluded that class differences were not all-important. Nevertheless there was still a deep suspicion amongst the working classes of anyone, regardless of class, who tried to start some association – 'who does he think he is?' – or to present a common grievance to the powers that be. Although the middle classes were more ready to start up new associations for discussion, working-class men also discussed their ideas together. However, this was more likely to take place with chosen friends at work or in the pub. The living areas of different groups of people, the 'localities', could be mapped out and analysed by class and interests. However, the resulting charts were not uniform. Areas where the different classes lived could sometimes be concentric rings, but were wedge-shaped like slices of cake in others. And, once more, the classes did not readily mix. The existing data were enough to show that phrases like 'community spirit' or the 'culture of the town' were more wishful thinking than reality.

So the answer to the first two questions was a modified 'No'. Roughly similar localities within different towns showed different distributions of interests. Class and life-style failed to explain all the differences. Pahl wrote that the new increase in mobility of the workforce was an important factor in a different location-system of friends. This breakdown of traditional patterns could possibly lead to a new system of social networks.

Old and new networks

Social networks are not a new idea. In Jane Austen's novel *Pride and Prejudice*, there was a splendid moment when the superior Mr Darcy managed, once again, to get on the wrong side of Mrs Bennet, this time by suggesting that there are too few families to visit in the countryside. She protested indignantly 'But as to not meeting with many people in this neighbourhood, I believe there are few neighbourhoods larger. I know we dine with four and twenty families.'

Within what she called 'the neighbourhood' were families of her class that formed a social network for the Bennets to visit and to invite the others back to their homes. Of course there were many others, the visible workers. Further afield there was an even more extensive network of family and friends, with whom Mrs Bennet's daughters could stay, either in fashionable Bath or even in the far away and wicked London. Pahl points out that without such escape-routes the country could indeed become a rustic prison for the middle classes, just as Darcy had feared it would.

Despite all that the Labour government had achieved in terms of a more equal national distribution of power during the 1960s and 1970s, local control was still more likely to be in the hands of the middle classes. Since we shall be talking to the inhabitants of Market Town, one to one, about their personal interests and fears, broad brush results in terms of social class will not be possible. We intended, from the start, to ask each person we interviewed to suggest a friend or acquaintance to be the next one on the list, so as to gain an impression of the network structure. To some extent this worked well. However, our interviewees often ran out of suggestions for others to interview and we started to worry that we might be confining ourselves too rigidly to particular classes or interest groups. But the network structure did become apparent, and as time passed we found ourselves talking to people who knew others from different groups and so straddled two or more interest groups, as people do. It was as though we were exploring the series of overlapping mini-cultures of meanings, or states of generic awareness, which constituted part of a network. This is how the anthropologist Clifford Geertz described this weasel word, 'culture', in 1973. 'Believing with Max Weber that man is an animal suspended in webs of significance he himself has spun, I take culture to be those webs, and the analysis of it to be … an interpretation of meaning' (Geertz 1973: 5).

For a while this definition of culture as a network of meanings was enough, but to those continuing to work in the field the definition began to assume too much cultural uniformity. Later Geertz, and some others, saw that the concept of an overarching culture needed to be broken up so as to reflect the many ways in which each of us allow our personal meanings to change as we talk to other people. In the present project we had known that we would need a more humanist, personal approach if we were to understand the fragile and protean self-images presented during interview. Our task would be to present some conglomerations of these two kinds of awareness of science, whether they were local interruptions to the general stream of consciousness or the more general and shared background understandings, like that presented by the older view of culture.

A similar psychological and humanistic approach characterises a review of urban sociology by Peter Dickens (1990). It was striking to find that this sociological work admitted novelists into an exploration of the social order, just as was done in the opening sections of this chapter. Dickens writes about the operation of individual human agency within social groups in a new civil society:

> There is a dimension to spatial or urban sociology which has largely gone missing from recent work. This is the 'expressive order'; how people in

> face-to-face contact understand society and themselves and express their feelings to others, [and their] 'moral careers', referring to people's attempts to construct a sense of esteem in their own and other people's eyes … [and] 'ontological security' the sense of personal niche, identity and belonging which people seek as social relations stretching over time and space.
>
> (Dickens 1990: 25)

Even in that short extract we can see the advantages to be gained by seeing this whole exploration of public awareness of science as a pluralist one. The confrontation between the personal and the social, the local and the global, modernism and postmodernism, did not need to raise conflict. All have their place; all will affect the outcomes at least to some extent. In this expressive approach Dickens uses concepts such as 'moral careers', 'social honour in others' eyes' and 'the construction of our living autobiography' which are drawn from the works of social psychologists such as Goffman (1959), Harré (1979, 1983) and Giddens (1978, 1990). All of these concepts will prove to be essential for the closer interpretation of our interview data.

Because everything in our society is changing at such an ever-increasing rate, we may sometimes need to take into account the global dimensions of a community and the information flow around an individual. This is where we might encounter again the 'space–time distantiation' and the 'space of flows' that followed the introduction of faster travel. In today's Market Town, members of the public can number friends and relatives who live in the next village, the next town or even another country as part of their own social circle. But the new kinds of information networks, as described by Castells, have much more to do with economic knowledge generation and flow than just friendship and discussion. For our purposes they are all-important. Observing that the new power-dominating society is often in the hands of a small elite, Castells coined the aphorism 'elites are cosmopolitan, people are local'. Our little Market Town may well be short of top-rank elite financiers, but some limited aspects of such high-flown networks are also to be found connected to what seems small, local and familiar.

Social networks depend upon friendships. Old ones, which have grown from earlier employment (in our case this may be scientific employment including nursing and teaching), make networks which last longer. But some old types of employment have fallen so far from modern use that the ways of talking about, say, farming have changed dramatically. Not only have numbers dropped, the kind of employment has also changed from being a sociable way of working to isolation in a large tractor. Tightly knit networks can provide a means of social control, while loose ones offer a sense of freedom which seems real and reassuring. But there are always nodes in the networks and through these the influence of politics and economics infiltrate the workplace. Nationwide groups dedicated to special issues, and the multinational companies and institutions that wield much greater trading power, are also changing. So there may be more frequent exchanges of rather standardised opinions about new science in the tight networks of old established friendship. The looseness and extension of

others encourages a wider range of contacts and more adventurous dipping into newer fields of scientific knowledge. In later chapters we shall be faced with problems of self-education on this kind of autonomous dipping into different aspects of science under the heading of autodidactism (Solomon 2003). Any suggestion of risk to ourselves in the circumstances of a new scientific development will be likely to increase our awareness and stress, like a tightening of the tension in a network.

To summarise, we can see that the public awareness of science seems to operate in two different ways. It can be a low-level, taken-for-granted background knowledge, which is recollected without disturbing the gentle stream of consciousness very much. It is used in commonplace social exchanges and easily recognised metaphors. But there is also a sharper and more personal awareness of some of the features of science which can interrupt the stream of consciousness. The first kind of knowledge derives from people speaking casually together. In answer to our first question when we asked 'Do you have any interests in science?' it was often the easy common-sense reply which emerged first. But for some people there were also sharper reactions triggered by a sudden switch of awareness into a higher gear. Many of our interviewees did not immediately recall any interest in science at all, but then, after a few prompts, more replies burst out, replete with expressively remembered content. It could be 'Oh no, not GM foods!' or a 'I loved science at school' or an emphatic 'No I'm not interested in physics or chemistry – yuck!' These were the more expressive replies, strongly personal and affective. They could be concerned with the new contentious areas of scientific ethics – human embryo tissue used to repair damaged organs, or IVF births tailored to produce a remedy for a threatened sibling. The mechanism of remembering is thought to operate in several different ways, but the chief difference is brought about by the presence or absence of the emotional burden that it provokes.

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