Preface to the Japanese and e-book editions

What happened at Fukushima has not changed what is known of the benefits and dangers of nuclear radiation. However, it has highlighted many of the arguments and I have added an epilogue that discusses these; otherwise the text is largely unaltered from the first print edition. As was the case for earlier accidents some reactors at Fukushima were destroyed but the impact of the released radiation on the population has been overstated with significant consequences for all those affected. Initial reactions around the world to Fukushima and its implications for nuclear technology have varied from one nation to another, depending in part on its historical experience. Nuclear technology can do much for our lives and our view of it should be based on science -- and that is the same in every country. Political and geological instabilities affect many aspects of a nation's life, and nuclear questions should not be exceptional.

It is natural that when there is an accident the question should be asked '*who is to blame?'* but this question may have no answer even when many must pay for the consequences. I hope that this book with its epilogue will provide a welcome and accessible account of the science and a basis for understanding, mutual trust and optimism for the future.

I have taken the opportunity to clarify the section '*Doses in the environment*' in chapter 7.

Wade Allison, Oxford, June 2011

Preface to the first English edition

The human race is in a dilemma; it is threatened by economic instability on one hand and by climate change on the other. Either of these could lead to widespread unrest and political turmoil, if the right choices are not made now. In particular, prosperity without carbon emission implies a comprehensive

switch in our sources of energy. With luck, the activity generated by the process of switching will also contribute to prosperity in the short and medium term. There are many solutions – wind, tidal, solar, improved efficiency – but the most powerful and reliable source is nuclear. However, it is widely supposed that this presents a major problem of safety. Is this long-held concern about radiation and nuclear technology fully justified? Straightforward questions should have simple answers, and the simplest answer is *No*. Explaining and exploring the question and this answer in accessible terms is the subject of this book.

Over the years I have taught and studied many areas of physics, including nuclear physics and medical physics, although I have never had a close link with the nuclear industry. While it always seemed clear to me that radiation safety was somewhat alarmist and unbalanced, in earlier decades the apparent freedom to opt for fossil fuel as the primary source of energy meant that there was no special reason to confront public perceptions of the issue. But now the situation has changed, and it is time to address the whole question.

But how, and with what voice? A discussion in popular terms that would appeal to the native common sense of the reader is too easily dismissed by the science. But scientific answers are impenetrable to many readers, and so fall on deaf ears. A way forward is to vary the tone, sometimes scientific but still accessible, and sometimes with illustrations and examples that appeal to general experience. Nevertheless, I shall probably tax each reader's tolerance in places, one way or the other, and for that I apologise. While ways of avoiding the use of equations have been found except in some footnotes, use is made of the scientific notation for very large and small numbers.[1] Finding passages that seem either trivial or impenetrable, the reader is encouraged to skip forward to rejoin further on. The passages that discuss recent scientific results are supported with references labelled in square brackets in the text and listed in full at the back. Most references may be found on the Web at the address

1 Thus 10^6 means one million, 1 followed by six noughts. Similarly 10^{-6} means one millionth part.

given – but the text is self-contained and does not suppose that these are consulted. Also at the back, there is a short list of books and papers, headed *Further Reading*.

The story starts with the physical science, much of which has been established for decades – the atmosphere, the atomic nucleus and radiation. And then it moves on to the effect of radiation in biology, most of which was not so well known 30 years ago. Often, popular science is written to amaze and inspire – and that is important. But here the target is more prosaic and practical, namely a clear understanding of the scientific background to some of the threats and decisions that are likely to determine our environment and thence our survival. The central question is this: how significant are the health risks due to radiation and nuclear technology? In Chapters 6 and 7 the current evidence is shown with the relevant ideas in modern biology. Not all questions can be answered completely yet, but they can be answered quite well enough. The conclusions are rather surprising, and do not match well with currently enforced radiation safety levels. This challenge by modern radio-biology to radiation safety regulation is well aired in scientific papers, but has not been explained to the community at large, who have a significant interest in the matter. The costs of nuclear technology are very high, in part because of the exceptional radiation safety provision that is made. Scaling back such provision by a large factor would have a major beneficial effect on the financial viability of an extensive nuclear power programme.

These scientific findings do not depend on climate change, although that is what makes the question important at this time. But why, in the past, did most of the human race come to hold extreme views about the dangers of radiation and nuclear technology? The last part of the book describes what nuclear technology now offers, a large-scale supply of carbon-free electric power, with further options for the supply of food and fresh water.

E M Forster wrote

> *I suggest that the only books that influence us are those for which we are ready, and which have gone a little farther down our particular path than we have yet gone ourselves.*

I hope that for some readers the message of this book is timely.

To keep the discussion focussed on a few main points, many important topics have been omitted or just noted in passing – in particular, the subject of micro-dosimetry is treated rather briefly, in spite of its importance for future understanding. No doubt mistakes have been made too, and credit not given where it was due. Such choices, mistakes and lapses are mine, and I apologise for them.

I have benefited from conversations with many colleagues during the writing of this book. It has been a privilege to have had the opportunity for quiet reflection and study, undisturbed by the pursuit of grant funding that distorts so much academic study today. This work would not have reached fruition without the contributions of many people. Former students and members of their families, members of my own family too, have spent long hours, reading and providing feedback on my efforts to produce an accessible account. In particular, I should like to thank Martin Lyons, Mark Germain, James Hollow, Geoff Hollow, Paul Neate, Rachel Allen, John Mulvey and John Priestland for their reading of the text and important comments. Chris Gibson and Jack Simmons have provided me with invaluable comment and information. Throughout, I have relied heavily on the encouragement of Elizabeth Jackson and my wife, Kate – their advice and persistence were essential. I thank Kate and all members of my family for their love and tolerance over the past three years while I have been rather absorbed.

Finally I would like to thank Paul Simpson of LynkIT and Cathi Poole of YPS for their enthusiastic ideas and *can do* reaction to the task of printing and promoting this book and its message.

Wade Allison,
Oxford, September 2009