

The Fairy Tales of Science

A Study of Popular Science Books

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Volume One

Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma at any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by any other person except when due reference is made in the text. The empirical work described within was not carried out with any other person.

The original manuscript of *Hunting the Double Helix* has been edited according to normal publishing practice.

A handwritten signature in black ink, appearing to read 'A. Meyer', written in a cursive style.

Anna Jane Meyer

*“Comrades, leave me here a little, while as yet 'tis early morn:
Leave me here, and when you want me, sound upon the bugle horn.*

*'Tis the place, and all around it, as of old, the curlews call,
Dreary gleams about the moorland flying over Locksley Hall;*

*Locksley Hall, that in the distance overlooks the sandy tracts,
And the hollow ocean-ridges roaring into cataracts.*

*Many a night from yonder ivied casement, ere I went to rest,
Did I look on great Orion sloping slowly to the West.*

*Many a night I saw the Pleiads, rising thro' the mellow shade,
Glitter like a swarm of fire-flies tangled in a silver braid.*

*Here about the beach I wander'd, nourishing a youth sublime
With the fairy tales of science, and the long result of Time.....”*

Opening lines of “Locksley Hall”
by Alfred, Lord Tennyson (1809-1892)

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Abstract

A visit to any major bookstore reveals a group of books that fit within the genre entitled 'Popular Science'. On these shelves, a diverse collection of texts can be found, on topics as varied as evolution, space travel, astronomy, biography and science history. Defined here as 'books about science which do not require a specialist knowledge in the subject of the book in order to be read, enjoyed and understood', popular science books are a significant science communication medium.

Despite this, and the apparent recent increase in the popularity of these books, little critical evaluation of the genre exists. A reason given for this is that the popular science book genre is very diverse, making analysis difficult. In this thesis, two avenues of research were undertaken to begin to aid this situation. First, a study was carried out to identify and characterise the sub-genres that exist within the popular science book genre. This revealed that the genre can be divided into 12 distinct categories, each with unique defining features. A 'diagram of relationships' for the categories within the genre was also developed. Following this, the features of a group of bestsellers in one of the identified categories, 'Stories of Scientific Endeavours or Events', was investigated. From this, a list of common characteristics of successful popular science books was compiled for this category.

The results of both lines of research were then applied and exemplified in the production of an 'artifact of science communication' – a new, full-length popular science book on ancient DNA research: *Hunting the Double Helix: How DNA is solving puzzles of the past* (published by Allen & Unwin in 2005).

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Chapter One

Introduction

The books contained within the 'popular science' genre are a diverse collection, encompassing works that range from explanations of science, to science history, biography, collections of science facts, practical science guides and illustrated volumes, covering topics as varied as evolution, space travel, astronomy, genetics and artificial intelligence. Defined here as 'books about science which do not require a specialist knowledge in the subject of the book in order to be read, enjoyed and understood', popular science books are a significant science communication medium.

Despite this role, and the apparent recent increase in the popularity of the genre (Leane, n.d.b), few academic studies of the genre have been carried out (Buchanan, 1991; Leane, n.d.b; Leane, personal communication, October 30, 2001; Lewenstein, personal communication, October 24, 2001; Smith, 1996; Turney, 1999). One of the reasons given for this is that the diversity of the genre makes analysis problematic (Leane, n.d.b; Turney, 1999; Turney, 2001b). Any analysis which aims to investigate, for example, the features of bestselling popular science books (Chapter 4) is meaningless when the genre is treated as a whole. It is clear, therefore, that any study of popular science books must first take into account the following question: into what different categories, or 'sub-genres' can popular science books be divided? Although a number of opinions exist on the characteristics which differ amongst popular science books and the categories into which the genre can be divided, no systematic study has been published on this topic.

Popular science books are a significant science communication medium. Some books, however, may be more successful in this role than others, and the factors that lead to success may vary between the individual categories that exist within the genre. There are different ways that 'success as a science communication medium' could be defined, but one is to use sales rankings. Sales success varies greatly from book to book, with some, such as Stephen Hawking's *A Brief History of Time* (1988), selling many copies and gaining prominence on bestseller lists, while others are less successful. A range of opinions can be found as to the reasons why some popular science books sell more successfully than others. Little research has been conducted, however, as to whether these opinions accurately reflect the real features of bestselling popular science books, and no research has been conducted as to the features of bestselling popular science books in specific categories.

The primary objectives of this thesis are to overcome the barrier to research that is the diversity of the popular science book genre by defining and characterising the different categories that exist within it; to analyse the features of bestselling books in a specific category; and to exemplify the results of both avenues of research in the production of an 'artefact of science communication' – a new popular science book on ancient DNA.

The results of this research will be of benefit in both the commercial and academic arenas. In the commercial world, the classification scheme will benefit those involved in producing popular science books as it will allow editors, publishers and authors to focus on a particular sub-genre when designing new books, and to incorporate the defining features of it into the publication. This could lead to increased sales, as readers who are drawn to particular categories of books will enjoy new publications that reliably contain the defining features of their sub-genre of choice. Additionally, the classification scheme could allow publishers to analyse which categories of books are the most economically viable, and this information could help in making decisions about which books to publish. Book producers could also benefit from the research on the features of bestselling popular science books, as it will provide information that could be useful when designing new books that focus on stories of scientific endeavours or events, by helping to produce books that are likely to succeed.

In a similar way, this research will benefit those involved in selling popular science books, including both online and physical retailers and those involved in advertising and marketing. For example, knowledge of the categories of popular science books could allow new groupings of popular science books on shelves in bookstores and in advertising brochures. Books within the same sub-genre could be grouped together, making it easier for readers who favour particular categories to find books that appeal to them. This, too, could increase sales.

Finally, this research will benefit popular science book readers, as the information that it gives authors, publishers and sellers, both regarding the features of the books themselves and in how they are displayed for sale, could assist in readers choices about which books to buy and read, and could increase the likelihood that they will enjoy the books that they purchase.

In the academic world, the work will be of interest to researchers in science communication. For example, one of the aims of science communication is to explain and discuss current science in a form that is accessible to non-specialists. Popular science books are an important medium for achieving this aim, and several of the categories identified in Chapter 3 identify this as a main focus or significant feature. The use of this information by future science communication researchers

could lead to greater success in communicating new scientific advances to non-scientists. A number of other uses for the work are contained within the thesis; for example, the classification scheme could be used in the future as a basis for research on the readership of popular science books.

In this thesis, two lines of research on the popular science book genre were undertaken. The first of these was a study to identify and characterise the categories that exist within the popular science book genre. A sample list of 94 current popular science books was assembled, and from the shared and differing characteristics seen between the books in this sample, a list of 12 individual categories was compiled. The detailed characteristics of each category were investigated, and the categories arranged into a 'diagram of relationships' for the genre.

The second area of research was an investigation of the common features of a sample of bestselling popular science books in the category 'Stories of Scientific Endeavours or Events'. Opinions outlined in the literature were used to compile a list of features which may aid success. The items on this list were then compared to a number of current bestsellers and, from the patterns that emerged, a list of common features which may contribute to the success of books in this category was compiled.

The results of both avenues of research were then applied and exemplified in the production of a new, full-length popular science book on ancient DNA: *Hunting the Double Helix: How DNA is solving puzzles of the past*. The book was written for this PhD project as an 'artefact of science communication', to make an original contribution to the genre and to exemplify the results of the research conducted on the popular science book genre. Designed to demonstrate the defining characteristics of the category 'Stories of Scientific Endeavours or Events' revealed in Chapter 3 and the bestselling features of it revealed in Chapter 4, the finished book is a 62,000-word collection of 7 chapters of stories of scientific endeavours that have been carried out within the field of ancient DNA research. The book has been commercially published by Allen & Unwin (Sydney, Australia, 2005).

This thesis is divided into two volumes. Volume One contains the five chapters relating to the analysis: Chapter 2 provides a review of literature related to popular science books; Chapter 3 discusses the categories that exist within the genre, their defining features and their relationships to each other; Chapter 4 contains an analysis of the features of bestsellers in the category 'Stories of Scientific Endeavours or Events'; and Chapter 5 contains the background and construction of the new popular science book, *Hunting the Double Helix*, and how it relates to the research contained in Chapters 3 and 4. Volume Two contains a copy of the text of the published book.

In the next chapter, the literature related to popular science books is reviewed.

Chapter Two

Literature Review

Introduction

This chapter is a discussion of a number of aspects of the current literature related to popular science books. The chapter begins with a discussion of definitions of popular science books and their readership, followed by a commentary on the place of popular science books in the discipline of science communication and the role of the genre in 'The Two Cultures' debate. The chapter ends with an examination of the popular science 'boom' and a discussion of the lack of critical evaluation of the popular science book genre.

Definitions of 'Popular Science Book'

Most definitions describing popular science books centre around the concept of books about science that are designed for a lay, or non-specialist audience. Turney (2001b) defined popular science books as "books about science for non-professionals" (p. 47); Rayl (1992) classed popular science books as "those that bring scientific knowledge to the public in a voice that the layman can understand and appreciate" (para. 2); and Leane, in her study of popular physics books stated that: "Most obviously, the function of these books is to make science accessible to non-scientists" (n.d.a, p. 4). Ben-Ari defined popular science books more tightly as "books written by scientists for a popular audience" (1999, Ups and downs section, para. 1).

Leane, however, (n.d.a) questioned what is meant by a lay audience. Is this an audience consisting of one group of people with similar educational and socio-economic backgrounds, and does it exclude those who are specialists in the topic that the book is about? Rogers (1992, p. 232) also queried what a 'general readership' really means. Does it mean scientists from other disciplines, or graduates from non science fields, educated professionals such as doctors and lawyers, or even those without high levels of formal education, such as "plumbers and butchers"? MacDonald-Ross (1987, p. 178) believes that "we cannot make do...with a simple dichotomy between 'professional' and 'public'". If 'public' refers to literate non-specialists, this group still encompasses a wide range of people, including university graduates, scientists in other specialities, or even early school-

leavers. The term 'public' covers people who are vastly different in reading skills, knowledge of science and interests.

Crowden (1994) suggested that popular science book authors such as Richard Dawkins have shown that popular science books can in fact have a wide audience, appealing to non scientists and scientists alike. Sapp (1995, p. 34) made a similar comment, saying that the audience for popular science is "extremely heterogeneous", including high school or university students, intelligent and curious laypersons, and concerned citizens or consumers who are seeking information for practical purposes. Nixon (1991) made the point that because science is relevant to our everyday lives, many wish to read about it.

MacDonald-Ross (1987), however, outlined the potential popular science book readers in more detail, dividing them into the following categories:

- Specialists with the same background as the author (not considered part of the general public)
- Scientists from other specialities
- Science teachers
- Technologists
- Other professional qualifications
- Humanities graduates
- 18+ school leavers
- 16+ school leavers

MacDonald-Ross believes that few books are read by the 16+ school leaver category, and suspects that most are read by teachers of science and fellow scientists.

Although the audiences for popular science books are varied, this does not matter in reality, because "at a basic level many popular science books will serve all their needs equally well" (Sapp, 1995, p. 34). The books are written at a level designed to be appropriate for the broadest possible audience, assuming little or no prior knowledge of the subject area. This raises a number of questions. If Sapp's comments are correct and, as a general rule, popular science books are written to suit those readers with the least scientific knowledge, how does this affect the satisfaction of other readers? Could an alternative be that the different types of popular science books are written to appeal to different audiences? This could be an interesting topic for future research.

Jerry Lyons, physics editor at W.H. Freeman, believes that science books may be especially relevant to many of the well educated people in society. "Everyone has a father or an uncle who is an engineer but has a lifelong interest in astronomy and is willing to read semi-technical things" (quoted in Nixon, 1991, p.33). Peter Guzzardi, Hawking's editor and Harmony vice president, said that there is a large number of intelligent and educated people amongst the public who enjoy the challenge presented by books like *A Brief History of Time* (Nixon, 1991). Buchanan (1991) also suggested that the general audience for popular science information are well educated (tertiary level), with higher levels of income, and are knowledgeable about science.

The audience for a popular science book can include those with a vocational interest in the subject, or scientists from another discipline. Although not able to make sense of primary scientific literature in the field, this audience looks for information at slightly more advanced technical levels. Many popular science books are written for these audiences (Sapp, 1995). Pulitzer prize winner Edward O. Wilson holds the opinion that because science is increasingly complex, popular science books can be very useful for scientists wanting to understand material from fields outside their expertise (Rayl, 1992). Agent John Brockman expressed a similar idea, saying that some new disciplines are multidisciplinary, meaning that experts from a wide range of fields work together. In order for the experts to communicate with each other, non technical language has to be widely used in these multidisciplinary fields. Writing popular science books can be a useful way for experts in a multidisciplinary field to communicate with each other at a level all can understand (Mantell, 1995).

Ben-Ari (1999) believes that it is highly likely that the audience for popular science books includes scientists as well as non-scientists. Leane, too, (n.d.a) made the point that some popular science books, although they are outwardly designed for non-specialists are often, in reality, also aimed at experts. The purpose of this type of popular science book is to introduce controversial new ideas to the author's scientific colleagues, ideas which might have been refused publication in traditional scientific journals because they were too speculative or vague. This goes against the usual idea that science popularisations are a way of simply transmitting knowledge from the scientific community to the public.

Bruce Lewenstein, Professor of communication and science and technology studies at Cornell University, believes that different types of science book appeal to different types of readers. The more popular, bestselling types of popular science books tend to appeal to non-specialist, general readers, whereas more influential, revolutionary science books are more often read by scientists or those with a close interest in the field (quoted in *Selling science*, 2001).

Rabiner (1994) pointed out that a proportion of the market for many science books is thought to include readers who are actually anti-science and anti-rational. Books on topics such as cosmology, evolution and ecology, such as a book about life on other planets, may be appealing to this group.

Several authors pointed out, however, that there is a lack of actual data on the readership of popular science books. MacDonald-Ross (1987) discussed survey research data collected for the book industry, pointing out that it is not possible to obtain detailed information about science books for the public from these surveys, as no category covers these books satisfactorily. Clewis (1989, p. 14) also mentioned the lack of data about the readership of popular science books. Whilst there is literature on who reads newspaper science, “Little information appears to be available on the readers of science books”. Buchanan (1991) made the point that there is little research on who buys books and actually reads them, and although the assumption is that those who buy books will read them, this may or may not be true. Book sales figures do not reflect additional readers from library copies or copies that get passed on from one reader to the next.

It would be useful, in a thesis such as this, to be able to give an accurate, brief readership profile for the popular science book genre. Given the current lack of formal research on the topic of the readership of popular science books, however, this is a difficult matter. This is further complicated by the diversity of the genre and the possibility of a different readership profile for each type of popular science book. Together, this adds justification to the need to divide the popular science book genre into a series of sub-genres, and suggests that for the future, a study which profiles the readership of each sub-genre identified in this thesis would be of interest.

Buchanan also pointed out that the issue of who reads popular science books may not be as relevant to authors as many think, at least in some respects. Most beginning writers are told to decide who their audience is. When it comes to the level of technicality this is good advice, but it should not be taken too rigidly when it comes to subject matter or presentation. Instead, “the most successful books are those that the author wants to write, those that appeal to the author”. It is not a good idea to try and contort one’s writing to “reach some contrived, imagined, and possibly nonexistent audience” (p. 8).

Bearing in mind the above points about the readership of popular science books, I believe a more inclusive definition for 'popular science book' would be:

“Books about science which do not *require* a specialist knowledge in the subject of the book in order to be read, enjoyed and understood”

Leane (n.d.a) also discussed a number of problems with the meaning and connotations of the terms 'popular' and 'popularisation'. However, she elected to “accept and employ” (p. 12) these terms rather than adopt new ones, whilst asking her readers to accept that they are used provisionally, and with a number of qualifications.

Leane stated that it can be difficult to decide if a particular book can be considered a part of the popular science genre. There are few sources which define exactly how to determine whether a book can be included in the category 'popular science'. Leane, however, made some suggestions. One way is to look at who the author intends the audience to be. There are problems with this, as the intentions of the author often do not equate with the responses of the readers. Reviewers also often complain that a book does not match the audience that it is intended for, and there is even disagreement on the subject between different reviewers. There are some other signals to look for within the book itself, for example:

...use of colloquialisms, avoidance of jargon, use of novelistic techniques...mathematical content; and various commercial strategies, including the cover artwork, the layout of the text, its title, the classification of the book, and where it is placed in bookshops. (p. 14)

Yet there is no foolproof method to categorise a book as popular science, and a book that might be classified as 'academic' by one publisher, might be classified as 'popular' by another. Overall, Leane took the approach of acknowledging the problems with the usual definition of popular science books, recognising that it is a somewhat blurry category, but working with it anyway.

Popular Science Books and Science Communication

As noted by Burns, O'Connor and Stockmayer (2003), popular science books fall within the discipline of science communication. It is worthwhile, therefore, to focus briefly on an examination of their place within this discipline.

The following scheme could be used for this purpose:

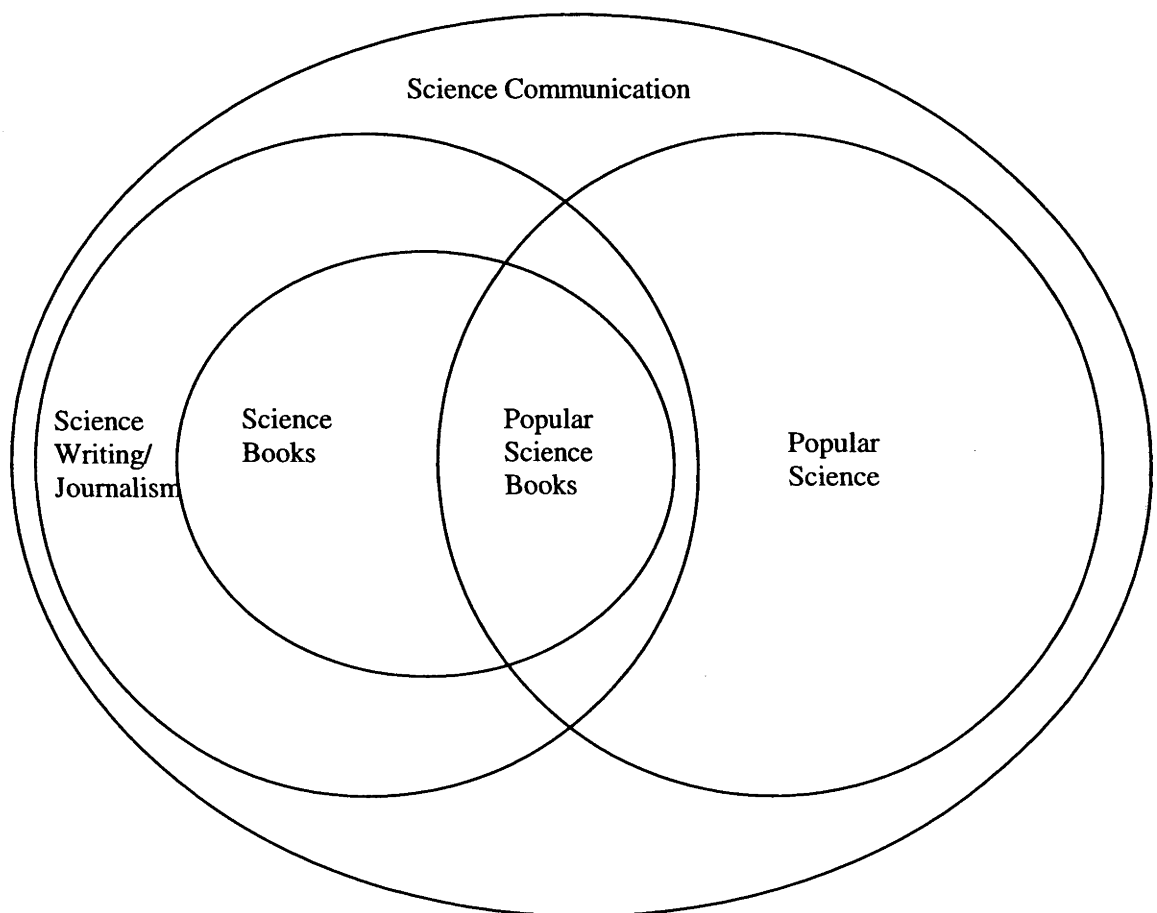


Figure 2.1: The Place of Popular Science Books in Science Communication

The largest circle in Figure 2.1 represents all the activities encompassed within the banner of 'science communication'. The body of literature surrounding the discipline of science communication is large, and opinions as to its exact nature vary. However, Stocklmayer (personal communication, July 15, 2001) defined science communication as:

...the development, application or study of various skills, media and activities with the purpose of making meaning of a message. The message relates to *science*, and opportunities and constraints for the meaning-making process are provided by *communication* theory and practice.

This issue is explored in greater detail by Burns, O'Connor and Stocklmayer (2003).

In practice, science communication uses many different media, and includes many different activities. Science communication includes discourse between scientists and non-scientists, as well as among scientists themselves. It can be both formal and informal. Burns et al. (2003) mentioned the following examples of science communication activities (p. 195):

- Education at schools, colleges and universities that may include lectures, tutorials, workshops, laboratory sessions and other learning activities
- Accredited courses and training programs
- Academic and professional conferences, presentations, and seminars
- Production of science textbooks and distance education materials
- Science centres and museums
- Media programs or coverage on film, television, radio, or in print
- Community or Internet forums on scientific topics
- Science groups, clubs and societies
- Computer-based activities on CD-ROM or WWW
- Science shows and theatre
- Open days at universities and research organisations
- Popular science books and magazines
- Community or school-based involvement in collecting research data
- Science competitions, events and festivals

The various activities of science communication could be categorised many ways, into many different subsets. However, in Figure 2.1 I have chosen to highlight just three of these subsets that are relevant to my discussion. These are the 'popular science' subset, the 'science writing/journalism' subset, and the 'science books' subset. As I will now discuss, all three of these come together to make up the category of 'popular science books'.

The 'popular science' subset is usually taken to mean any science communication activities that involve a non-specialist audience. Eger (1993) refers to popular science as "science for the general reader" (p. 186), and Charlton (1990) refers to popularisation as "communicating beyond the peer group" (p. 28). Examples of popular science activities include television lectures and documentaries, radio talks, science journalism, competitions, press releases, books for children, and features in magazines such as *New Scientist* (Charlton, 1990).

The 'science writing/journalism' subset includes all types of writing about science. Some forms of science writing can be considered a subset of 'popular science', for example popular newspaper and magazine articles, and popular science books. Other forms of science writing are not usually considered to be popular science, for example, professional science articles, conference proceedings, and laboratory manuals.

Several studies investigated some of the features that separate popular science writing from professional science writing (for example, Sapp, 1995). Other authors pointed out, however, that the divisions between professional and popular science writing are not always sharp edged. Turney (1999) made the point that there are no clear divisions between popular science books and professional scientific communication. Popular science books make different demands on their readers than papers in scientific journals, but they should be seen as part of a continuum of science communication rather than as separate activities. Eger (1993) also challenged the "well-established distinction between 'science itself' and 'popular science'" (p. 186), and discussed a category of popular science book: "new epic of science" (p. 186), which is viewed as popular, but in reality blurs the boundaries between professional and popular science writing. This category, and Eger's discussion is outlined in more detail later in this thesis.

The 'science books' subset of Figure 2.1 includes all books about science, and therefore falls entirely within the subset of 'science writing'. According to Lewenstein (personal communication, October 24, 2001) there are several categories of science books, including textbooks, reference books, conference proceedings, popular science books, bestsellers and prizewinners, and influential

science books. As discussed earlier, popular science books are defined as books for non-specialists, therefore they can be considered to be those books within the 'science book' subset which overlap with the 'popular science' subset.

In summary, therefore, popular science books are a branch of science communication. Within this discipline, popular science books can be considered a subset of popular science, and also a subset of science books, which are in turn a subset of science writing/journalism.

Popular Science Books and 'The Two Cultures' Debate

In 1959 British chemist C.P. Snow published *The Two Cultures*, a book centred around the observation that there is a gap in understanding between two groups of academics: those in the humanities, and those in the sciences. According to Snow, these groups can not communicate with each other effectively, leading to misunderstandings and distrust. Snow also believed that this gap in understanding exists in wider society. In a revised edition of *The Two Cultures*, published in 1963, Snow hoped there would be the emergence of a group, the 'third culture', who could bridge this gap between literature and science. Snow envisaged this group as being literary individuals who could communicate with scientists.

Brockman (1995) agrees with Snow's idea of a 'third culture' bridging the gap between the worlds of science and literature, but believes that it exists in the form of scientists who write books for the public, rather than literary intellectuals who communicate with scientists. Brockman cited the recent publishing success of a number of science books, and named a range of scientists whom he considers to be part of the third culture, such as Paul Davies, Martin Rees, Richard Dawkins and Stephen Jay Gould. "In addition ... the contribution of science journalists – many of whom are distinguished writers and notable thinkers – must also be recognized" (p. 20).

Turney (1996), however, disagrees with Brockman's ideas, pointing out that there are few scientists who can produce books that actually sell. Turney gave several examples of scientists who obtained high value contracts to write books but who did not succeed in selling their popular science books in great numbers, and disagrees with the view that scientists can bring readers closer to the science and explain it more accurately, as they may be too close to have a real perspective on the worth of particular scientific research. Brockman (1996) in turn, disagrees with Turney's views, quoting examples of popular science books written by scientists that did sell well.

Leane (n.d.a) expressed a similar view to Brockman, saying that popular physics books themselves can be viewed as an interface between the two cultures, for a number of reasons. First, these types of books make science accessible to non-scientists, including the literary community who, in most cases, can access scientific ideas only through popularisations. Second, when scientists write popularisations, they must make use of the tools of the literary trade. Popularisations must capture the reader's attention, like novels, and so popular science writers need to learn literary techniques. Physics popularisations therefore bridge the two cultures gap in two ways – they make science accessible to the literary community and, in writing the books, the scientific community learns tricks of the trade from the literary community. Thus, via the physics popularisation, each of the two cultures learns something about each other's culture.

The Popular Science Book 'Boom'

According to Leane (n.d.b), there exists a common belief that there has been a popular science book 'boom' within the publishing industry in the late twentieth century. In a detailed study, Leane examined evidence for this boom, and investigated its nature, its possible causes, and its implications. In order to gain an indication of the nature and extent of the boom, Leane interviewed publishers, booksellers, journalists and popular science writers, and reviewed articles in science magazines and newspapers, finding many claims of this recent boom within the popular science book genre. It is worth noting, however, that the available literature on this topic is somewhat dated. The sources referred to in the following discussion represent the most recent literature available.

I have also found considerable evidence of these claims in my own reading. For example, Turney (1999) commented that writing, selling and reading popular science books is in a boom phase at the moment, and since the mid-1980s these books have become much more popular than they were in the two decades before this. This boom goes beyond previous times when popular science books were very popular, such as in the 1930s. This time, there are more authors involved and more books which are seen as publishing 'events'. In another article, Turney repeated this thought, commenting that it is now fashionable again for scientists to write books for the general public (Turney, 1996). In a third article, Turney asserted that there are more popular science books in bookstores than there ever have been in the past (2001b). Turney summed up his thoughts about the boom in the following sentences:

The 1980s and 1990s saw a boom in popular science writing. Scientists writing non-technical books and professional writers who specialise in science topics have both benefited from an apparent upsurge of interest – among publishers and readers – in works which attempt to explain the ideas of contemporary science and their significance. A number of scientist authors, mainly from Britain and the US, have become minor celebrities. The strength of ‘popular science’ as a category has encouraged bookshops, review editors and commentators to take notice. This in turn has helped sustain production of new titles. In the UK, the Aventis (formerly Rhone-Polenc) science book prize now routinely receives a hundred or so entries each year. (2001a, p. 226-227)

According to chairman of judges in the 2001 Samuel Johnson award, Andrew Marr, there is a great deal of public interest and excitement in non-fiction in general at the moment, and particularly for popular science books, more so than that which exists for novels (Gibbon, 2001). Lewenstein (personal communication, October 24, 2001) also commented on this, mentioning that non-fiction bestsellers in fact sell about twice as many copies as fiction bestsellers. Bradford and Loose (1994) commented that they believe there is a “strong, growing global market for popular science books” (p. 41), and Ellmann (1998) believes that it is now normal for popular science books to be present on bestseller lists, and for their authors to appear on television. Guzzardi said that in recent decades a popular science book has been extremely popular at regular five or ten year intervals, but that in the last five years there has been one every year (Nixon, 1991)*. Rabiner (1994) believes there is currently a great demand amongst the “general book buying public” (para. 15) for scientific literacy and currency, and that scientists are currently in a very good position to have their work published and widely reviewed, better even than writers of other types of serious non-fiction.

Bhatiani (2001) claims that in the 1970s and 1980s, popular science books had a low profile and it was difficult to entice publishers to take them on. Nowadays, it is quite usual “to find science books such as Dava Sobel’s *Longitude* and Simon Singh’s *Fermat’s Last Theorem* high on the bestseller lists” (p. 158). In fact, science as a whole has become popular with the general public. As well as science books, science is also now a common feature of movies, and is used widely in advertising. Public interest and support for science in general is very high at present, and the popularity of science writing is one of the most striking features of this. Ferrell (1992, p. 11) believes that we are currently in a ‘golden age’ of science writing, with many “well-researched, carefully and beautifully written, ambitious books about the process of science, the history of science, the people who are doing science around the world”, and found it ironic that although science literacy is reportedly on

*It must be noted, however, that this reference dates back 14 years. This statement would have been more convincing had a more recent update been available. Unfortunately, the literature surrounding this topic is dated.

the decline, science writing is just the opposite. Rayl (1992) too, agreed that popular science books have become a new 'trend' (para. 2), with increasing numbers of scientists becoming involved in mass-market publishing. It is interesting to pose the question of why the popularity of popular science books is apparently increasing at the same time as science enrolments at University are apparently decreasing. To examine this fully is beyond the scope of this thesis, but this would be an interesting area for future research.

There is a number of opinions as to the causes of this boom. As Leane (n.d.b) also discovered, however, a number of commentators mention the phenomenal success of Stephen Hawking's *A Brief History of Time* as a major contributing factor. *A Brief History of Time*, published in 1988 achieved unprecedented sales figures. It spent almost 100 weeks on the New York Times bestseller list during 1988 and 1989 (Nixon, 1991), and sold 729,00 copies in its first year, and 410,000 more copies in the following year (Leane, n.d.b). In total, the book sold more than 1 million copies in hardcover (Rayl, 1992). Since then, it has sold more than 10 million copies and been translated into 40 languages (Ben-Ari, 1999; Overbye, 2001).

As pointed out by Leane (n.d.b), many commentators consider the book a phenomenon in popular science publishing, and mention it as being a cause of the popular science boom. Overbye (2001), called the book "one of the largest energy fields in the history of publishing" (p. F5). Rayl (1992) hypothesised that the growth in popular science books stems from the outstanding success of *A Brief History of Time*, and believed that the trend was set to continue for some time, perhaps spurred on by the public's speculated general fascination with science. Ben-Ari (1999) commented that the success of books like *A Brief History of Time* has led to an increased awareness that a significant audience exists for serious science books, written by scientists, that are designed for a broad readership, and Shurkin (1994) commented that "Steven [sic] Hawking had a monstrous bestseller ... so suddenly all books by famous scientists became hot properties" (para. 6).

Bhatiani (2001) too, named *A Brief History of Time* as one of several possible causes of the current popularity of popular science books. The trend began with Carl Sagan's *Cosmos* (1960), followed by Stephen Hawking's *A Brief History of Time* (1988), and the number and quality of good science books has increased every year. Since the success of *A Brief History of Time*, publishers have been trying to "fulfil the public's seemingly insatiable desire for knowledge about science" (p. 158). Sipchen (1990, p. E1) commented that before *A Brief History of Time* was published, "the non-fiction marketplace was a black hole for science books". Whilst self-help books, cooking guides and biographies of high profile people were popular, "the egghead stuff disappeared into a cultural cosmic void".

Appleyard (1999) also picked Hawking's book as worthy of comment:

The list of science bestsellers on both sides of the Atlantic is long and getting longer. Following the cosmic success of Stephen Hawking's *A Brief History of Time*, there have been scientific chart-busters from Richard Dawkins, Stephen Jay Gould, Edward O. Wilson, Steven Pinker and perhaps a dozen others. In certain circles it is routine, these days, to hear high-profile scientists discussing six and seven-figure advances from New York publishers...much of this writing is of a breathtakingly high standard. (p. 4)

Overbye (2001) commented too, that *A Brief History of Time*, together with Carl Sagan's *Cosmos* gave a commercial lift to the science book genre, and helped in the publication of a number of other popular science books on similar topics to Hawking's book. Rodgers (1992) made a similar comment, saying that as a result of the success of *A Brief History of Time*, publishers were persuaded easily to sign up a number of other popular science authors with large royalty advances. However, this seems to be true exclusively in the United States, and not the UK, where the Hawking phenomenon apparently did not have such an effect.

Leane (n.d.b), however, asserted that the success of *A Brief History of Time* might be responsible for affecting and even distorting opinions on the existence of a popular science boom, rather than actually being a cause of a boom, finding several commentators who did not believe that *A Brief History of Time* actually did lead to a popular science boom. Leane also found that in the US, the boom might have begun before the publication of *A Brief History of Time*. Turney (1999) made a similar comment, saying that although the boom in popular science writing is commonly credited to the success of *A Brief History of Time*, other scientists were writing very successful books before this, and many have done so since.

As well as the discussions of *A Brief History of Time*, a number of commentators had other ideas as to the causes of the popular science boom. Turney (2001a), for example, believes that the 'Hawking effect' (p. 227) is part of the answer, and that the opinion of Mirchandani (1994) that the boom is due to "the search for meaning in what is largely a post-religious society" (p. 227) might also be part of the explanation, although he does not believe either of these factors are the entire answer. Turney believes that the 'dynamism' (p. 244) of scientific research over the last thirty years has also had a role in the popular science boom.

According to Bhatiani (2001), non-fiction in general has seen an increase in popularity recently, and there has been growth in popular science writing in general, which combines “good story telling with feeding the public thirst for self-improvement” (p. 158). The advent of book prizes, such as the Aventis Prizes, have also contributed to the boom in popularity of popular science books. Marr made a similar comment, saying that this interest and excitement may be due to a ‘renaissance’ in popular non-fiction in Britain that has occurred recently, which includes non-fiction books in the fields of “biography, history, science writing and memoirs” (Gibbon, 2001, p. 1). Gibbon added that people are interested in popular science books because “there is a great searching for answers to the big truths”, and so books which “take on the great issues of time, space and who we are” have captured people’s interest.

Two commentators also believe that features of the writing itself may have a role. Michael Holroyd, biographer of George Bernard Shaw and Lytton Strachley, believes that non-fiction authors are so popular currently because they have started using many of the techniques used by novelists (Gibbon, 2001). Singh (2000) believes that the current boom in popular science publishing is partly caused by the recent trend for science writers to pay more attention to the story behind the science.

It is also worth considering that further contributors to the boom may be a rise in the global population, and specifically a rise in literacy rates in certain parts of the world. It is also possible that the range of popular science book categories may have not increased, and there are simply more books available in existing categories. Based on available evidence, however, it is not possible to make a judgement on whether these issues are actually the case.

Leane (n.d.b), however, questioned the validity of the claims of a popular science boom, describing them as generally “vague and speculative” (p. 55), and saying that it is “possible to find data which supports the argument that there is or was no boom” (p. 55). After examining a set of data on the recent history of popular science publishing, Leane found for a variety of reasons, “drawing conclusions from these figures is problematic” (p. 57). Therefore, “there would seem to be an argument for caution regarding claims of a sales boom” (p. 60).

I also found several sources which cast doubt on the magnitude and nature of the popular science boom. Editor Susan Rabiner (Mantell, 1995), and Tallack (2004) both believe that the peak has been and gone for popular science books. Rabiner believes this may be because society has now caught up with what is happening in science, and that “there’s not enough new work jelling together to generate new books” (p. 42). A similar sentiment was echoed by Tallack. Macmillan senior

editor John Michael agreed with the view that it is possible to catch up with what is happening in science, but believes that the new developments that are happening in biology, such as the Human Genome Project, may provide fascinating new material for popular science books (Mantell, 1995).

Mantell (1995) pointed out that even given the current popularity of popular science books, publishers should not generally expect astronomical sales figures compared with some other genres. Mantell interviewed Freeman editor Elizabeth Knoll, who said that if a popular science book sells 10,000 copies, then this is considered a success, and found that other publishers cited similar figures, with the conclusion that if a popular science book sells in the low to mid five figure range, then this can be considered a success. Rayl (1992) concurred, saying that most popular science books do not sell more than 20,000 copies, even though 60,000 copies or more are necessary to gain a place in the bestseller lists.

Buchanan (1991) also believes that sales of popular science books are generally modest, pointing out that at the time of writing, only five science books have made it onto the annual non-fiction, hardcover bestseller list since 1975. "It is apparent, then, that science books make up a small percentage of bestsellers" (p. 6). Durrani (1998) also agreed, cautioning potential popular science writers not to have unrealistic expectations, as the majority of popular science books sell just a few thousand copies. Leane (n.d.b) too, examined figures which indicate that even bestselling popular science books do not sell as well as fictional bestsellers. MacDonald-Ross (1987) distinguished between the sales success of two different types of popular science books, and holds the view that few books aimed at the public which are works of pure science reach fast-seller lists, and those that do are "spin-offs from television series or provide the basis for practical or social topics of great interest to the general reader" (p. 178). People buy books that are sold to them as containing benefits they recognize and want. Books *based on* scientific research on the other hand, can have huge sales and influence as long as they are on topics of interest to the general reader such as social topics, ecology, health and fitness.

Nixon (1991), however, disagreed with the previous authors, and remarked that in fact popular science authors can sometimes get excellent advances, giving the example of literary agent John Brockman, who has gained high advances for popular science books. Nixon also mentioned several other literary agents who have gained high advances for authors of popular science books.

Overall, Leane (n.d.b) recommended caution in accepting some of the claims about a popular science boom. Although the majority of opinions stated that there has been a recent boom, she found a general lack of useable quantitative data on the subject to either confirm or refute these

claims, and the data she did manage to obtain may actually indicate that the genre has remained static from the 1970s to the 1990s, although precise conclusions are difficult. Some of these claims may have been exaggerated, and should be regarded with caution. Leane also made the point that although there was general agreement amongst her sources that there was a boom, there were “a wide range of opinions about its nature and causes” (p. 52), and concluded that the boom in popular physics publishing at least is a “real but complex phenomenon” (p. 79), but the exact causes and significance may not be known until a later date.

In conclusion, it seems likely that there was a popular science book boom in recent times, a trend which appears to have begun in the late 1980s. A range of opinions are also available as to its cause, but it is possible that a general increase in interest in science among the general public may be a significant factor. However, it must be noted that, as pointed out by Leane (n.d.b), there is little quantitative data available to support claims of a boom, so it should be regarded with caution. It must also be recognised that the literature in this area is dated, and therefore firm conclusions can not be drawn about what has occurred in the last few years. A more quantitative examination of the state of popular science book publishing as it stands today would, therefore, be an interesting area for future research.

Critical Evaluation of the Popular Science Book Genre

Several authors commented on the existence of a lack of academic studies applied to the genre of popular science books. Turney (1999) pointed out that most comments on the ‘new wave’ (p. 121) of popular science books have come from journalists, and that there has been little academic analysis in this area to date. Lewenstein supported this view, commenting that there is not a great deal of scholarly work in the area of popular science books yet (personal communication, October 24, 2001). Leane also made a similar comment, saying that although there has been some work in the field, in her opinion it is still very much underdeveloped, and that the rise of cultural studies has meant that many types of popular texts now get studied, but not popular science books, despite the influence they have on the public’s image of science (personal communication, October 30, 2001).

Leane, (n.d.b) pointed out that analyses of contemporary popular science writing in general are rare, and the analyses that do exist concentrate on popular science writing in science magazines or newspapers, but not books. Studies have been made of the language of scientific research itself, but popular science writing has largely been ignored, and the body of literary analyses of science writing is heavily weighted towards pre-twentieth century eras. Because science is so important in

the twentieth century, and that physics and astronomy specifically are interesting to people and are relevant in many major concerns of world, it would be expected that physics popularisations would have been the subject of devoted studies, but this has not been the case. Buchanan (1991) commented that studies of many other forms of popular science research do exist, but popular science books tend to be overlooked. Studies of popular science that do exist concentrate on television, newspapers and magazines, and informal education such as visits to museums, but not books. As an example, Buchanan mentioned a recent study which looked at all of these types of science popularisation, but did not mention the role of books in science popularisation.

These opinions were supported by searches I conducted of a wide variety of databases of academic literature which cover diverse topics, including literature, social science, education, and general science, as well as a number of multi-disciplinary databases. The details of these searches are outlined in Table 2.1.

Table 2.1: Database Searches Performed in Sourcing Current Literature on Popular Science Books

Database	Date Searched	Search Terms
Humanities Full Text	2/5/02	Popular Science Book Popular Science Books Science Books Science Book Science Writing Science Communication
Web of Science (all three indexes)	2/5/02	Popular Science Book Popular Science Books ³ Science Books Science Book Science Writing
Project Muse	3/5/02	Popular Science Book Popular Science Books Science Books Science Book Science Writing
Science Direct	3/5/02	Popular Science Book Popular Science Books Science Books Science Book Science Writing
JSTOR	8/5/02	Popular Science Book Popular Science Books Science Books Science Writing

Table 2.1 continued

AEI	9/5/02	Popular Science Book Popular Science Books Science Books Science Book Science Writing
Dissertation Abstracts	9/5/02	Popular Science Book Popular Science Books Science Books Science Book Science Writing
General Science Plus (ProQuest) 1999 to Present	9/5/02	Popular Science Book Popular Science Books Science Books ¹
ERIC	9/5/02	Popular Science Book Popular Science Books ³ Science Books Science Book Science Writing
Index to Theses	13/5/02	Popular Science Book Popular Science Books Science Books Science Book
International Bibliography of the Social Sciences	13/5/02	Popular Science Book Popular Science Books Science Books Science Book
LION: Literature Online	13/5/02	Popular Science Book Popular Science Books Science Books Science Book
MLA International Bibliography	13/5/02	Popular Science Book Popular Science Books Science Books Science Book
Wiley Interscience	13/5/02	Popular Science Book Popular Science Books Science Books Science Book
PCI	13/5/02	Popular Science Books Popular Science Book Science Book ²
FirstSearch (Arts and Humanities Search)	17/5/02	Popular Science Book Popular Science Books Science Books Science Book
FirstSearch (Essay and General Literature Search)	17/5/02	Popular Science Book Popular Science Books Science Books Science Book
FirstSearch (Humanities Index)	17/5/02	Popular Science Book Popular Science Books Science Books Science Book ²

Table 2.1 continued

FirstSearch (Periodical Abstracts)	Begun 17/5/02, completed on 28/6/02	Popular Science Book Popular Science Books Science Books Science Book
FirstSearch (Social Sciences Search)	17/5/02	Popular Science Book Popular Science Books Science Books Science Book ²
Ingenta (Uncover Plus)	28/6/02	Popular Science Book Popular Science Books ³ Science Books Science Book
Ingenta (Online Articles)	28/6/02	Popular Science Book Popular Science Books Science Books Science Book
Current Contents (Full)	28/6/02	Popular Science Book Popular Science Books ³ Science Books Science Book

¹This search returned 850 articles so was refined to the following sub-searches: Science Books: Criticism; Science Books: Critique; Science Books: Analysis; and Science Books: Appreciation.

²Checks of the first approximately 50 results showed that the articles did not appear relevant to popular science books, therefore these searches were abandoned.

³Search repeated 22/2/05

These searches confirmed that indeed, critical evaluations of the popular science book genre are rare. As pointed out by Turney (1999), most of the articles that do exist are popular articles themselves, published in newspapers or magazines. The majority are commentaries by those in the publishing world, or opinions of established popular science writers, primarily aimed at providing useful tips for those aspiring to be authors of popular science books, or advice for those who enjoy reading them. Reviews and a small number of studies of individual books or authors also exist, but there is very little in the way of peer reviewed, academic research into the popular science book genre.

Turney pointed out one possible reason as to why this lack of academic evaluation of popular science books might exist – the diversity of the genre. Popular science books do not form a “single, easily defined genre” (2001b, p. 47). Instead, many different types of books exist under the ‘popular science’ banner, making evaluation difficult. This point is also mentioned in another article by Turney (1999), who said that popular science is “not a single, simple genre, or even a single type of book” (p. 121). The reason that the genre is so diverse is in the way that the popular science book category is defined. The definition of popular science writing as “writing about science that is not intended for an exclusively professional audience”, means that it is not surprising that the genre is

diverse, as there are a number of ways this definition can apply, and a variety of reasons for doing popular science writing (Turney, 1999, p.121).

Mantell (1995) made a similar point, mentioning that popular science books include a wide variety of styles, all very different to each other. Some of these include “narrative accounts of breakthroughs, hands-on manuals, reference works, biographies, histories and explorations of ethical questions” (p. 40). Leane (n.d.b) agreed with this, pointing out that in publishing data, the category of ‘popular science’ groups together all types of books which range from books by Richard Dawkins and Stephen Hawking, to *The Little Book of Feng Shui*, and *The Rough Guide to the Internet*. A category which groups all of these types of books together is “all but meaningless” (p. 60).

In addition to this, Leane (n.d.b) found that in book industry data, popular science books are often not classed as a separate category, but instead are grouped together with all other types of science book, making analysis of the popular science book genre difficult. MacDonald-Ross (1987) made a similar comment, and discussed survey research data collected for the book industry, pointing out that it is not possible to get detailed information about science books for the public from these surveys, as no category covers the genre satisfactorily.

Turney (2001b) also believes that the lack of academic research into popular science books is in part because there is currently no established method, no critical vocabulary, for critically evaluating books in this genre. Leane believes that the lack of analysis could also be due to current trends in critical analysis, trends that have meant that it has not been thought necessary within the literary community, for various reasons, to study popularisations, even though they have been aware of their existence.

It is clear, then, that there is room for further analysis of the popular science book genre. In the next chapter, this process begins, with a detailed investigation of the different categories of popular science books.

Chapter Three

A 'Taxonomy' For The Popular Science Book Genre

Introduction

The previous chapter included a discussion of the lack of research on the popular science book genre, despite its apparent recent increase in popularity. One of the barriers to the study of popular science books is the diversity of the genre (Leane, n.d.b; Turney, 1999; Turney, 2001b). 'Books about science which do not require a specialist knowledge of the subject of the book in order to be read, understood and enjoyed', is by nature a broad and diverse collection of texts, ranging from complex explanations of quantum physics such as Stephen Hawking's *A Brief History of Time* (1988), to historical accounts of scientific endeavours, such as Dava Sobel's *Longitude* (1998), to fun books of science facts, such as Adam Spencer's *Book of Numbers* (2000).

Because the genre of popular science books is diverse, any analysis which aims to investigate, for example, the features of bestselling popular science books (Chapter 4), is meaningless when the genre is treated as a whole. The saying 'compare apples with apples' becomes impossible when confronted with the fruit salad of the popular science book genre. It is clear, therefore, that any study of popular science books must first take into account the following question: into what different categories, or 'sub-genres' can popular science books be divided? Answering this question will allow particular sub-genres of interest to then be analysed individually.

Although a number of opinions exist about the characteristics which differ amongst popular science books and about the categories into which the genre can be divided, no systematic study has been published on this topic. This chapter aims to address this gap, with a detailed investigation of the different categories of popular science books.

A sample list of 94 current popular science books was assembled, and from the shared and differing characteristics seen between the books in this sample, a list of 12 individual categories was compiled. The detailed characteristics of each category were investigated, and the categories arranged into a 'diagram of relationships' for the genre. Before describing this classification, however, a brief review of the previous literature about categories of popular science books is presented.

Literature Review

Categories of Popular Science Book

New Scientific Ideas

Shermer (2001) identified a type of popular science book in which the author introduces and discusses a new scientific idea. Written for a non-specialist audience, they are also “original works of science appreciated and cited by professionals in his field...and fields beyond” (para. 4). These are not simply compilations of others’ work, but introduce new ideas for the first time by scientists, both to the general public and other scientists. Two examples of books in this category, both by Stephen Pinker, are *The Language Instinct* and *How the Mind Works*.

Turney (1999) made a similar point, citing the example of *Descartes’ Error*, by Antonio R. Damasio, a book which is clearly addressed to the general reader, but is “also a new synthesis of Damasio’s ideas about how emotion and reason interact” (p. 123). Although the book is a popularisation, it also aims to persuade fellow scientists about the author’s ideas and approach.

Leane (n.d.a) believes that the purpose of this type of book may be to introduce controversial new ideas to the author’s scientific colleagues which might have been refused publication in traditional scientific journals because they were too speculative or vague. These books are often more mathematical than other popular books, and are often classed as ‘semipopular’ (p. 14). The idea that books in this category may have the role of introducing controversial new scientific ideas has been proposed by several others. Computer designer and popular science author Daniel Hillis said that many scientists write books because “there are certain kinds of ideas that have absolutely no way of getting published in the scientific community” (Turney, 1996, para. 12). Turney believes this view may be too strong, but agreed that a number of scientists do use books to discuss their more unorthodox ideas. In a later article, Turney expanded on this, saying that by presenting new scientific ideas in this format, “elements of ... thinking...that ... would be obliged to expunge from a scientific paper” (Turney, 1999, p. 123) can be retained. For example, this might include hypotheses with few facts to support them or facts in doubt. This allows the researcher to explore and present their ideas in a much freer format than in traditional scientific literature, and allows the ideas to enter the scientific literature, through others’ citations. Steven Pinker, Professor of psychology at MIT believes that books in this category also allow the opportunity to look for answers to scientific questions that are often ignored in a scientific field, because “they are not the type of hypotheses that you test

day to day in your grant-supported research” (Shermer, 2001, para. 44). These might be questions in which the general public is interested, but academics do not usually become involved. Leane (n.d.a) believes that authors of this type of book are also likely to aim to merge scientific disciplines together, and this may mean that publishing is not possible in a traditional scientific forum.

One anonymous author noted that scientists writing this type of book can occasionally overstate the case for their theory, and in the process, weaken it and blemish a book which would otherwise be “intriguing and provocative” (Books and arts, 2001, Criticism and criticality section, para. 5). Although ‘grand claims’ may help to sell books and generate publicity, it may be more prudent to adhere to scientific principles: “present a hypothesis, examine the data, and leave readers to conclude what they will” (Criticism and criticality section, para. 6).

Eger (1993) called books of this type: “the new epic of science” (p. 186). They combine high quality writing with scientific depth. Usually written by scientists, especially famous ones, they are often very serious in theme and mood, with complicated technical ideas. Because of this, they can be difficult, demanding reads, a point reiterated by Rabiner (1994). Eger agreed with the idea that these books can often be used to cross professional barriers within branches of science, and have an impact on serious thinking in non-scientific fields. These books have a common basic structure: ‘P-S-P’ (philosophy-science-philosophy). Beginning with a philosophical survey, which poses human or social problems and relates them to an aspect of science, the science is then discussed at length, often with ‘great excitement’ and an emphasis on new discoveries. The books end with the original problems, together with proffered solutions based on the science that has just been discussed. Although these books focus on different branches of science, all are based around aspects of universal/cosmic evolution. This type of book is generally classified as a popularisation, but they are fundamentally different from other popular science books, and are aimed neither at specialists or casual readers. An example given is *Gödel, Escher, Bach* (1999), by Douglas Hofstadter.

Explanation of Current Science

A second category of science book is that which is designed primarily to explain current science to a non-specialist audience (Rabiner, 1994; Sapp, 1995). According to Rabiner, these books are unlike the previous category. They are not intended to introduce new ideas or influence scientific opinion, but simply explain cutting-edge science to intelligent readers who are interested. Wilford (1997) called them “books that bring a new concept in science to the public attention” (p. 49).

A similar point is made by a different, anonymous author, who said that certain popular science books are “about the substance of science; about what the scientists believe to be true about the world” (Post prospero, 1994, para. 3). These books do not say a great deal about how discoveries were made or how scientific beliefs came about. The best science books of this type are those in which the author does not simply state what they know, but instead aim to convince the reader that their approach to knowledge itself is correct.

Bowring, science publisher at Allen & Unwin (personal communication, October 24, 2001) mentioned that popular science books on complex topics such as “general relativity, string theory or some aspect of evolution” can be difficult to read. The audience for these books is likely to be members of the general public who are scientifically literate, and may often include those with some science education.

Morrison & Morrison (1999) combined this category and the one above into a type of science book that they called monographs. These are the most technical science books. Some of them “opened an entire new discipline” (para. 5), whereas others, essentially, summarise.

Advocacy Books

Wilford (1997) identified a further category of popular science book which is aimed to “argue a position or sound an alarm” (p. 49). Books of this type often revolve around topics such as environmental issues or threats of disease, or even ‘fringe’ science, such as UFOs. Wilford called these ‘advocacy’ books (p. 49).

Books Which Examine Science Itself

Morrison & Morrison (1999) mentioned an additional category: ‘science itself examined’ (Science itself examined section). An example is Thomas Kuhn’s *The Structure of Scientific Revolutions* (1996), a theory on the process of science, which argues that scientific research is centred around a series of ‘paradigms’, that researchers use as a basis and focus for research. Periodically, ‘scientific revolutions’ occur, which create new paradigms and change the focus of research – a contrasting view to the traditional idea of science as a process of steady, cumulative fact-gathering.

Stories of Particular Science Endeavours

McDonald (2000) mentioned that some popular science books concentrate on telling the story surrounding a particular historical scientific endeavour, citing Dava Sobel's *Longitude* as a leader in this category. These books are generally short, with a strong narrative storyline, and are particularly popular at present. Bowring mentioned that these types of books are often less 'scientific' than other types of popular science book, and are written for those adults who, rather than seeking a complex scientific explanation, simply "want a good read about an interesting subject" (personal communication, October 24, 2001). Horgan (1997) believes this category has much to offer, and has great potential for the future of popular science books, as the history of science has many great achievements that would make appealing subjects for books. "The future of science books may be science's past" (p. 39).

History of Science

A further category of popular science book is the history of science (Morrison & Morrison, 1999), consisting of books which trace a single theme in science history. This category includes illustrated 'encyclopedic' books, for example.

Biography and Autobiography

Biographies and autobiographies of scientists are two other categories identified in the literature (Morrison & Morrison, 1999). Sapp (1995) commented that biographies and autobiographies are about the people involved in science, as well as the social context in which they lived and worked, and that writing about science in this way can be useful in personalising science. Similarly, Rabiner, in an interview with Nixon (1991) said that biographies and autobiographies can provide an ideal avenue into science, as they are accessible to non-scientists whilst still allowing an insight into how science operates. "They immerse us in the world of research and ideas without a blackboardful of equations" (p. 34). Turney (1999) also holds the view that biographies, although primarily aimed at telling the lives of scientists, still very often involve explanations of science also.

Turney (1999) sees autobiography as a complement to biography, but believes that the autobiography category is in itself quite diverse. Differences in approach depend on how much the author focuses on explaining their science, versus telling their life story, versus telling the story of their scientific work.

Practical Guides to Scientific Activities

Bradford and Loose (1994) and Turney (1999) identified a further category: 'how to' practical guides to scientific activities and topics, such as dinosaur hunting, amateur astronomy, fossil hunting, personal disease management or how to build a computer. Turney mentioned that these books are similar to textbooks, but are different in the way that they relate to the reader.

'Fun' Science Books

Bowring (personal communication, October 24, 2001) identified a category of science book - collections of essays and short explanations about a variety of 'fun' science topics. suitable for both children and non-scientifically educated adults alike. Books by Karl Kruszelnicki are an example, such as *Pigeon Poo, the Universe and Car Paint* (1996), and *Q&A with Dr K* (2001).

Dictionary-Type Collections of Science Facts

Turney (1999) mentioned books which consist purely of collections of scientific 'facts': "dictionaries or primers for scientific literacy" (p. 122), which present the facts of an area of science, with little discussion of historical context, or other background information. Examples include *Collins Gem Physics Basic Facts* (1996), and *Weatherwise* (1999).

Field Guides

Morrison and Morrison (1999) discussed field guides, which "compile and compactly describe many nouns of modern science" (Field guides section, para. 1). In these books, "images are of central importance" (Field guides section, para. 1), and the category includes atlases, illustrated guides, and field guides to birds.

Regional Science Books

Buchanan (1991) discussed 'nontechnical regional science books' (p. 7), which provide scientific information for a lay audience on the flora, fauna, geology and environment in a small area. This type of book appeals to well-educated, often young people, interested in learning more about a region and environment, and can often be more difficult in terms of readability than best-selling popular science books.

Characteristics of Popular Science Books

Morrison and Morrison (1999) made the point that the categories of popular science book are “by no means sharp edged” (para. 4). Turney (1999), too, said that the categories he named are not mutually exclusive.

Together with the opinions and comments described above about categories of popular science books, a number of further comments regarding specific characteristics of popular science books are relevant to this study. A discussion of these follows.

Novel-Like Versus Encyclopedia-Like Popular Science Books

Leane (n.d.a) identified a group of popular science books, relevant to her own study, as those which appear outwardly like novels, as opposed to those which appear in an encyclopedia-like format.

Inclusion of Story Elements

Some popular science books involve an explanation of current science, but also tell an engaging story, including extras such as biographical detail on the researchers, as well as tales of how their discoveries were made (Bradford & Loose, 1994).

Wilford (1997) made a similar point, and said that some science books include the stories of the history of a branch of research, including the “trials and triumphs of earlier scientists” (p. 48), as well as surveying current knowledge in a particular field. Interwoven with the narrative are explanations of the science itself. A variation of this is the “miniaturist approach” (p. 49), which involves focusing on one scientist or team of scientists but using their work to tell the story of an entire branch of science.

Singh (2000) believes that it is becoming increasingly common for science writers to write more about the story behind the science. This type of book is sometimes called ‘narrative non-fiction’ (p. 21). Dava Sobel’s *Longitude* and Deborah Cadbury’s *The Dinosaur Hunters* (2000) are examples of books in this category. Singh, however, cautioned against authors “concentrating too much on the story and forgetting about the science” (p. 21). For example, *A Beautiful Mind* (1998) by Sylvia Nasar, is an entertaining read, but does not include enough explanations of game theory. A balance is needed between an explanation of science and the telling of an interesting story, and Singh mentioned his own *Fermat’s Last Theorem* (2002), as an example

of a book which achieves this. “I tried to create drama, exploit plot twists and build characters. In short, I wanted to use narrative to enrich the mathematics” (p. 21).

Turney (2001a) pointed out that many recent popular science books centre around the sciences that naturally lend themselves to becoming stories or narratives, and that these books are very appealing.

Inclusion of Elements of Informed Speculation

Rabiner (1994) mentioned that some books combine “solid science with informed speculation” (para. 21). These books are often written by ‘cutting-edge’ scientists, and are on ‘cutting-edge’ topics. Such books may be increasingly popular, especially in fields where actual breakthroughs are slow in coming.

Differences Between Popular Physics and Popular Biology Books

Leane (n.d.a) believes that popular physics and popular biology books, which are two of the sciences most frequently subjected to popularisations, are presented differently from each other by popularisers. Popular physics books tend towards a ‘gee-whizz’ (p. 9) mode, whereas popular biology books tend toward being explanatory.

Narrative Non-Fiction

Downes (2001) discussed ‘narrative non-fiction’, a general type of non-fiction book which includes, but is not specific to the popular science genre. These books do not simply provide information, as many non-fiction books do, but instead have many of the features of fiction, including engaging the reader’s interest, and being entertaining to read. Books in this category can be on topics from a range of disciplines, including science, and in fact often cross subject boundaries, mixing history, science, biography, and other disciplines. This crossing of subject boundaries is done deliberately, to appeal to a non-specialist audience.

The comments outlined above indicate that there are a variety of opinions about the characteristics which differ amongst popular science books and about the categories into which the genre can be divided. The remainder of this chapter involves a detailed investigation of the different categories of popular science books, into which these comments are integrated.

Research Questions

The research in this chapter aimed to address the following questions:

1. Into which categories can the genre of popular science books be divided?
2. What particular characteristics can be used to define each category?

Method

The following method was used in this study:

1. A sample list of 94 current popular science books was compiled.
2. From the information contained in the literature, an initial list of characteristics that vary significantly between different popular science books was compiled. Some levels within variables were introduced but most were introduced at a later stage in the research, as a result of analysis of the sample.
3. Each book was read in detail and, based on observations made during this process, further variables were introduced to the list. The majority of levels were also introduced within each variable at this stage.
4. As reading of the sample progressed and patterns of shared and varying characteristics began to emerge, books in the sample were grouped into a number of different categories. The characteristics of each category began to be noted at this stage.
5. After an initial reading of all the books in the sample, the list of characteristics, and the levels within each characteristic was finalised.
6. Books in the sample were then checked again against this final list, and the patterns that emerged were noted.
7. Based on the final patterns of shared and differing characteristics, the books in the sample were finalised into a number of categories, and the detailed characteristics of each category were noted.
8. A 'diagram of relationships' between categories of the popular science book genre was developed.

The approach used in this study can be compared with a taxonomy in biology, which is defined as: "The science of classifying plants, animals and microorganisms into increasingly broader categories based on shared features" (MS Office dictionary definition).

Results and Discussion

Compiling of Sample

A sample list of 94 current popular science books was compiled for use in this study. The aim was to obtain a representative sample of popular science books which are current, popular, and readily available. A range of sources was chosen in an attempt to obtain a representative sample of what was currently-available both internationally and locally. Therefore, lists were chosen from bookstores in Australia (Dymocks and Angus and Robertson), the USA (Amazon) and the UK (Waterstones). The sources included a mixture of online and physical retailers.

The list was compiled from the following sources:

1. The top 25 “most available ‘popular science books’” from Dymocks.com.au, as of 1/5/2002 (Table 3.1).
2. The top 25 “bestselling ‘popular science’ books” from March 1999 to Sept 2001 from Angus and Robertson Australia. Where a book from list 1 was repeated, it was omitted from this list and the next book down selected in its place (Table 3.2).
3. The top 25 “bestselling ‘popular science’ books” from Waterstones.co.uk Waterstones’s website is run in association with Amazon.co.uk. Again, repeats from lists 1 and 2 were omitted and the next book down selected (Table 3.3).
4. The top 19 “bestselling ‘science’ books” for 2000 from Amazon.com. ‘Science’ books rather than ‘popular science’ books were selected as Amazon.com did not have a category specifically named ‘popular science’. Close examination revealed however, that the books on the Amazon.com ‘science’ could comfortably be defined as popular science books for the purposes of this study. Again, repeats from lists 1, 2 and 3 were omitted (Table 3.4).

Some advantages of this sampling technique are that the lists were readily available, up-to-date and contained books that had been recently published and were widely available both locally and internationally. The books were also ranked in order of sales (and availability, in one case), giving a good indication as to their popularity compared with other books in the genre.

There are, in fact, very few available lists of current popular science books that do not involve retailers. As in many other studies, the total population of popular science books is poorly defined, and there is no definitive list identifying all members of this population. In this light, booksellers may be one of the better ways of identifying a sample from the population of popular science books as retailers are the means by which these books become available to the public, and they have a vested interest in developing such lists. Clearly, an assumption of this sampling technique is that this is the case.

A disadvantage of the sampling method is that information was not readily available on the definitions that retailers have used in classifying their popular science books as members of the genre. The definition of a popular science book developed in this thesis is “books about science which do not require a specialist knowledge in the subject of the book in order to be read, enjoyed and understood”. It is not clear if retailers used a similar definition in developing their lists. However, anecdotally, booksellers often utilise the genres specified by publishers, who have an intimate knowledge of the books they publish, and therefore are in a good position to place a book within a particular genre. In forming the initial list, the definition of ‘popular science book’ used by the retailer was accepted at face value. However, before being included in the analysis, each book in the sample was examined for its fit with the definition of popular science book developed in this thesis. Two books were excluded from the analysis (see note following Table 3.4) on the basis that they did not sufficiently match with this definition of a popular science book. Books were examined again during the course of the analysis, and all remaining were found to fit with the definition established here.

Another factor that needs to be considered is that the sample is biased, as all books in the list have reached the bestseller lists of international publishers. As this is a thesis concerned largely with the features of bestselling popular science books and in the production of a book that aims to exemplify these features, this bias was intentionally introduced. A potential problem, however, is that it is possible that if a wider sample was taken, further categories may emerge among those that do not achieve the same sales success as the books in this sample.

The books in the sample are presented in the tables that follow:

Table 3.1: Books from Dymocks "Most Available 'Popular Science Books'" List

Title	Author	Date	Publisher
The map that changed the world: A tale of rocks, ruin and redemption	Simon Winchester	2002	London: Penguin Books
Fidgeting fat, exploding meat & gobbling whirly birds and other delicious science moments (new moments in science #4)	Karl Kruszelnicki (illustrations by Karen Young and Adam Yazxhi)	1999	Sydney: HarperCollins Publishers
Water: The drop of life	Peter Swanson	2001	Minnetonka, MN: NorthWord Press
Uncle Tungsten: Memories of a chemical boyhood	Oliver Sacks	2001	London: Picador
The universe in a nutshell	Stephen Hawking	2001	London: Bantam Press
Charles Darwin in Australia	FW Nicholas and JM Nicholas	2002	Cambridge, UK: Cambridge University Press
The dinosaur hunters: A true story of scientific rivalry and the discovery of the prehistoric world	Deborah Cadbury	2000	London: Fourth Estate Ltd
Oyster: The amazing story of a unique Australian mollusc	Nicolette Stasko	2000	Sydney: HarperCollins Publishers
The queen's conjurer: The science and magic of Dr Dee	Benjamin Woolley	2002	London: Flamingo
Living dolls: A magical history of the quest for mechanical life	Gaby Wood	2002	London: Faber and Faber Ltd
How much does the Earth weigh?	Marshall Brain	2001	New York: Hungry Minds
Longitude: The true story of a lone genius who solved the greatest scientific problem of his time	Dava Sobel	1998	London: Fourth Estate Ltd
A brief history of time: From the big bang to black holes	Stephen Hawking	1988	Toronto: Bantam Books
Evolution's workshop: God and science on the Galapagos islands	Edward J Larson	2001	London: Allen Lane, The Penguin Press
Evolution: The triumph of an idea	Carl Zimmer	2001	New York: HarperCollins Publishers
A gap in nature: Discovering the world's extinct animals	Tim Flannery, Peter Schouten	2001	New York: Atlantic Monthly Press
Animal: The definitive visual guide to the world's wildlife	David Burnie, Don E Wilson (Eds)	2001	New York: DK Publishing Inc
Ice age	John Gribbon and Mary Gribbon	2001	London: Allen Lane, The Penguin Press

Table 3.1 continued

Title	Author	Date	Publisher
Wildlife wars: My battle to save Kenya's elephants	Richard Leakey and Virginia Morell	2002	London: Pan Books
The code book: The secret history of codes and code-breaking	Simon Singh	1999	London: Fourth Estate Ltd
Galileo's daughter: A drama of science, faith and love	Dava Sobel	1999	London: Fourth Estate Ltd
Light years: An explanation of mankind's enduring fascination with light	Ian Clegg	2001	London: Judy Piatkus (Publishers) Ltd
Q & A with Dr K: Why it is so?	Karl Kruszelnicki	2002	Sydney: HarperCollins Publishers
Rivals: Conflict as the fuel of science	Michael White	2001	London: Vintage
Thomas Kuhn and the science wars	Ziauddin Sardar	2000	New York: Totem Books

Table 3.2: Books From Angus & Robertson "Bestselling 'Popular Science' Books" List

Title	Author	Date	Publisher
Guns, germs and steel: A short history of everybody for the last 13,000 years	Jared Diamond	1998	London: Vintage
The sacred balance: Rediscovering our place in nature	David Suzuki, with Amanda McConnell	1997	Sydney: Allen & Unwin
E=mc ² : A biography of the world's most famous equation	David Bodanis	2000	London: Macmillan
From naked ape to superspecies: A personal perspective on humanity and the global eco-crisis	David Suzuki, Holly Dressel	1999	Toronto, Canada: Stoddart Publishing Co. Ltd
Adam Spencer's book of numbers	Adam Spencer	2000	Ringwood, Vic, Australia: Penguin Books
Astronomy 2000: A practical guide to the night sky (Eastern Australian edition)	Glenn Dawes, Peter Northfield and Ken Wallace	1999	Strathfield, NSW, Australia: Quasar Publishing
Astronomy 2001: A practical guide to the night sky (Eastern Australian edition)	Glenn Dawes, Peter Northfield and Ken Wallace	2000	Georges Hill, NSW, Australia: Quasar Publishing
Unweaving the rainbow: Science, delusion and the appetite for wonder	Richard Dawkins	1998	London: Penguin Books

Table 3.2 continued

Title	Author	Date	Publisher
Munching maggots, Noah's flood & TV heart attacks and other cataclysmic science moments (new moments in science #3)	Karl Kruszelnicki (illustrations by Karen Young and Peter Pound)	1998	Sydney: HarperCollins Publishers
Pigeon poo, the universe & car paint and other awesome science moments (new moments in science #1)	Karl Kruszelnicki (illustrations by Reg Lynch and Peter Pound)	1996	Sydney: HarperCollins Publishers
The great arc: The dramatic tale of how India was mapped and Everest was named	John Keay	2001	London: HarperCollins Publishers
Fermat's last theorem: The story of a riddle that confounded the world's greatest minds for 358 years	Simon Singh	2002	London: Fourth Estate
A walk through the southern sky: A guide to stars and constellations and their legends	Milton D Heifetz and Wil Tirion	2000	Cambridge, UK: Cambridge University Press
Weatherwise: Fact fiction folklore	David Ellyard	1999	Sydney: ABC Books
The blind watchmaker	Richard Dawkins	2001	London: Penguin Books
Flying lasers, robofish and cities of slime: and more brain-bending science moments (new moments in science #2)	Karl Kruszelnicki (illustrations by Reg Lynch and Peter Pound)	1997	Sydney: HarperCollins Publishers
The fifth miracle: The search for the origin of life	Paul Davies	1998	London: Penguin Books
Collins gem physics basic facts	Eric Deeson and Ken Dobson	1996	Glasgow, UK: HarperCollins Publishers
Full moon	Michael Light	1999	London: Jonathan Cape, Random House
Plague wars: A true story of biological warfare	Tom Mangold and Jeff Goldberg	1999	New York: St Martin's Press
Earth time	David Suzuki	1998	St Leonards, NSW, Australia: Allen & Unwin
Collins gem biology basic facts	TA McCahill	2001	Glasgow, UK: HarperCollins Publishers
The southern sky guide	David Ellyard and Wil Tirion	1993	Cambridge, UK: Cambridge University Press

Table 3.3: Books From Waterstones ‘Bestselling ‘Popular Science’ Books’ List

Title	Author	Date	Publisher
The science of discworld II: The globe	Terry Pratchett, Ian Stewart and Jack Cohen	2002	London: Ebury Press
The future of life	Edward O Wilson	2003	London: Abacus
It must be beautiful	Graham Farmelo (Ed)	2002	London: Granta Books
The science of discworld	Terry Pratchett, Ian Stewart and Jack Cohen	1999	London: Ebury Press
The field: The quest for the secret force of the universe	Lynne McTaggart	2003	London: Element
The illustrated a brief history of time (updated and expanded edition)	Stephen Hawking	1996	New York: Bantam Books
Right hand, left hand: The origins of asymmetry in brains, bodies, atoms and cultures	Chris McManus	2002	Cambridge, MA: Harvard University Press
The origin of species by means of natural selection: Or the preservation of favoured races in the struggle for life	Charles Darwin	1985	London: Penguin Books
Genome: The autobiography of a species in 23 chapters	Matt Ridley	2000	London: Fourth Estate Ltd
What evolution is	Ernst Mayr	2001	New York: Basic Books
Our cosmic habitat	Martin Rees	2002	London: Weidenfeld and Nicholson
Six not-so-easy pieces	Richard Feynman, Roger Penrose (Introduction)	1997	London: Penguin Books
The science book: 250 milestones in the history of science	Peter Tallack (Ed)	2001	London: Cassell and Co
Robot: The future of flesh and machines	Rodney A Brooks	2002	London: Allen Lane, The Penguin Press
The universe next door: The making of tomorrow's science	Marcus Chown	2001	Oxford, UK: Oxford University Press
The elegant universe: Superstrings, hidden dimensions, and the quest for the ultimate theory	Brian Greene	2000	London: Vintage
Of moths and men: An evolutionary tale: Intrigue, tragedy & the peppered moth	Judith Hooper	2002	London: Fourth Estate
Malignant sadness: The anatomy of depression	Lewis Wolpert	1999	London: Faber and Faber Ltd
The common thread: A story of science, politics, ethics and the human genome	John Sulston & Georgina Ferry	2002	London: Bantam Press

Table 3.3 continued

Title	Author	Date	Publisher
Phantoms in the brain: Human nature and the architecture of the mind	VS Ramachandran & Sandra Blakeslee	1999	London: Fourth Estate
The 85 ways to tie a tie: The science and aesthetics of tie knots	Thomas Fink and Yong Mao	2001	London: Fourth Estate
Three roads to quantum gravity: A new understanding of space, time and the universe	Lee Smolin	2001	London: Phoenix
Emergence: From chaos to order	John H Holland	1998	Reading, MA: Helix Books
The demon-haunted world: Science as a candle in the dark	Carl Sagan	1996	New York: Ballantine Books

Table 3.4: Books From Amazon.com "Bestselling 'Science' Books" List

Title	Author	Date	Publisher
Failure is not an option: Mission control from mercury to Apollo 13 and beyond	Gene Kranz	2001	New York: Berkley Publishing Group
Rare Earth: Why complex life is uncommon in the universe	Peter D Ward & Donald Brownlee	2004	New York: Copernicus Books
Voodoo science: The road from foolishness to fraud	Robert L Park	2000	Oxford, UK: Oxford University Press
Nonzero: History, evolution & human cooperation	Robert Wright	2001	London: Abacus
Just six numbers: The deep forces that shape the universe	Martin Rees	2001	New York: Phoenix
The design of everyday things	Donald A Norman	1988	London: The MIT Press
Flu: The story of the great influenza pandemic of 1918 and the search for the virus that caused it	Gina Kolata	2001	London: Pan Books
Gödel, Escher, Bach: An eternal golden braid	Douglas R Hofstadter	1999	New York: Basic Books
Zero: The biography of a dangerous idea	Charles Siefe, Matt Zimet (Illustrator)	2000	New York: Penguin Books
Driving Mr Albert: A trip across America with Einstein's brain	Michael Paterniti	2000	London: Abacus
Darwin's ghost: The origin of species updated	Steve Jones	1999	New York: Ballantine Books
The structure of scientific revolutions	Thomas S Kuhn	1996	Chicago: The University of Chicago Press
The selfish gene	Richard Dawkins	1999	Oxford, UK: Oxford University Press

Table 3.4 continued

Title	Author	Date	Publisher
Off the planet: Surviving five perilous months aboard the space station Mir	Jerry M Linenger	2000	New York: McGraw-Hill
Surely you're joking, Mr. Feynman!: Adventures of a curious character	Richard P Feynman	1985	London: Vintage
The illustrated longitude: The true story of a lone genius who solved the greatest scientific problem of his time	Dava Sobel, William J H Andrewes (Illustrations)	1999	London: Fourth Estate
The mysteries within: A surgeon explores myth, medicine, and the human body	Sherwin B Nuland	2001	New York: Touchstone
Hyperspace: A scientific odyssey through parallel universes, time warps and the 10 th dimension	Michio Kaku	1995	New York: Anchor Books
Mother nature: Maternal instincts and the shaping of the species	Sarah Blaffer Hrdy	2000	London: Vintage

Note: Two books from the sample appeared to be mis-categorised, as they are not science-related: *Unlimited Power*, by Anthony Robbins and Joseph McClendon, and *The Word Museum*, by Jeffrey Kackirk. One additional book could not be identified properly, as it was described simply as *The Calendar*, with no author, publication date or publisher given. As several books with this title are currently available, it was not possible to identify which specific book the list referred to. Therefore, these three books were omitted from the analysis.

List of Variable Characteristics of Books in the Sample

17 characteristics can be identified which vary significantly between books in the sample. These are:

- Arrangement of content
- Profession of author(s)
- Science topic
- Scientific language
- New scientific ideas/theories
- Explanation/discussion of current science
- Advocacy/argument
- Practical science guidance
- Biography
- Autobiography
- Events of science
- Story of science endeavour
- Explanation/discussion of historical science
- Elements of science fiction/fantasy
- Paper type
- Illustrations
- Format

Table 3.5 explains each characteristic in detail:

Table 3.5: Variable Characteristics of Books in Sample

<p>Arrangement of Content</p>	<p>Some of the books in the sample are designed to be read in entirety, from beginning to end, while the others consist of sections (chapters or parts of chapters) that can be read independently. In line with Leane's discussion (n.d.a), these alternatives can be referred to as:</p> <ul style="list-style-type: none"> • Beginning to end (novel-like) • In parts, out of order (encyclopedia-like) <p>Some books in the sample consist of a series of short facts and explanations. Of the books that are constructed in this way, some contain facts and explanations in alphabetical order, others in non-alphabetical order. The remaining books consist of a continuous narrative thread. This characteristic can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Continuous narrative • Short facts/explanations in alphabetical order • Short facts/explanations in non-alphabetical order
<p>Profession of Author(s)</p>	<p>The authors of the books in the sample (as evidenced by the information contained within each book) come from a variety of professions, including scientists in the field of the book, scientists from other disciplines, non-science academics, and professional science writers.</p>
<p>Science Topic</p>	<p>The scientific discipline or specific scientific topic on which the book is focused varies between different books in the sample.</p>
<p>Scientific Language</p>	<p>The level of jargon and/or equations varies between books in the sample. Some books contain a relatively high level of jargon and equations (compared with other popular science books), while others have very little or none. This characteristic can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Language generally non-specialist (book has very few or no jargon terms and/or equations) • Some jargon/equations (book has some jargon terms and/or equations but noticeably less than those in the third alternative) • Relatively high level of jargon/equations (book has noticeably more jargon and/or equations compared to other books in the sample)

Table 3.5 continued

<p>New Scientific Ideas/Theories</p>	<p>A feature of some popular science books is that the author presents their own new scientific ideas or theories (Books and arts, 2001; Eger, 1993; Hillis (Turney, 1996); Leane, n.d.a; Pinker (Shermer, 2001); Rabiner, 1994; Shermer, 2001; Turney, 1996; Turney, 1999). In this sample, this feature ranges from an overriding theme of the book to a minor or non-existent feature. This characteristic can therefore be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent
<p>Explanation/ Discussion of Current Science</p>	<p>A feature of some books is that they explain current science to a non-specialist audience (Bowring, personal communication, October 24, 2001; Morrison & Morrison, 1999; Post prospero, 1994; Rabiner, 1994; Sapp, 1995; Wilford, 1997). The majority of books in the sample contain this trait, however the extent varies considerably. This characteristic can therefore be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent
<p>Advocacy/ Argument</p>	<p>In some books, the author does not simply state what he or she knows, but instead argues a position and tries to convince the reader that their approach is correct (Wilford, 1997). This idea is reflected in a number of books in this sample in which the author advocates, or argues the case for, a particular scientific theory or idea (new or existing), rather than simply presenting it or explaining it. The extent to which this is a feature varies considerably, and this characteristic can therefore be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent
<p>Practical Science Guidance</p>	<p>Some popular science books are designed for the purpose of providing practical guides to scientific activities (Bradford & Loose, 1994; Turney, 1999). This is the case for a number of books in the sample. This characteristic can be divided simply into two options:</p> <ul style="list-style-type: none"> • Yes (meaning the book is designed for the purpose of providing a practical guide to a scientific activity) • No (meaning the book is not designed for the purpose of providing a practical guide to a scientific activity)

Table 3.5 continued

<p>Biography</p>	<p>Some popular science books have a biographical component, focusing on the lives of individuals (Bradford & Loose, 1994; Morrison & Morrison, 1999; Rabiner (Nixon, 1991); Sapp, 1995; Turney, 1999). In the books in this sample, the extent to which this is a feature also varies considerably. This characteristic can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent <p>Of the books in the sample that contain a significant biographical component, some books focus primarily on one scientist, while others focus on a number of scientists equally. Two options can be given for this feature:</p> <ul style="list-style-type: none"> • One (or two) individuals particularly the focus • Several individuals equally the focus
<p>Autobiography</p>	<p>Some books in the sample contain aspects of autobiography. This feature can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent
<p>Events of Science</p>	<p>A feature of some popular science books is that they discuss the events that occurred as scientific discoveries were made (Bradford & Loose, 1994; Singh, 2000; Turney, 2001a; Wilford, 1997). This is the case for a number of books in the sample. This feature can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent

Table 3.5 continued

<p>Story of Science Endeavour</p>	<p>Some popular science books are centred around the story of a particular historical science endeavour (Bowring, personal communication, October 24, 2001; Horgan, 1997; McDonald, 2000). This is the case for a number of books in the sample. This characteristic can be divided simply into two options:</p> <ul style="list-style-type: none"> • Yes (meaning the book does centre around the story of a particular historical science endeavour) • No (meaning the book does not centre around the story of a particular historical science endeavour)
<p>Explanation/Discussion of Historical Science</p>	<p>Some books in the sample include the explanation and discussion of historical scientific ideas and theories. The extent to which this is the case varies, and this characteristic can be divided into three options.</p> <ul style="list-style-type: none"> • Main focus of book • Significant secondary feature • Minor/non-existent
<p>Elements of Science Fiction/Fantasy</p>	<p>Some books in the sample contain elements of science fiction/fantasy. These are interspersed with discussions of science, and are written to illuminate the science in the book. This characteristic can be divided simply into two alternatives:</p> <ul style="list-style-type: none"> • Yes (meaning the book does contain elements of science fiction/fantasy) • No (meaning the book does not contain elements of science fiction/fantasy)

Table 3.5 continued

<p>Paper Type</p>	<p>The weight of the paper used in books in this sample varies between individual books. This characteristic can be divided into three alternatives:</p> <ul style="list-style-type: none"> • Regular (that of an average paperback) • Intermediate (slightly thicker than that of an average paperback but thinner than a full colour illustrated book) • Thick (that of a high quality, full colour illustrated book) <p>The gloss level of the paper also varies between individual books in the sample. This characteristic can also be divided into three alternatives:</p> <ul style="list-style-type: none"> • Matt • Semi-glossy (slight sheen) • Glossy
<p>Illustrations</p>	<p>The majority of books in the sample contain illustrations, however illustration type and whether the illustrations are a dominant feature of the book (equal to or overshadowing the text) varies between books.</p> <p>Illustration type can be divided into three alternatives (or a combination of these options):</p> <ul style="list-style-type: none"> • No illustrations • Black and white illustrations • Illustrations that contain one to three separate colours • Full colour illustrations <p>Dominance of illustrations can also be divided into two options:</p> <ul style="list-style-type: none"> • Dominant • Supplementary

Table 3.5 continued

Format	<p>The size of the books in the sample varies considerably. The following three sizes will be used in this study:</p> <ul style="list-style-type: none">• Small (front cover surface area less than 20 000 mm²)• Medium (front cover surface area between 20 000 and 45 000 mm²)• Large (front cover surface area greater than 45 000 mm²) <p>Height x width of each book is also given (in mm)</p>
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List of Categories of Popular Science Book

Based on the patterns of shared and differing characteristics amongst books in the sample, 12 categories of popular science book were identified. These are:

1. New Scientific Ideas/Theories
2. Explanation/Discussion of Current Science
3. Environmental Advocacy
4. Philosophy of Science
5. Stories of Scientific Endeavours or Events
6. History of Branches or Topics in Science
7. Biography
8. Autobiography
9. Practical Science Guides
10. Fun Collections of Facts or Short Explanations
11. Dictionary-Like Reference
12. Coffee-Table Pictorials

A detailed discussion of each category and its characteristics follows.

Discussion of Individual Categories

Category 1: New Scientific Ideas/Theories

Summary of Category

This category consists of books that are centred around the author's own new scientific ideas/theories, and all other aspects of the books hinge on this idea/theory. Books in this category are very 'science rich', with significant levels of explanation and discussion of current science (in support of the central idea/theory). They are centred around science topics with unanswered questions, such as evolution. A main focus is an advocacy/argument element, in support of the central idea/theory.

Books in this group contain no significant 'story' elements of biography, autobiography, discussions of events, or stories of science endeavours. They do not have significant levels of explanation/discussion of historical science, and most do not have elements of science fiction/fantasy. They are not practical science guides.

These books are novel-like, with a continuous narrative thread, and most are written by scientists. They have a mid-range level of jargon/equations. All are medium sized, printed on regular matt paper, and most have black and white illustrations, supplementary to the text.

This is one of the major sub-genres mentioned in the literature review (discussed by Books and arts, 2001; Eger, 1993; Hillis (Turney, 1996); Leane, n.d.a; Pinker (Shermer, 2001); Rabiner, 1994; Shermer, 2001; Turney, 1996; Turney, 1999). Their comments are reflected in the following discussion.

Books from Sample in Category

Six books from the sample exemplify this category. These are:

- *Guns, Germs and Steel*, by Jared Diamond
- *Rare Earth*, by Peter Douglas Ward and Donald Brownlee
- *The Selfish Gene*, by Richard Dawkins
- *Nonzero*, by Robert Wright
- *The Origin of Species*, by Charles Darwin
- *Gödel, Escher, Bach*, by Douglas Hofstadter

Brief Description of Each Book

Guns, Germs and Steel, by Jared Diamond: Diamond presents a theory as to why certain parts of the world - for example, Europe - became powerful, rich nations, whilst other regions, such as Africa and the Americas, were not as technologically capable and had a great deal less military might. Using evidence from an extensive range of sources, Diamond argues that the discrepancies are not due to any intrinsic differences in the people in different parts of the world, but rather can be attributed to different resources allowing different developments in different regions.

Rare Earth, by Peter Douglas Ward and Donald Brownlee: Ward and Brownlee propose and explain their 'Rare Earth' hypothesis: that complex life, such as plants and animals, is unlikely to exist in other parts of the universe, whilst simple, unicellular life - for example, bacteria - is likely to exist outside of Earth. As in *Guns, Germs and Steel*, the authors argue the validity of their hypothesis using evidence from a range of sources.

The Selfish Gene, by Richard Dawkins: Dawkins presents, explains and discusses the implications of his 'Selfish Gene' theory of natural selection: that evolution occurs as the result of natural selection acting on genes, rather than on groups, species, or individuals, as evolutionary experts often believe. Dawkins discusses a variety of evidence for his theory, and outlines how the theory can explain the way in which behaviour, and other characteristics of living organisms, evolved. One chapter of the book also centres around Dawkin's 'meme' theory of cultural transmission.

Nonzero, by Robert Wright: Wright argues that due to non-zero sum interactions (interactions where both parties are affected by the outcome in the same way – either positive or negative), complexity in society, and in nature, tends to increase over time. Wright looks first at human cultural evolution, and argues that the human tendency to conduct non-zero sum interactions has led human society throughout history to tend towards greater complexity, which will continue to grow, leading ultimately to a global society, with global governance. Wright argues that the same increase in complexity is true of biological evolution, and poses the question of whether the directionality found in both biological and cultural evolution suggests that evolution has a higher purpose, and a designer.

The Origin of Species, by Charles Darwin: Darwin's classic theory of natural selection, published, as it was originally in the 1850s, in the form of a popular science book.

Gödel, Escher, Bach, by Douglas Hofstadter: Hofstadter develops an argument as to how mathematics, logic, and in particular, patterns, lie behind the nature of consciousness, and how this can be applied to the understanding of how the mind works and to the development of artificial intelligence. Particularly relevant to his discussion is mathematician Gödel's 'strange loop' idea. Together with discussing the maths and logic that lie behind consciousness, Hofstadter uses the art of Escher and the music of Bach, and the patterns contained within these, to illustrate and compare his points. Fictional dialogues between characters based on Lewis Carroll's writing are also used.

Table 3.6: Matrix of Characteristics for Books From Sample in New Scientific Ideas/Theories Category

	Gun, Germs and Steel	Rare Earth	The Selfish Gene	Nonzero	The Origin of Species	Gödel, Escher, Bach
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of physiology, contributes in ecology and evolutionary biology	Professor of geological sciences and palaeontology (Ward), and professor of astronomy (Brownlee)	Professor of public understanding of science	Not specifically stated but commentary within book suggests science writer	1800s 'gentleman scientist', studied evolution and natural history	Professor of cognitive science and computer science
Science Topic	Anthropology (Human Cultural Evolution)	Extraterrestrial Life	Evolution (Natural Selection)	Anthropology and Evolution (Human Cultural and Biological Evolution)	Evolution (Natural Selection)	Consciousness and Artificial Intelligence
Scientific Language	Language generally non-specialist	Relatively high level of jargon/equations	Some jargon/equations	Some jargon/equations	Some jargon/equations	Relatively high level of jargon/equations
New Scientific Ideas/Theories	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Explanation/Discussion of Current Science	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature
Advocacy/Argument	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Practical Science Guidance	No	No	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavour	No	No	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No	No	Yes

Table 3.6 continued

	Gun, Germs and Steel	Rare Earth	The Selfish Gene	Nonzero	The Origin of Species	Gödel, Escher, Bach
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary
Format	Medium: 197 x 130	Medium: 233 x 155	Medium: 196 x 129	Medium: 198 x 127	Medium: 198 x 129	Medium: 235 x 167

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): The majority of authors in this category are trained, practicing scientists, working in the field of science that the book is centred around. An exception to this may be *Nonzero*, where the information within the book suggests that the author is a professional science writer – although this is not specifically stated. This pattern is in agreement with Shermer (2001), who commented that this type of popular science book involves new ideas introduced for the first time *by scientists* [my emphasis].

Science Topic: Four of the six books are centred around aspects of evolution (*Guns, Germs and Steel*, *The Selfish Gene*, *Nonzero*, and *The Origin of Species*). One focuses on extraterrestrial life (*Rare Earth*), and one on consciousness and artificial intelligence (*Gödel, Escher, Bach*). It is noteworthy that these are disciplines where questions remain unanswered, leaving much scope for the new ideas and theories that are the defining feature of the books in this category.

Scientific Language: The level of scientific language varies between individual books, but on average is mid-range, compared to other categories. Three books in this category have some jargon/equations, and two have a relatively high level of scientific language: *Rare Earth* and *Gödel, Escher, Bach*. In contrast, *Guns, Germs and Steel* has relatively non-specialist language. This mid-range is in agreement with Shermer's comment (2001) that although these books are "original works of science..." (para. 4) they are suitable for a non-scientist audience, and with Turney (1999)'s view that although books of this type are also aimed at fellow scientists, they are popularisations.

New Scientific Ideas/Theories: The author's new scientific ideas or theories are the main focus and the defining feature of all the books in this category. Each book is centred around one central new idea or theory, and all other features of the book hinge upon this idea/theory. In *Guns, Germs and Steel*, the theory is that different resources in different parts of the world are the cause of the differences between the wealth, power and technology of societies in different regions. In *Rare Earth*, the theory is that 'complex' life (such as animals or plants) is not likely to exist in other parts of the universe, whilst 'simple' life (such as bacteria) is. In *The Selfish Gene*, the theory is that evolution occurs as a result of natural selection acting on genes, rather than on groups, species or individuals. In *Nonzero*, the theory is that due to non-zero sum interactions, complexity in society and in nature tends to increase over time. In *The Origin of Species*, the theory is Charles Darwin's classic theory of natural selection and in *Gödel, Escher, Bach*, the theory is that maths, logic and patterns lie behind the nature of consciousness.

This spectrum of subject matter is in line with the ideas of Hillis (Turney, 1996); Leane (n.d.a); Pinker (Shermer, 2001) and Turney (1996), who commented that the purpose of this type of popular science book may be to introduce controversial new ideas to the author's scientific colleagues – ideas that the authors may otherwise have difficulty getting published, or that may normally be ignored in a scientific field. The ideas/theories in this category: the origins of human wealth and power; the existence of extraterrestrial life; the existence and action of natural selection; and the nature of consciousness and

artificial intelligence, are all areas that are indeed prone to controversy, and many of the ideas in these disciplines are speculative, and may be difficult to integrate into traditional scientific literature.

Turney (1999) commented that this type of book can allow scientists more freedom to present and explore their new ideas than is usually possible in mainstream scientific literature, with elements such as tentative hypotheses, hunches, and facts that may be in doubt. This is indeed the case for the books in this category, which all contain these elements to some degree.

Explanation/Discussion of Current Science: In all books in this category, the explanation and discussion of current science is a significant secondary feature. Throughout each book, explanations and discussions of current science feature extensively, in order to support and to help explain the central scientific idea/theory.

Advocacy/Argument: This is a main focus of all the books in this category. In line with the new scientific ideas/theories presented in the books, all books in this category have a persuasive or argumentative flavour, with the authors building an argument for and providing evidence to back up their idea or theory.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography, Autobiography, Events of Science, Story of Science Endeavour and Explanation/Discussion of Historical Science: These are not significant features of any of the books in this category.

Elements of Science Fiction/Fantasy: Most books in this category do not contain this feature, with the exception of *Gödel, Escher, Bach*. This is one of the only two categories to contain this feature.

Paper Type: All books in this category use regular matt paper.

Illustrations: Most books in this category contain black and white illustrations, supplementary to the text. The exception is *Nonzero*, which is not illustrated.

Format: All books in this category are medium sized.

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Most authors are scientists in the field of the book
- Centred around science topics with unanswered questions, such as evolution
- Mid-range level of jargon/equations
- Defining feature is that books are centred around a new scientific idea/theory which may be controversial/speculative

- Explanation/discussion of current science is a significant secondary feature, to support central idea/theory
- Argument/persuasion a main focus, in support of central idea/theory
- Not practical science guides
- Biography, autobiography, events of science, story of science endeavour and explanation/discussion of historical science are not significant features
- Elements of science fiction/fantasy is not a feature of most books
- Regular matt paper
- Most have black and white illustrations, supplementary to the text
- Medium sized

Category 2: Explanation/Discussion Of Current Science

Summary of Category

This category consists of books that are centred around the explanation/discussion of current science, and all other aspects of the books hinge on this characteristic. Books in this category are very 'science rich', and are centred around a broad spectrum of science topics. New ideas/theories may be present, but are not the main focus of the book. Argument/persuasion elements may also be present, but in support of previously-existing theories.

Most books contain no significant 'story elements' of biography, autobiography, discussion of events, or stories of science endeavours, and in those that do, these elements are always secondary to the explanation/discussion of current science. Most do not have significant levels of explanation/discussion of historical science, and most do not have elements of science fiction/fantasy. They are not practical science guides.

Most books in this group are novel-like, with a continuous narrative thread, and most are written by scientists. They have on average a relatively high level of scientific language. All are medium sized, printed on regular matt paper, and most have black and white illustrations, supplementary to the text.

This type of book is mentioned by several authors in the literature review (Bowring, personal communication, October 24, 2001; Morrison & Morrison, 1999; Post prospero, 1994; Rabiner, 1994; Sapp, 1995). Their comments are reflected on in the following discussion.

Books from Sample in Category

Twenty five books from the sample exemplify this category. These are:

- *A Brief History of Time*, by Stephen Hawking
- *Three Roads to Quantum Gravity*, by Lee Smolin
- *Our Cosmic Habitat*, by Martin Rees
- *Just Six Numbers*, by Martin J Rees
- *The Blind Watchmaker*, by Richard Dawkins
- *The Fifth Miracle*, by Paul Davies
- *Genome*, by Matt Ridley
- *Robot*, by Rodney A Brooks
- *Phantoms in the Brain*, by V S Ramachandran and Sarah Blakeslee

- *Mother Nature*, by Sarah Blaffer Hrdy
- *The Elegant Universe*, by Brian Greene
- *Six Not-So-Easy Pieces*, by Richard P Feynman
- *Malignant Sadness*, by Lewis Wolpert
- *The Universe Next Door*, by Marcus Chown
- *Emergence*, by John Holland
- *Right Hand, Left Hand*, by Chris McManus
- *Hyperspace*, by Michio Kaku
- *What Evolution is*, by Ernst Mayr
- *Oyster*, by Nicolette Stasko
- *The Field*, by Lynne McTaggart
- *Darwin's Ghost*, by Steve Jones
- *The Design of Everyday Things*, by Donald A Norman
- *The 85 Ways to Tie a Tie*, by Thomas Fink and Yong Mao
- *The Science of Discworld*, by Terry Pratchett, Ian Stewart, and Jack Cohen
- *The Science of Discworld II*, by Terry Pratchett, Ian Stewart, and Jack Cohen

Brief Description of Each Book

A Brief History of Time, by *Stephen Hawking*: Stephen Hawking's bestseller, which explains current theories about the origin, nature, and fate of the universe.

Three Roads to Quantum Gravity, by *Lee Smolin*: Smolin discusses his own and other scientists' research towards finding a solution to the issue of quantum gravity.

Our Cosmic Habitat, by *Martin Rees*: Rees discusses many aspects of the universe, including how it is believed to have begun, what it is made of, and how it may end. The discussion also includes controversial ideas in cosmology, such as parallel universes and life outside of Earth. Throughout the book, Rees gives his opinion as to which theories he finds most plausible, and which ones he believes are unlikely to be accurate.

Just Six Numbers, by *Martin J Rees*: Rees explains how life is possible only because aspects of the universe, such as the strength of gravity and expansion speed, are exactly as they are. If this was not the case, life would be a physical impossibility. Six aspects of the physical nature of the universe which are particularly important are discussed in detail.

The Blind Watchmaker, by *Richard Dawkins*: Dawkins explains, discusses and strongly advocates Darwinian natural selection. The evidence for natural selection is discussed and Dawkins explains why opponents of the theory, and those advocating competing theories, are likely to be incorrect.

The Fifth Miracle, by *Paul Davies*: Davies discusses and explains aspects of life, such as its nature, the first organisms, how life fits within the laws of physics, the origins of life, whether life could exist on other planets, especially Mars, and whether life is a chance or expected occurrence. Davies gives his opinion as to which theories are the most plausible.

Genome, by *Matt Ridley*: This book consists of a series of chapters, each loosely focussed on a gene from each of the 23 human chromosomes. Ridley discusses and explains the science surrounding each gene, and related scientific topics.

Robot, by *Rodney A Brooks*: Brooks begins with a brief history of robotic research, discussing the robots his laboratory has built. Following this is a discussion of robots that are currently being developed, and of those that are planned for the future. Brooks discusses whether robots could ever take over from humans, whether genuine 'artificial intelligence' is possible, and how humans could one day become 'part robot', through implants of robotic technology.

Phantoms in the Brain, by *V S Ramachandran and Sarah Blakeslee*: Ramachandran discusses aspects of his life's research on patients suffering from neurological injuries or disorders, and how these patients have given insight into how parts or functions of the human brain appear to work. Each chapter focuses on a particular function or phenomenon of the human brain. As well as established theories, Ramachandran discusses a number of his own theories, some of which are quite new and, he admits, speculative.

Mother Nature, by *Sarah Blaffer Hrdy*: Hrdy discusses scientific theories surrounding maternity and evolution in animals and humans, with a particular focus on the evolutionary perspective. Theories that have been popular in the past, what is still often assumed based on these theories, and what more recent research has shown to be the case are covered.

The Elegant Universe, by *Brian Greene*: In this book, Greene explains and discusses string theory. Beginning with a discussion of the background to the theory, including Einstein's relativity, and 'standard' theories of quantum mechanics, the book then moves on to string theory and how it might solve problems inherent in other theories.

Six Not-So-Easy Pieces, by *Richard P Feynman*: A collection of six of Richard Feynman's lectures on relativity, originally designed for undergraduate students.

Malignant Sadness, by Lewis Wolpert: Wolpert, an embryologist who has personally suffered from depression, looks at what is currently known about depression from a scientific perspective, examining issues such as the diagnosis of depression, depression in other cultures, the causes of depression, and its treatment.

The Universe Next Door, by Marcus Chown: Chown explains and discusses speculative theories surrounding the universe, such as multiple universes, the origin of the universe and life, and extra dimensions.

Emergence, by John Holland: 'Emergence' refers to systems and models where complexity emerges from simple elements. Holland discusses how maths can be used to study emergent phenomena, such as games, maps, computer models, machine learning and modelling networks of neurons, and also explains that the scientific study of emergence could be used to study phenomena such as the evolution of nations and the spread of ideas.

Right Hand, Left Hand, by Chris McManus: An explanation and discussion of the science behind asymmetry and left and right handedness in nature. McManus begins with a brief history of biology and handedness, particularly in the human body, and continues with issues such as left and right in world cultures, the meaning of left and right, why left and right are easily confused, why the heart is on the left, asymmetry and biological molecules, why humans are right or left handed, and the brain and handedness. The book ends with a discussion of myths surrounding left and right handedness, and a selection of facts involving left and right handedness.

Hyperspace, by Michio Kaku: 'Hyperspace' theory postulates that the universe has unseen extra dimensions. Beginning with the history of hyperspace theory and research, subsequent chapters explain and discuss aspects of hyperspace theory, such as evidence for extra dimensions, creation of the universe and what came before, parallel universes, black holes, time travel, travel to other universes, and what may happen in the future.

What Evolution is, by Ernst Mayr: An in-depth explanation and discussion of evolutionary theory. The book begins with a short history of evolutionary thought and research, and moves onto topics such as evidence for evolution, the origin of life, the direction evolution has taken, why evolution occurs, natural selection, adaptation, speciation and human evolution.

Oyster, by Nicolette Stasko: Stasko discusses many aspects of oysters from an Australian perspective. The content is a mixture of historical snippets surrounding oysters, modern oyster farming in different regions of Australia, the eating of oysters, and the oyster's biological makeup, life cycle and breeding habits.

The Field, by Lynne McTaggart: A discussion of research surrounding the 'zero-point field', which is postulated to involve energy in the universe connecting everything together. McTaggart discusses zero-point field based research into phenomena such as homeopathy, memory storage, ESP, and other phenomena which are usually considered to be unexplainable scientifically.

Darwin's Ghost, by Steve Jones: An 'updated' version of Charles Darwin's *Origin of Species*. In a similar format to the original, but with arguments drawn from modern science and society.

The Design of Everyday Things, by Donald A Norman: Norman explains and discusses the psychology surrounding the design and use of 'everyday objects', including principles of good functional design, the psychology of how we interact with objects, and psychological principles that make items harder or easier to use.

The 85 Ways to Tie a Tie, by Thomas Fink and Yong Mao: A book about neck ties and neck tie knots. The authors begin with a history of ties and tie knots, followed by the science of tie knots, including knot theory. The remainder of the book discusses the 85 different tie knots that the authors have calculated to exist. Diagrams of how each knot can be tied are given, interspersed with historical background on certain well-known tie knots.

The Science of Discworld, by Terry Pratchett, Ian Stewart and Jack Cohen: The authors explain and discuss the history of the universe, including how the universe began, how atoms formed and the principle of emergence. The book then focuses on how the solar system formed, the shape and structure of the Earth, the atmosphere and oceans, and the moon. The final section is a discussion of the origins of life, evolution, the Ice Ages, the dinosaur extinction, the evolution of mammals, and finally, human evolution, the brain and culture, and how the universe might one day be explored. Each chapter of science is interspersed with a chapter of fiction, which forms a story written to fit in with the popular 'Discworld' fantasy series. In this book, the wizards of 'Unseen University' conduct an experiment which makes a new universe, which they then observe as it evolves. The fiction chapters closely follow the content of the science chapters, helping to explain the science as the book progresses.

The Science of Discworld II, by Terry Pratchett, Ian Stewart, and Jack Cohen: The authors explain and discuss aspects of human evolution, the human mind, culture and science. Again, each chapter of science is interspersed with a chapter of fiction, which forms a story written to fit in with the 'Discworld' series. In this book, the wizards of 'Unseen University' go into the globe (our Earth) and visit parts of history, making changes and saving the world from invading elves. Again, the fiction chapters help to explain the science as the book progresses.

Table 3.7: Matrix of Characteristics for Books From Sample in Explanation/Discussion of Current Science Category

	A Brief History of Time	Three Roads to Quantum Gravity	Our Cosmic Habitat	Just Six Numbers	The Blind Watchmaker	The Fifth Miracle	Genome
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of theoretical physics	Professor of physics	Professor of astronomy, Astronomer Royal	Professor of astronomy, Astronomer Royal	Professor of public understanding of science	Professor of physics	Science writer
Science Topic	Cosmology	Quantum Gravity	Cosmology	Cosmology	Evolution (Natural Selection)	Evolution (Origin of Life)	Human Genetics
Scientific Language	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Some jargon/equations	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Some jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Significant secondary feature	Significant secondary feature	Main focus of book	Significant secondary feature	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent

Table 3.7 continued

	A Brief History of Time	Three Roads to Quantum Gravity	Our Cosmic Habitat	Just Six Numbers	The Blind Watchmaker	The Fifth Miracle	Genome
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavour	No	No	No	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations
Format	Medium: 179 x 107	Medium: 197 x 130	Medium: 205 x 143	Medium: 197 x 130	Medium: 181 x 111	Medium: 182 x 111	Medium: 198 x 129

Table 3.7 continued

	Robot	Phantoms in the Brain	Mother Nature	The Elegant Universe	Six Not-So-Easy Pieces	Malignant Sadness	The Universe Next Door
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of computer science and artificial intelligence	Professor of neuroscience	Professor of anthropology	Professor of physics and mathematics	Professor of theoretical physics	Professor of biology (embryology)	Science writer and broadcaster
Science Topic	Artificial Intelligence/Robotics	Neuroscience	Evolution (Maternal Instincts)	String Theory	Relativity	Medicine (Depression)	Cosmology
Scientific Language	Language generally non-specialist	Some jargon/equations	Language generally non-specialist	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Some jargon/equations	Relatively high level of jargon/equations

Table 3.7 continued

	Robot	Phantoms in the Brain	Mother Nature	The Elegant Universe	Six Not-So-Easy Pieces	Malignant Sadness	The Universe Next Door
New Scientific Ideas/Theories Explanation/Discussion of Current Science	Significant secondary feature	Significant secondary feature	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Significant secondary feature	Significant secondary feature	Significant secondary feature	Main focus of book	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No	No
Biography	Significant secondary feature. Several individuals equally focussed on	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Significant secondary feature	Significant secondary feature	Significant secondary feature	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent
	Significant secondary feature	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	No	No	No	No	No	No	No
Story of Science Endeavour	Significant secondary feature	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Historical Science	No	No	No	No	No	No	No
Elements of Science Fiction/Fantasy	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Paper Type	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations and full colour illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations	No illustrations
Illustrations	Supplementary	Supplementary	Supplementary	Supplementary	Supplementary	Supplementary	Supplementary

Table 3.7 continued

	Robot	Phantoms in the Brain	Mother Nature	The Elegant Universe	Six Not-So-Easy Pieces	Malignant Sadness	The Universe Next Door
Format	Medium: 241 x 164	Medium: 197 x 128	Medium: 234 x 167	Medium: 198 x 130	Medium: 198 x 130	Medium: 215 x 139	Medium: 233 x 157

Table 3.7 continued

	Emergence	Right Hand, Left Hand	Hyperspace	What Evolution Is	Oyster	The Field	Darwin's Ghost
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Majority of chapters are Continuous narrative. Final two chapters are short facts/explanations in non-alphabetical order	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of psychology and of electrical engineering and computer science	Professor of psychology and medical education	Professor of theoretical physics	Professor of evolutionary biology	Poet, critic and editor	Science/medical journalist and writer	Not stated
Science Topic	Emergent Phenomena	Biological Asymmetry and Handedness	Hyperspace Theory	Evolution	Biology/Aquaculture (Oysters)	Parapsychology	Evolution (Natural Selection)
Scientific Language	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Some jargon/equations	Relatively high level of jargon/equations	Language generally non-specialist	Relatively high level of jargon/equations	Language generally non-specialist
New Scientific Ideas/Theories	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature

Table 3.7 continued

	Emergence	Right Hand, Left Hand	Hyperspace	What Evolution Is	Oyster	The Field	Darwin's Ghost
Explanation/Discussion of Current Science	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Main focus of book
Practical Science Guidance	No	No	No	No	No	No	No
Biography	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Minor/non-existent	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent
Story of Science Endeavour	No	No	No	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations	Black & white illustrations. Supplementary
Format	Medium: 240 x 160	Medium: 240 x 160	Medium: 203 x 132	Medium: 202 x 135	Medium: 194 x 125	Medium: 198 x 130	Medium: 234 x 158

Table 3.7 continued

	The Design of Everyday Things	The 85 Ways to Tie a Tie	The Science of Discworld	The Science of Discworld II
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Initial chapters beginning to end (novel-like), with continuous narrative. Remainder in parts, out of order (encyclopedia-like), with short facts/explanations in non-alphabetical order.	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Computer executive, former professor of cognitive science	Physicists	Fiction author (Pratchett), professor of mathematics (Stewart), and reproductive biologist (Cohen)	Fiction author (Pratchett), professor of mathematics (Stewart), and reproductive biologist (Cohen)
Science Topic	Psychology of the design of everyday objects	Mathematics/Knot Theory	The History of the Universe and of Earth	The human mind, evolution and culture
Scientific Language	Some jargon/equations	Some jargon/equations	Language generally non-specialist	Language generally non-specialist
New Scientific Ideas/Theories	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent

Table 3.7 continued

	The Design of Everyday Things	The 85 Ways to Tie a Tie	The Science of Discworld	The Science of Discworld II
Practical Science Guidance	No	No	No	No
Biography	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent
Story of Science Endeavour	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	Yes	Yes
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations, red full colour illustrations. Dominant	No illustrations	No illustrations
Format	Medium: 229 x 152	Medium: 177 x 125	Medium: 240 x 160	Medium: 240 x 158

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: Almost all books in this category are, like category 1, novel-like, designed to be read in entirety from beginning to end, with a continuous narrative thread. Two exceptions to this are: *Right Hand, Left Hand*, where the final two chapters consist of short facts/explanations in non-alphabetical order, and *The 85 Ways to Tie a Tie*, where the initial chapters are novel-like with a continuous narrative, and later chapters are encyclopedia-like, with short facts/explanations in non-alphabetical order.

Profession of Author(s): Like category 1, the majority of authors in this category are trained, practicing scientists, working in the field of science around which the book is centred. Two exceptions are books where the authors are scientists in different fields from the topic of the book: *The Fifth Miracle*, where the author is a Professor of Physics, but the book is about the origin of life, and *Malignant Sadness*, where the author is a Professor of Embryology, but the book is about depression. Also present in this category are four books where the authors are professional writers: *Genome*, where the author is a science writer, *The Universe Next Door*, where the author is a science writer/broadcaster, *Oyster*, where the author is a poet, critic and editor, and *The Field*, where the author is a science journalist.

Science Topic: The books in this category cover a wide spectrum of science topics. Aspects of physics such as cosmology, quantum gravity, string theory, relativity and hyperspace theory (extra dimensions) are the most common, and are the topic of nine books: *A Brief History of Time*, *Three Roads to Quantum Gravity*, *Our Cosmic Habitat*, *Just Six Numbers*, *The Elegant Universe*, *Six Not-So-Easy Pieces*, *The Universe Next Door*, *Hyperspace* and part of *The Science of Discworld*. Aspects of evolution are the topics for a further seven books: *The Blind Watchmaker*, *The Fifth Miracle*, *Mother Nature*, *What Evolution Is*, *Darwin's Ghost*, *The Science of Discworld II* and part of *The Science of Discworld*.

Other topics (each the subject of only one book) are human genetics (*Genome*), artificial intelligence (*Robot*), neuroscience (*Phantoms in the Brain*), medicine (*Malignant Sadness*), emergent phenomena (*Emergence*), biological asymmetry and handedness (*Right Hand, Left Hand*), aquaculture/biology (*Oyster*), parapsychology (*The Field*), knot theory (*The 85 Ways to Tie a Tie*) and the science and psychology of everyday objects (*The Design of Everyday Things*).

This category includes all topics present in the first category (evolution, extraterrestrial life, consciousness and artificial intelligence), but spans a broader spectrum, covering topics from most areas of current science.

Scientific Language: The level of scientific language in this category also varies between individual books. Twelve have a high level of jargon/equations - one, *Six Not-so-Easy Pieces*, has such a high level of jargon and, in particular, equations, that it requires specialist knowledge to be understood, which raises questions as to whether it should be classed as a popular science book. Seven books have some jargon/equations, and six have language that is generally non-specialist.

It is interesting to note that there is a large proportion of books in this category with a relatively high level of scientific language (48%), higher than in category 1 (17%). This level of scientific language seems surprising given that these books are by definition designed to be suitable for non-scientists. Bowring (personal communication, October 24, 2001) believes, however, that although certain popular science books can be difficult to read, the audience for this type of book is likely to be members of the public who are scientifically literate, and may often include those with some science education. This may indeed be the case for the books in this category. It was, however, not anticipated that this category would have a higher proportion of books with relatively high levels of scientific language compared with category 1, where the audience would be expected have similar or higher levels of scientific training.

New Scientific Ideas/Theories: A little more than half the books in this category (15) do not feature the author's new scientific ideas/theories to a significant level, and are focused entirely on the explanation/discussion of previously published, current science. Contrary to the opinion of Rabiner (1994), the remaining 10 books in this category do feature the author's new scientific ideas/theories. Unlike category 1, however, the author's new ideas are not the main focus of the book, but are secondary to the explanation and discussion of previously published, current science. The authors own ideas are added where relevant.

Explanation/Discussion of Current Science: The explanation and discussion of current science is the main focus of all the books in this category (Bowring, personal communication, October 24, 2001; Morrison & Morrison, 1999; Post prospero, 1994; Rabiner, 1994; Sapp, 1995), and all other features of the books hinge upon, and are secondary to, this explanation/discussion. These books are about "what scientists believe to be true about the world" (Post prospero, 1994, para. 3).

Each book focuses on a particular aspect of current science (as outlined under 'Science Topic'). The authors explain current scientific thinking surrounding this topic, and discuss the results and implications of current research. In contrast to category 1, the explanations and discussions do not simply support the author's new idea/theory, but are the central focus of the book.

Advocacy/Argument: In contrast to category 1, in approximately half the books in this category (14), the avocation or argument for a particular theory or idea is not a significant feature. Instead, the authors simply explain and discuss current science ideas and theories, without discussing to any significant level their own preferences or beliefs. In eight books, the avocation or argument for a particular theory or idea is a significant secondary feature. Alongside their explanation and discussion of current science, the authors discuss, in places, why they believe particular ideas or theories are correct.

In three books (*The Blind Watchmaker*, *The Elegant Universe*, and *Darwin's Ghost*), the advocacy or argument for a particular theory or idea is a main focus of the books. Like category 1, these books have an advocatory or argumentative flavour - together with explaining/discussing an aspect of current science, the authors also argue in favour of a particular theory. In this category, however, the advocacy/argument is in favour of a previously-existing idea/theory, not the author's own new idea/theory being presented for the first time. In both *The Blind Watchmaker* and *Darwin's Ghost*, the authors explain and discuss

Darwinian evolution, and argue why this approach is correct. Similarly, in *The Elegant Universe*, the author explains and discusses string theory, and argues why it, too, is correct.

The author of *Post prospero* (1994), sees this feature as a strength of this type of book, saying that the best science books of this type are ones in which the author does not simply state what they know, but instead try to convince the reader that their approach to knowledge is correct.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: Like category 1, most books in this category do not have a significant amount of biography, concentrating instead on explanation/discussion of current science. Seven books do have biography as a significant secondary feature, discussing in places the scientists involved in the research that the book is centred around (*Genome*, *Robot*, *Mother Nature*, *Right Hand*, *Left Hand*, *Hyperspace*, *The Field*, and *The 85 Ways to Tie a Tie*). All books which feature biography focus equally on several individuals, with biographical detail secondary to the explanation and discussion of current science.

Autobiography: Autobiography is not a significant feature of most books in this category. Four exceptions to this are: *Robot*, *Phantoms in the Brain*, *Mother Nature*, and *Malignant Sadness*, where autobiography is a significant secondary feature. In *Robot*, the author discusses his own research and how he became interested in robots. In *Phantoms in the Brain*, the author discusses his own research and the stories of patients he has treated. In *Mother Nature*, the author again discusses her own research, and in *Malignant Sadness*, the author discusses his personal experience with depression. Like biography, the aspects of autobiography are secondary to the explanation and discussion of current science.

Events of Science: The events of science are not a significant feature of most of the books in this category. Seven books, however: *Robot*, *Mother Nature*, *Right Hand*, *Left Hand*, *Hyperspace*, *Oyster*, *The 85 Ways To Tie a Tie*, and *The Science of Discworld*, include the discussion of the events of science as a significant secondary feature. This is contrast with the opinion of the author of *Post prospero* (1994), who believes this type of book does not say a great deal about how discoveries were made, and about how scientific beliefs came about. The books in this sample show that this can be a feature of this category, but always secondary to the explanation/discussion of current science.

Story of Science Endeavour: This is not a feature of any of the books in this category.

Explanation/Discussion of Historical Science: This is not a feature of most books in this category, but eight books do have this as a significant secondary feature: *Genome*, *Robot*, *Mother Nature*, *The Elegant Universe*, *Right Hand*, *Left Hand*, *Hyperspace*, *Oyster*, and *The Science of Discworld*. In all cases this is secondary to the explanation and discussion of current science.

Elements of Science Fiction/Fantasy: Like category 1, most books in this category do not contain this feature, with two exceptions: *The Science of Discworld* and *The Science of Discworld II*. This is the only other category to contain this feature.

Paper Type: All books in this category use regular matt paper.

Illustrations: Most books in this category, too, (16) are illustrated with black and white illustrations, which are supplementary to the text. One book, *Mother Nature*, also has full colour illustrations, and one book, *The 85 Ways to Tie a Tie* is more heavily illustrated, with black and white illustrations, red illustrations, and full colour illustrations. The illustrations in this book are dominant. Like category 1, a minority (five) books in this category are not illustrated.

Format: All books in this category are medium sized.

Summary of Characteristics of Books in this Category

- Most are novel-like with a continuous narrative thread
- Most authors are scientists in the field the book focuses on
- Centred around a broad spectrum of science topics. Aspects of physics such as cosmology, quantum mechanics and relativity, and evolution particularly common
- Average level of scientific language relatively high
- New ideas/theories may be present, but are not the main focus of the book
- Defining feature is that books are centred around explanation/discussion of current science
- May have advocacy/argument as a significant secondary feature in support of previously existing idea/theory
- Not practical science guides
- Biography, autobiography and events of science are not significant features of most books
- Story of science endeavour is not a feature
- Explanation/discussion of historical science and elements of science fiction/fantasy are not significant features of most books
- Regular matt paper
- Most have black and white illustrations, supplementary to the text
- Medium sized

Category 3: Environmental Advocacy

Summary of Category

This category consists of books centred around advocacy/argument concerned with environmental issues, and all other aspects of the books hinge on this characteristic. Books in this category are very 'science rich', with significant levels of explanation/discussion of current science (in support of the advocacy/argument). They do not contain new ideas/theories to a significant level.

Books in this group contain no significant 'story' elements of biography, autobiography, discussions of events, or stories of science endeavours. They do not have significant levels of explanation/discussion of historical science, and do not have elements of science fiction/fantasy. They are not practical science guides.

These books are novel-like, with a continuous narrative thread, and most authors are scientists active in publicising environmental issues. The books have on average a mid-low level of scientific language. All are medium sized, printed on regular matt paper, and some have black and white illustrations, supplementary to the text.

This is similar to the 'advocacy' category identified by Wilford (1997).

Books from Sample in Category

Four books from the sample exemplify this category. These are:

- *The Sacred Balance*, by David Suzuki and Amanda McConnell
- *The Future of Life*, by Edward O Wilson
- *Earth Time*, by David Suzuki
- *From Naked Ape to Superspecies*, by David Suzuki and Holly Dressel

Brief Description of Each Book

The Sacred Balance, by David Suzuki and Amanda McConnell: Suzuki and McConnell begin by explaining that humans have basic needs such as air, water, soil, and biodiversity, which are tied to the environment. Next is a discussion of the effect modern society is having on the environment and how this affects our basic needs, and what humans can do to be more 'ecologically friendly'. Readers are urged to act on this issue in their own lives.

The Future of Life, by Edward O Wilson: A discussion of the dire state that the natural world is in, where it is heading, and what should be done to help solve the problem. Wilson discusses the rising human population and how this is affecting biodiversity, the decline of species and natural environments, how and why humans need nature, and why humans naturally appreciate nature. Finally, he suggests some solutions to the problem.

Earth Time, by David Suzuki: A discussion of the problems with the environment that we currently face, and how society causes them. Suzuki discusses issues such as: the fact that the Earth is in crisis; that there is much that is unknown, meaning technology is based on incomplete knowledge; population increase and its impact on the planet; movement to cities and increasing consumption; information distortion; economic systems and the environment; and politics and the environment. Suzuki ends with a discussion of why nature is needed, suggestions for educational practices that are environmentally aware, how to enjoy simple things, natural farming methods, and better fisheries management.

From Naked Ape to Superspecies, by David Suzuki and Holly Dressel: A discussion of the problems with the environment that we currently face, and how today's society causes them. Suzuki and Dressel cover topics such as insects and bacteria and their importance, biodiversity, our dependence on nature, excess consumption, environmental issues and the media, genetic engineering, patents on biological materials, economics and the environment, globalisation, multinational corporations and the third world, and what can be done to rectify the situation.

Table 3.8: Matrix of Characteristics for Books From Sample in Environmental Advocacy Category

	The Sacred Balance	The Future of Life	Earth Time	From Naked Ape to Superspecies
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Geneticist, science writer, broadcaster, and environmentalist (Suzuki), and documentary writer (McConnell)	Professor of biology	Geneticist, science writer, broadcaster, and environmentalist	Geneticist, science writer, broadcaster, and environmentalist (Suzuki) and writer (Dressel)
Science Topic	Environmental Science/Ecology	Environmental Science/Ecology	Environmental Science/Ecology	Environmental Science/Ecology
Scientific Language	Language generally non-specialist	Some jargon/equations	Language generally non-specialist	Language generally non-specialist
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature
Advocacy/Argument	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Practical Science Guidance	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavour	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations	No illustrations
Format	Medium: 195 x 130	Medium: 198 x 127	Medium: 230 x 153	Medium: 229 x 154

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): One book in this category, *The Future of Life*, has an author who is a trained, practicing scientist, working in the field of science that the book is centred around. The remaining three books in this category have the same author (Suzuki), who is a trained geneticist, but now works as an environmentalist, science writer and broadcaster. Two of Suzuki's books (*The Sacred Balance* and *From Naked Ape to Superspecies*) have co-authors who are professional writers.

Science Topic: All books in this category focus on environmental science/ecology. This is in line with Wilford's suggestion (1997) that 'advocacy' books often revolve around topics such as environmental issues or threats of disease. This is a defining feature of this category.

Scientific Language: The books in this category have a lower overall level of scientific language, compared to the first two categories. Three books: *The Sacred Balance*, *Earth Time* and *From Naked Ape to Superspecies*, have generally non-specialist language. One book, *The Future of Life*, has some jargon/equations but, in contrast to the first two categories, no books in this category have a relatively high level of jargon/equations.

New Scientific Ideas/Theories: In contrast to the previous two categories, the author's new scientific ideas/theories do not feature significantly in any books in this category. However, their *opinion* on previously-existing scientific ideas is a major feature (see advocacy/argument).

Explanation/Discussion of Current Science: In all books in this sample, the explanation/discussion of current science is a significant secondary feature which supports the author's advocacy/argument.

Advocacy/Argument: Like category 1, all books in this category have an advocatory or argumentative flavour, with the authors building an argument and providing evidence in the form of explanations/discussions of current science. However, in contrast to category 1, the advocacy/argument in this category is not based around the author's new idea/theory, but rather is based around previously identified environmental issues. The authors of the books in this category all argue that environmental problems exist and that certain action needs to be taken, and urge the reader to recognise that these problems exist, and to act on them. All other characteristics of the books hinge on this central environmental argument/avocation. This is in line with Wilford's comment (1997) that advocacy books "argue a position or sound an alarm" (p. 49).

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: Like categories 1 and 2, most books in this category do not have a significant biographical component, with the exception of *From Naked Ape to Superspecies*, which has biography as a significant secondary feature, focusing equally on several individuals.

Autobiography, Events of Science, Story of Science Endeavour, Explanation/Discussion of Historical Science and Elements of Science Fiction/Fantasy: These are not significant features of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: Two books in this sample, *The Sacred Balance* and *The Future of Life* contain black and white illustrations that are supplementary to the text. The remaining two books are not illustrated.

Format: All books in this category are medium sized

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Most authors are scientists active in publicising environmental issues
- Defining feature is that books are centred around environmental science/ecology
- Average level of scientific language mid-low
- Authors new scientific ideas is not a significant feature
- Explanation/discussion of science topics is a significant secondary feature, in support of central argument
- Defining feature is that books are centred around advocacy/argument concerned with environmental issues
- Not practical science guides
- Biography is not a significant feature of most books
- Autobiography, events of science, story of science endeavour, explanation/discussion of historical science and elements of science fiction/fantasy are not significant features
- Regular matt paper
- Some books have black and white illustrations, supplementary to the text
- Medium sized

Category 4: Philosophy of Science

Summary Of Category

This category consists of books that are centred around the philosophy of science, and all other aspects of the books hinge upon this characteristic. In other characteristics, books in this category are more diverse than many other categories. Some have significant levels of explanation/discussion of current science, and some contain significant levels of new ideas/theories in the philosophy of science. Advocacy/argument may be a main focus.

Books of this type contain no significant elements of biography, autobiography, or stories of science endeavours. Some contain significant levels of discussions of events, and some contain explanations/discussions of historical science. They are not practical science guides, nor do they contain elements of science fiction/fantasy.

These books are novel-like, with a continuous narrative thread, and are written by scientists or other academics from fields related to the philosophy of science. They have a mid-range level of jargon/equations. Most are medium sized, and are printed on regular matt paper. None are illustrated.

This type of book was mentioned just once in the literature, by Morrison and Morrison (1999). The example they gave was *The Structure of Scientific Revolutions*, which also appears in this sample.

Books From Sample In Category

Five books from the sample exemplify this category. These are:

- *Unweaving the Rainbow*, by Richard Dawkins
- *Voodoo Science*, by Robert L Park
- *The Demon-Haunted World*, by Carl Sagan
- *The Structure of Scientific Revolutions*, by Thomas S Kuhn
- *Thomas Kuhn and the Science Wars*, by Ziaddin Sardar

Brief Description of Each Book

Unweaving the Rainbow, by Richard Dawkins: Dawkins discusses negative images of science, why these exist, and how the situation can be improved. Beginning by discussing the belief that science destroys wonder in the world, Dawkins argues why this belief is incorrect, discussing examples where science is wondrous, such as the science behind light and sound, and DNA fingerprinting. Next is a discussion of astrology, supernatural and

paranormal events, alien sightings and uncanny co-incidences, which are not scientific but take over from the 'true' wonder of science. Dawkins discusses why these phenomena are incorrect or unlikely, and why they are readily accepted with no real evidence. Next is a discussion of how metaphors and imagery can be misused in scientific thinking, including 'bad poetic science' in evolutionary theory, particularly that used by Stephen Jay Gould. A number of examples of good poetic science are given, including genetic cooperation, the brain as a model of an animal's personal history, and the evolution of the human brain compared to the evolution of computers.

Voodoo Science, by Robert L Park: Park discusses examples of 'voodoo' science - science which is either incorrect or fraudulent, including cold fusion, power lines and cancer, alternative therapies, and 'free' energy.

The Demon-Haunted World, by Carl Sagan: A discussion centred around the importance and role of science in society. Sagan begins with a discussion of pseudoscience, giving examples such as 'evidence' of civilisations on other planets, claims of alien abduction, UFOS, and crop circles. Next is a discussion of how science works, conflict between science and religion, and negative consequences of science. Skepticism and its deficiencies are examined, why science is considered difficult, science teaching, the importance of literacy, science on television, 'curiosity-driven' science, how scientific methods can be used to help improve society, and the importance of free speech.

The Structure of Scientific Revolutions, by Thomas Kuhn: Kuhn's theory of the process of science, which argues that scientific research is centred around a series of 'paradigms', that researchers use as a basis and focus for research. Periodically, 'scientific revolutions' occur, which create new paradigms and change the focus of research. This contrasts with the traditional view of science as a process of steady, cumulative fact-gathering.

Thomas Kuhn and the Science Wars, by Ziauddin Sardar: Sardar discusses the 'science wars' - the reaction of scientists to Kuhn and other sociologist's views of science and scientists. A brief history of ideas on the scientific process and the role of science in society is given, and Kuhn's work and the time in which he wrote is discussed, together with the philosophy of science after Kuhn.

Table 3.9: Matrix of Characteristics for Books From Sample in Philosophy of Science Category

	Unweaving the Rainbow	Voodoo Science	The Demon-Haunted World	The Structure of Scientific Revolutions	Thomas Kuhn and the Science Wars
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of public understanding of science	Professor of physics and science communicator	Professor of astronomy	Professor of linguistics and philosophy	Writer and professor of postcolonial studies
Science Topic	Philosophy of Science (Science and Wonder)	Philosophy of Science (Incorrect, Fraudulent and Junk Science)	Philosophy of Science (The Role of Science in Society)	Philosophy of Science (The Nature of the Scientific Process)	Philosophy of Science (Philosopher's Theories)
Scientific Language	Some jargon/equations	Some jargon/equations	Some jargon/equations	Some jargon/equations	Some jargon/equations
New Scientific Ideas/Theories	Main focus of book	Significant secondary feature	Main focus of book	Main focus of book	Minor/non-existent
Explanation/ Discussion of Current Science	Significant secondary feature	Significant secondary feature	Significant secondary feature	Minor/non-existent	Minor/non-existent
Advocacy/Argument	Main focus of book	Significant secondary feature	Main focus of book	Main focus of book	Minor/non-existent
Practical Science Guidance	No	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Significant secondary feature	Minor/non-existent	Significant secondary feature	Significant secondary feature
Story of Science Endeavour	No	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	No illustrations	No illustrations	No illustrations	No illustrations	No illustrations
Format	Medium: 198 x 130	Medium: 203 x 137	Medium: 210 x 140	Medium: 203 x 133	Small: 177 x 111

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: Again, all books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): The authors of all books in this category are academics, but due to the nature of the subject matter, their fields of study are not always within science. In three of the five books in this category, the authors are academics working in fields related to the philosophy of science: *The Structure of Scientific Revolutions*, where the author is a professor of linguistics and philosophy, *Thomas Kuhn and the Science Wars*, where the author is a professor of postcolonial studies and *Unweaving the Rainbow*, where the author is a professor of the public understanding of science. The authors of the remaining two books in this category are practising scientists, one in physics (*Voodoo Science*), the other in astronomy (*The Demon-Haunted World*).

Science Topic: All books in this category focus on aspects of the philosophy of science, or “science itself examined” (Morrison & Morrison, 1999, Science itself examined section). This is the defining feature of this category, and is an attribute unique to it.

The specific topics within the philosophy of science covered in this sample are diverse, and include: science and wonder (*Unweaving the Rainbow*); incorrect, fraudulent and junk science (*Voodoo Science*); the role of science in society (*The Demon-Haunted World*); the nature of the scientific process (*The Structure of Scientific Revolutions*); and a survey of the theories of various philosophers of science (*Thomas Kuhn and the Science Wars*).

Scientific Language: All books in this category have some jargon/equations, but again, in contrast to the first two categories, none have a relatively high level of scientific language.

New Scientific Ideas/Theories: In three books in this category: *Unweaving the Rainbow*, *The Demon-Haunted World* and *The Structure of Scientific Revolutions*, the author’s new ideas/theories are, as in category 1, the main focus of the book. However, the author’s new ideas/theories concern aspects of the philosophy of science, rather than theories within science itself.

In the remaining books in this category, the author’s new ideas/theories are less of a focus: In *Voodoo Science*, the author’s new scientific ideas or theories are a significant secondary feature, and in *Thomas Kuhn and the Science Wars*, the author’s new scientific ideas do not feature to a significant level.

Explanation/Discussion of Current Science: In three books in this category: *Unweaving the Rainbow*, *Voodoo Science* and *The Demon-Haunted World*, the explanation and discussion of current science is a significant secondary feature. Like category 1, in *Unweaving the Rainbow* and *The Demon-Haunted World*, aspects of current science are explained and discussed in order to support the authors’ new ideas/theories, and in *Voodoo Science*, current science is discussed in order to debunk ‘voodoo’ science theories.

The remaining two books in this category, *The Structure of Scientific Revolutions* and *Thomas Kuhn and the Science Wars*, do not explain and discuss current science to a significant level, but instead focus on the philosophy of science.

Advocacy/Argument: In three books in this category, the advocacy/argument of a particular scientific idea or theory is the main focus of the book. In *Unweaving the Rainbow*, Dawkins advocates and argues about the wonder of science. In *The Demon Haunted World*, Sagan argues a variety of topics centred around science and society and in *The Structure of Scientific Revolutions*, Kuhn argues his theory on the scientific process. In one book, *Voodoo Science*, advocacy/argument is a significant secondary feature, and in *Thomas Kuhn and the Science Wars*, advocacy/argument is not present to a significant level.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography and Autobiography: These are not significant features of any of the books in this category.

Events of Science: This is a significant secondary feature of three of the books in this category: *Voodoo Science*, *The Structure of Scientific Revolutions*, and *Thomas Kuhn and the Science Wars*. In the two remaining books in this category, the events of science are not a significant feature.

Story of Science Endeavour: This is not a feature of any of the books in this category.

Explanation/Discussion of Historical Science: Like the previous two categories, this is not a significant feature of the majority of the books in this category, with the exception of *The Structure of Scientific Revolutions*, where the author discusses a number of historical scientific theories in order to illustrate his ideas of paradigms and revolutions, and in *Thomas Kuhn and the Science Wars*, where the author discusses historical ideas about the philosophy of science.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: In contrast to all other categories, all books in this category are not illustrated.

Format: Most books in this category are medium sized, with the exception of *Thomas Kuhn and the Science Wars*, which is small.

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Authors are scientists or other academics
- Defining feature is that books are centred around aspects of the philosophy of science
- Level of jargon/equations is mid-range
- New ideas/theories in the philosophy of science may be present at varying levels
- Explanation/discussion of current science may be present as a significant secondary feature
- Advocacy/argument may be a main focus
- Not practical science guides
- Biography and autobiography are not significant features
- Events of science may be present as a significant secondary feature
- Story of science endeavour is not a feature
- Explanation/discussion of historical science may be present as a significant secondary feature
- Elements of science fiction/fantasy is not a feature
- Regular matt paper
- No illustrations
- Most are medium sized

Category 5: Stories Of Scientific Endeavours Or Events

Summary Of Category

This category consists of books centred around the stories of particular scientific endeavours or events, and all other aspects of the books hinge on this characteristic. In contrast to previous categories, books in this category are very 'story rich', with significant amounts of biographical detail and the events of science surrounding the endeavour interspersed into the central story. Centred around a variety of scientific topics, each book focuses on specific scientific endeavours or events. They do not have significant levels of autobiography.

Explanation/discussion of historical science is a significant secondary feature of books in this category, and explanation/discussion of current science may also be present as a significant secondary feature. Books in this category do not contain significant levels of new scientific ideas/theories or advocacy/argument. They are not practical science guides, and do not contain elements of science fiction/fantasy.

Books in this group are novel-like, with a continuous narrative thread, and most are written by science or non-fiction writers. They have a varying level of scientific language. Most are medium sized, printed on regular matt paper, and most have black and white illustrations, supplementary to the text.

This type of book was mentioned by Bowring (personal communication, October 24, 2001); Horgan (1997); and McDonald (2000), who specifically cited Dava Sobel's *Longitude*, which also features in this sample, as a leader in this category.

Books From Sample In Category

Six books from the sample exemplify this category. These are:

- *Longitude*, by Dava Sobel
- *The Great Arc*, by John Keay
- *Fermat's Last Theorem*, by Simon Singh
- *Flu*, by Gina Kolata
- *Rivals*, by Michael White
- *It Must be Beautiful*, by Graham Farmelo (Ed)

Brief Description of Each Book

Longitude, by Dava Sobel: The story of how the problem of how to measure longitude at sea was solved, centred largely around the life and work of John Harrison, who built a succession of accurate clocks designed to allow longitude to be accurately measured.

The Great Arc, by John Keay: The story of the mapping and geographical surveying of India carried out by the British in the early 1800s. Written in a chronological order, this is an account of what was done, when, and by whom.

Fermat's Last Theorem, by Simon Singh: Fermat's last theorem is a mathematical theory that French mathematician Pierre de Fermat claimed to have found a proof of in the 1600s. He did not, however, disclose the details of his proof and, since then, many mathematicians have tried to replicate his work, to no avail. Recently, mathematician Andrew Wiles succeeded at finding a proof to Fermat's last theorem. This book is an historical account of attempts to find a proof to the theorem, and of how it was eventually found.

Flu, by Gina Kolata: The story of the 1918 flu epidemic and the scientific research that has been carried out since to try to understand more about it.

Rivals, by Michael White: Eight stories, each focused on a different scientific endeavour in history involving rivalry between two or more parties. The book moves through history, beginning in the 1600s and ending in the present day. The stories are taken from a wide range of branches of science and technology, and include the invention of calculus, the discovery of oxygen, Darwin's theory of natural selection, the commercial development of electricity, the development of the atomic bomb, the elucidation of the structure of DNA, the space race, and the development of computing.

It Must be Beautiful, by Graham Farmelo (Ed): Eleven stories, each focused on the development of a different scientific equation. As in *Rivals*, the stories are taken from a wide range of branches of science and technology, and include $E=mc^2$, Schrodinger's wave equation, the mathematics of relativity, and the Yang-Mills equation.

Table 3.10: Matrix of Characteristics for Books From Sample in Stories of Scientific Endeavours or Events Category

	Longitude	The Great Arc	Fermat's Last Theorem	Flu	Rivals	It Must be Beautiful
Arrangement of Content	Beginning to end (novel-like). Continuous narrative Science writer	Beginning to end (novel-like). Continuous narrative Non-fiction writer	Beginning to end (novel-like). Continuous narrative Science writer, film and television producer	Beginning to end (novel-like). Continuous narrative Science writer	Beginning to end (novel-like). Continuous narrative Science writer	Beginning to end (novel-like). Continuous narrative Various scientists and science writers
Profession of Author(s)	Navigation (The History of Determining Longitude at Sea)	Cartography/Surveying (India)	Mathematics (Fermat's Last Theorem)	Medicine (The 1918 Flu)	Scientific Rivalry	Important equations
Science Topic	Navigation (The History of Determining Longitude at Sea)	Cartography/Surveying (India)	Mathematics (Fermat's Last Theorem)	Medicine (The 1918 Flu)	Scientific Rivalry	Important equations
Scientific Language	Language generally non-specialist Minor/non-existent	Language generally non-specialist Minor/non-existent	Relatively high level of jargon/equations Minor/non-existent	Some jargon/equations Minor/non-existent	Some jargon/equations Minor/non-existent	Some jargon/equations Minor/non-existent
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Minor/non-existent	Minor/non-existent	Significant secondary feature Minor/non-existent	Minor/non-existent	Significant secondary feature Minor/non-existent	Significant secondary feature Minor/non-existent
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No
Biography	Significant secondary feature. One individual particularly focussed on and several individuals equally focussed on Minor/non-existent	Significant secondary feature. Several individuals equally focussed on Minor/non-existent	Significant secondary feature. Several individuals equally focussed on Minor/non-existent	Significant secondary feature. Several individuals equally focussed on Minor/non-existent	Significant secondary feature. Several individuals equally focussed on Minor/non-existent	Significant secondary feature. Several individuals equally focussed on Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Main focus of book Yes	Main focus of book Yes	Main focus of book Yes	Main focus of book Yes	Main focus of book Yes	Main focus of book Yes
Story of Science Endeavour	Yes	Yes	Yes	Yes	Yes	Yes
Explanation/Discussion of Historical Science	Significant secondary feature	Minor/non-existent	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature

Table 3.10 continued

	Longitude	The Great Arc	Fermat's Last Theorem	Flu	Rivals	It Must be Beautiful
Elements of Science Fiction/Fantasy	No	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	No illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations	Black & white illustrations. Supplementary
Format	Small: 178 x 112	Medium: 197 x 130	Medium: 198 x 128	Medium: 197 x 129	Medium: 197 x 130	Medium: 197 x 130

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): In contrast to previous categories, authors of most books in this category are professional science or non-fiction writers. One exception is *It Must be Beautiful*, which is written by a variety of authors, both scientists and science writers. This is the first category where the authors are not predominantly or entirely scientists or other academics.

Science Topic: Each book in this category focuses on a different science topic, including: navigation – the history of determining longitude at sea (*Longitude*); cartography/surveying in India (*The Great Arc*); mathematics – Fermat’s last theorem (*Fermat’s Last Theorem*); medicine – the 1918 flu (*Flu*) scientific rivalry (*Rivals*) and important equations (*It Must be Beautiful*). The focus of most books in this category is narrower than many books in previous categories, as each book focuses on specific events or endeavours within a wider science topic (see section below: *Story of Science Endeavour*).

Scientific Language: The level of scientific language varies between different books in this category. Two books: *Longitude* and *The Great Arc* have language that is generally non-specialist; three books: *Flu*, *Rivals* and *It Must be Beautiful* have some jargon/equations, and one: *Fermat’s Last Theorem*, has a relatively high level of jargon/equations.

Bowring commented that these types of books are often less ‘scientific’ than other types of popular science books, because they are written for those adults who, rather than seeking a complex scientific explanation, simply “want a good read about an interesting subject” (personal communication, October 24, 2001). The books in this sample, however, indicate that, unexpectedly, this category does not have a lower overall level of scientific language than earlier categories.

New Scientific Ideas/Theories: This is not a feature of any of the books in this category.

Explanation/Discussion of Current Science: Explanation/discussion of current science is a less significant feature than all previous categories. Three books in this category: *Longitude*, *The Great Arc* and *Flu*, have no significant explanation/discussion of current science, and instead concentrate entirely on ‘story’ elements, and on the explanation/discussion of historical science. Two books: *Fermat’s Last Theorem*, and *Rivals* have explanation/discussion of current science as a significant secondary feature. These explanations, however, fit around, and are secondary to, the historical and biographical aspects of the stories the books centre around. This the opposite situation to categories 1, 2, and 4, all of which feature explanation/discussion of current science as a significant or main feature.

Advocacy/Argument: This is not a significant feature of any of the books in this category.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: This category has a higher level of biography than previous categories – a significant secondary feature of all books, second only to the story of the science endeavour and the events of science surrounding this that the book focuses on. Lives of individuals are told as they fit into the story of the scientific endeavour. All books focus equally on several individuals, however *Longitude* focuses particularly strongly on John Harrison, with significant content on several others.

Autobiography: This is not a significant feature of any of the books in this category.

Events of Science: In contrast to all previous categories, the events of science, such as how discoveries were made, and how scientific beliefs came about (Post prospero, 1994) are the main focus of all the books in this category. All books in this category are centred around the stories of specific scientific endeavours or events (see below) and, as well as the events of the main story, each book discusses broader events related to each story. For example, *Longitude* involves a discussion of the history of longitude problems throughout history, *Fermat's Last Theorem* discusses work on other mathematical theories, and *Rivals* discusses the history behind each rivalry.

Story of Science Endeavour: This is the main focus and the defining feature of all the books in this category. *Longitude* is the story of the way in which the problem of measuring longitude at sea was solved. *The Great Arc* is the story of the early surveying of India. *Fermat's Last Theorem* is the story of how Fermat's last theorem was solved. *Flu* centres is the story of the 1918 flu and the search to uncover its cause, each chapter of *Rivals* focuses on the story of a scientific endeavour involving rivalry, and each chapter of *It Must be Beautiful* focuses on the story of the development of a scientific equation.

All books have a strong narrative storyline (McDonald, 2000), with the story of the scientific endeavour as the central thread. Characteristics such as biographical detail, discussions of historical scientific ideas, and events of science related to, but outside the main story are situated within the central story and are secondary to it.

Explanation/Discussion of Historical Science: This is a significant secondary feature of most of the books in this category. The exception is *The Great Arc*, which does not discuss historical science to any significant level, focusing instead on the immediate events of the scientific endeavour. This is the only category so far to concentrate more on the explanation/discussion of historical science than the explanation/discussion of current science.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: Again, all books in this category use regular matt paper.

Illustrations: Four books in this category: *The Great Arc*, *Fermat's Last Theorem*, *Flu*, and *It Must be Beautiful*, have black and white illustrations that are supplementary to the text. The remaining two books in this category are not illustrated.

Format: Most books in this category are medium sized, with the exception of *Longitude*, which is small sized.

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Most authors are science or non-fiction writers
- Centred around a spectrum of topics, defining feature is that each book is focussed on a specific event
- Level of scientific language varies
- Authors ideas/theories is not a significant feature
- Explanation/discussion of current science may be present as a significant secondary feature
- Advocacy/argument is not a significant feature
- Not practical science guides
- Biography is a significant secondary feature
- Autobiography is not a significant feature
- Centred around the events of science, surrounding or related to a particular scientific endeavour
- Defining feature is that books are centred around stories of science endeavours
- Explanation/discussion of historical science is a significant secondary feature
- Elements of science fiction/fantasy is not a feature
- Regular matt paper
- Most have black and white illustrations, supplementary to the text
- Most are medium sized

Category 6. History Of Branches Or Topics In Science

Summary of Category

This category consists of books centred around the events in the history of a branch or topic in science. All other aspects of the books hinge on this characteristic. Like the previous group, books in this category are very 'story rich', with biographical detail as a significant secondary feature, and are centred around a range of topics in the history of science. Books in this group do not have significant levels of autobiography, and have a broader focus than the story of a particular science endeavour or event.

Some books contain explanations/discussions of current science, and explanation/discussion of historical science is a main or significant feature of most of the books in this category. These books do not contain significant levels of new scientific ideas/theories or advocacy/argument. They are not practical science guides, and do not contain elements of science fiction/fantasy.

Books in this sub-genre are novel-like, with a continuous narrative thread, and authors are a mixture of scientists, academics, professionals, and science or non-fiction writers. The level of scientific language varies between individual books. All are medium sized, printed on regular matt paper, with black and white illustrations, supplementary to the text.

The main difference between this category and the previous one is subtle. This category deals with telling the history of an entire branch or topic in science, whereas the previous one focuses on the story of a particular scientific endeavour.

This category was mentioned by Morrison and Morrison (1999).

Books from Sample in Category

Eleven books from the sample exemplify this category. These are:

- *E=mc²*, by David Bodanis
- *Light Years*, by Brian Clegg
- *Living Dolls*, by Gaby Wood
- *The Code Book*, by Simon Singh
- *Ice Age*, by John and Mary Gribbon
- *Evolution's Workshop*, by Edward J Larson
- *Of Moths and Men*, by Judith Hooper
- *Zero*, by Charles Siefe

- *The Dinosaur Hunters*, by Deborah Cadbury
- *The Mysteries Within*, by Sherwin B Nuland
- *Plague Wars*, by Tom Mangold and Jeff Goldberg

Brief Description of Each Book

E=mc², by David Bodanis: The history of the development of the equation $E=mc^2$ and a discussion of the applications for which it has been used. The book begins with the story of how the equation was first proposed by Albert Einstein, followed by the history of each part of the equation, and how the equation has been used, from its initial proposal by Einstein, to the development of the atomic bomb, to space research.

Light Years, by Brian Clegg: A history of the study of light, from ancient times to the present. The book includes stories of those involved in studying light throughout the history of research on the topic, and contains explanations of the science behind each discovery about light. As the story of the history of study of light develops, so too does the explanation of what light is, how it works and what it has been used for.

Living Dolls, by Gaby Wood: The history of mechanical life, from the 1700s until the early 1900s. The book consists of five separate stories about the use of mechanical life during this time, including androids (mechanical 'people' and animals), talking dolls, early film, and those who made a living by pretending to be mechanical dolls.

The Code Book, by Simon Singh: A history of codes, cyphers, cryptanalysis and cryptography. The book begins in ancient history with the simplest cyphers, and moves forward in a chronological order, telling the stories of the inventions of various cyphers, and how they were broken. As the history develops, Singh explains in detail the maths and logic behind each code.

Ice Age, by John Gribbon and Mary Gribbon: The history of the study of Ice Ages, starting from the first realisation in Victorian times that there might have been Ice Ages, until the present day. There are explanations of the state of scientific knowledge at each stage through history, intertwined with the lives of the people involved in making the discoveries, and a discussion of how ideas have changed over time.

Evolution's Workshop, by Edward J Larson: The history of scientific study in the Galapagos Islands from before Darwin's time until the present day. Included as the book progresses are explanations of the science linked with the Galapagos Islands, intertwined with the people involved in making the discoveries, and how ideas have changed over time, set against a backdrop of the history of the Galapagos Islands themselves.

Of Moths and Men, by *Judith Hooper*: The story of the study of the peppered moth in England, which has long been considered a textbook example of Darwinian Natural Selection. The moth exists in two different forms, peppered (pale with dark markings) and melanic (dark). It was traditionally thought that in the 1800s, the proportion of the melanic form of the moth increased, seemingly in response to industrial pollution darkening tree trunks, and that recently, the melanic form has been declining, seemingly in response to cleaner air. Recently, however, this view has been called into question, and the issue is still not resolved. This book documents the history of those who studied the moth, and discusses and explains the changing scientific ideas about the moth and its relationship to Darwinian Natural Selection.

Zero, by *Charles Siefe and Matt Zimet*: The history of how the concept of zero has been used throughout time in mathematics and physics. The book discusses the science and scientific thought surrounding the use of zero over many years of history, starting with ancient times.

The Dinosaur Hunters, by *Deborah Cadbury*: The story of the period when the earliest discoveries of dinosaur fossils were made. Included are the stories of the lives of the earliest dinosaur fossil hunters and collectors, and the arguments and rivalries that occurred between the first dinosaur experts.

The Mysteries Within, by *Sherwin B Nuland*: Nuland discusses the history of scientific thought and research behind a number of organs in the human body. A particular focus is on the myths that have surrounded each organ in the past, who proposed theories and conducted research on each organ, and how the myths of the past were shown to be incorrect. Interspersed with this are stories of Nuland's own experiences as a surgeon.

Plague Wars, by *Tom Mangold and Jeff Goldberg*: A history of twentieth-century biological weapons programmes and incidents. The authors discuss the history of biological weapons programmes in the US and Britain, and in a number of other countries. There is a strong focus on Russia, and also covered are Japan, Rhodesia, South Africa, Iraq and North Korea.

Table 3.11: Matrix of Characteristics for Books From Sample in History of Branches or Topics in Science Category

	E=mc²	Light Years	Living Dolls	The Code Book	Ice Age	Evolution's Workshop	Of Moths and Men
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Science writer, mathematics academic	Technology applications consultant	Non-fiction writer	Science writer, film and TV producer	Fellow in astronomy (J. Gribbin), young person's science writer (M. Gribbin)	Professor of history and law	Science writer
Science Topic	Relativity (E=mc ²)	Light	Mechanical Life	Cryptography/Cryptanalysis	Ice Ages	Science in the Galapagos Islands	Evolution (The Peppered Moth)
Scientific Language	Language generally non-specialist	Some jargon/equations	Language generally non-specialist	Relatively high level of jargon/equations	Some jargon/equations	Some jargon/equations	Some jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Significant secondary feature	Significant secondary feature	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent	Significant secondary feature
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No	No
Biography	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Story of Science Endeavour	No	No	No	No	No	No	No

Table 3.11 continued

	E=mc²	Light Years	Living Dolls	The Code Book	Ice Age	Evolution's Workshop	Of Moths and Men
Explanation/Discussion of Historical Science	Main focus of book	Main focus of book	Minor/non-existent	Main focus of book	Main focus of book	Significant secondary feature	Main focus of book
Elements of Science Fiction/Fantasy	No	No	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary
Format	Medium: 222 x 143	Medium: 196 x 129	Medium: 204 x 136	Medium: 196 x 128	Medium: 205 x 135	Medium: 240 x 164	Medium: 215 x 159

Table 3.11 continued

	Zero	The Dinosaur Hunters	The Mysteries Within	Plague Wars
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Science journalist	Television science producer and science writer	Surgeon	Journalists
Science Topic	Mathematics (The Number Zero)	Palaeontology (Dinosaurs)	Medicine (The Human Body)	Biological Warfare
Scientific Language	Relatively high level of jargon/equations	Language generally non-specialist	Some jargon/equations	Language generally non-specialist
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent

Table 3.11 continued

	Zero	The Dinosaur Hunters	The Mysteries Within	Plague Wars
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature
Practical Science Guidance	No	No	No	No
Biography	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on
Autobiography	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent
Events of Science	Significant secondary feature	Main focus of book	Main focus of book	Main focus of book
Story of Science Endeavour	No	No	No	No
Explanation/Discussion of Historical Science	Main focus of book	Significant secondary feature	Main focus of book	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary
Format	Medium: 203 x 129	Medium: 216 x 157	Medium: 213 x 140	Medium: 198 x 133

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are also novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): Approximately 50% of authors in this category are scientists/academics and the remainder are science/non-fiction writers.

Science Topic: Like the previous category, books in this category focus on a variety of science topics, including relativity ($E=mc^2$), light (*Light Years*), mechanical life (*Living Dolls*), cryptography/cryptanalysis (*The Code Book*), ice ages (*Ice Age*), evolution (*Evolution's Workshop* and *Of Moths and Men*), mathematics (*Zero*), paleontology (*The Dinosaur Hunters*), medicine (*The Mysteries Within*), and biological warfare (*Plague Wars*). The focus of each book is, however, wider than the previous category, concentrating on the history of an entire scientific topic or field, rather than a specific endeavour.

Scientific Language: Again, the level of scientific language varies between different books in this category. Four books have language that is generally non-specialist ($E=mc^2$, *Living Dolls*, *The Dinosaur Hunters*, and *Plague Wars*), five books have some jargon/equations (*Light Years*, *Ice Age*, *Evolution's Workshop*, *Of Moths and Men*, and *The Mysteries Within*), and two books have a relatively high level of jargon/equations (*The Code Book* and *Zero*).

This spread of scientific language is similar to the previous category, and indicates that this category, too, does not have a lower overall level of scientific language than previous categories.

New Scientific Ideas/Theories: This is not a feature of any of the books in this category.

Explanation/Discussion of Current Science: Like the previous category, the explanation/discussion of current science is a less significant feature than earlier categories. Five books in the sample have no significant explanation/discussion of current science, and instead, concentrate entirely on 'story' elements, and on the explanation/discussion of historical science. Explanation/discussion of current science is a significant secondary feature of the remaining six books in this sample: $E=mc^2$, *Light Years*, *The Code Book*, *Ice Age*, *Of Moths and Men*, and *Zero*. Like the previous category, however, the explanations/discussions of current science that do occur are not the main focus of the book, but instead, fit into the historical and biographical aspects of the areas of science history that the books centre around.

Advocacy/Argument: Like the previous category, this is not a significant feature of most of the books in this category. One exception is *Plague Wars*, which does contain advocacy/argument as a significant secondary feature, with the authors arguing of the danger of biological weapons.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: Like the previous category, biography is a significant secondary feature of all books in this category, second only to the events of science history. The lives of individuals are told as they fit into the central discussion of events. In all books, several individuals are equally focussed on.

Autobiography: Autobiography is not a significant feature of most of the books in this category, with the exception of *The Mysteries Within*, where autobiography is a significant secondary feature, containing passages about the author's own experience as a surgeon.

Events of Science: The events of the history of science are the main focus of all the books in this sample, with any biography and explanation/discussion of science fitting into the history as it unfolds. As Morrison and Morrison (1999) commented, these books trace a single theme in science history. $E=mc^2$ revolves around the history of how the equation was invented, and how it has since been used. *Light Years* focuses on the history of the study of light. *Living Dolls* focuses on five examples of mechanical life in history from 1700 to 1900. *The Code Book* gives a history of cyphers and the stories surrounding them. *Ice Age* gives a history of the study of ice ages. *Evolutions Workshop* gives a history of science in the Galapagos islands, beginning before Darwin's time and ending at the present day. *Of Moths and Men* gives a history of the study of the peppered moth. *Zero* gives a history of the study of the number zero, *The Dinosaur Hunters* gives a history of the early study of dinosaurs in England, *The Mysteries Within* gives a history of study and medicine surrounding a number of organs in the human body, and *Plague Wars* discusses the history of biological weapons in the twentieth century.

Story of Science Endeavour: This is not a feature of any of the books in this category as, in contrast to the previous category, books in this category discuss a broader history of a field or topic in science, rather than concentrating on one specific endeavour.

Explanation/Discussion of Historical Science: Together with the main discussion of the events of history, explanation/discussion of historical science is the main focus of seven books in this category: $E=mc^2$, *Light Years*, *The Code Book*, *Ice Age*, *Of Moths and Men*, *Zero*, and *The Mysteries Within*. This is a significant secondary feature of a further two books in this category: *Evolution's Workshop* and *The Dinosaur Hunters*. In only two books, *Living Dolls* and *Plague Wars*, was the explanation/discussion of historical science not a significant feature. This indicates that together with the events of science history, the history of the science itself, how ideas have changed over time and what was believed in the past is a very important feature of books in this category.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: All books in this category contain black and white illustrations that are supplementary to the text.

Format: All books in this category are medium sized.

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Authors are a mixture of scientists/academics/professionals and science or non-fiction writers
- Centred around a range of science topics in the history of science
- Level of scientific language varies
- Authors ideas/theories is not a significant feature
- Explanation/discussion of current science may be a significant secondary feature
- Advocacy/argument is not a significant feature of most books
- Not practical science guides
- Biography is a significant secondary feature
- Autobiography is not a significant feature
- Defining feature is that books are centred around the events of science in the history of a particular field
- Story of science endeavour is not a feature – focus is broader
- Explanation/discussion of historical science is a significant feature
- Elements of science fiction/fantasy is not a feature
- Regular matt paper
- Black and white illustrations, supplementary to the text
- Medium sized

Category 7: Biography

Summary of Category

This category consists of books centred around biography, and all other aspects of the books hinge on this characteristic. Books in this sub-genre are very 'story rich', with discussions of the events of science interspersed into the central biographical thread. They are centred around a range of science topics surrounding the lives of individuals. They do not contain significant levels of autobiography, and have a wider focus than the stories of specific science endeavours.

These books do not have significant levels of explanation/discussion of current science, new ideas/theories, or advocacy/argument. They are not practical science guides, and do not contain elements of science fiction/fantasy. Explanation/discussion of historical science, however, is a significant secondary feature of most of the books in this category.

Books in this group are novel-like, with a continuous narrative thread, and most authors are science or non-fiction writers. Language is generally non-specialist. Books are medium sized, printed on regular matt paper, with black and white illustrations, supplementary to the text.

This category was mentioned by Morrison and Morrison (1999); Rabiner (Nixon, 1991); Sapp (1995) and Turney (1999).

Books from Sample in Category

Four books from the sample exemplify this category. These are:

- *The Map that Changed the World*, by Simon Winchester
- *Charles Darwin in Australia*, by F W Nicholas and J M Nicholas
- *Galileo's Daughter*, by Dava Sobel
- *The Queen's Conjuror*, by Benjamin Woolley

Brief Description of Each Book

The Map that Changed the World, by Simon Winchester: The story of the life of William Smith, one of the pioneers of geology in England. Known as the 'father of English geology', Smith's greatest feat was creating the first geological map of England, the first of its kind. Through the story of Smith, his personal life, and his involvement in geology, a detailed history of early English geology is told.

Charles Darwin in Australia, by F W Nicholas and J M Nicholas: A biographical account of Charles Darwin's visit to Australia on the *Beagle* which follows his notes and diary. Some of Darwin's scientific

research and ideas are mentioned, but the book focuses primarily on the series of events that took place during his visit.

Galileo's Daughter, by Dava Sobel: A biography of the life and work of Galileo, with a focus on the correspondence between Galileo and his daughter, Maria Celeste.

The Queen's Conjuror, by Benjamin Woolley: A biography of the life and work of 16th century philosopher, 'scientist', and magician John Dee.

Table 3.12: Matrix of Characteristics for Books From Sample in Biography Category

	The Map that Changed the World	Charles Darwin in Australia	Galileo's Daughter	The Queen's Conjuror
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Non-fiction writer	Animal geneticist (F Nicholas), and librarian (J Nicholas)	Science writer	Non-fiction writer and broadcaster
Science Topic	Geology	Evolution and Natural History	Astronomy	Sixteenth Century Science and Magic
Scientific Language	Some jargon/equations	Language generally non-specialist	Language generally non-specialist	Language generally non-specialist
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No
Biography	Main focus of book. One individual particularly focussed on	Main focus of book. One individual particularly focussed on	Main focus of book. One individual particularly focussed on	Main focus of book. One individual particularly focussed on
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Main focus of book	Minor/non-existent	Significant secondary feature	Significant secondary feature
Story of Science Endeavour	No	No	No	No
Explanation/Discussion of Historical Science	Significant secondary feature	Minor/non-existent	Significant secondary feature	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No	No	No

Table 3.12 continued

	The Map that Changed the World	Charles Darwin in Australia	Galileo's Daughter	The Queen's Conjuror
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations and full colour illustrations. Supplementary
Format	Medium: 197 x 128	Medium: 198 x 128	Medium: 197 x 129	Medium: 195 x 129

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): Like category 5, authors of most books in this category are science or non-fiction writers. The exception is *Charles Darwin in Australia*, where the authors are an animal geneticist and a librarian.

Science Topic: Again, books in this category focus on a variety of science topics, including geology (*The Map that Changed the World*), evolution and natural history (*Charles Darwin in Australia*), astronomy (*Galileo's Daughter*) and sixteenth-century science and magic (*The Queen's Conjuror*). Each book focuses on the science surrounding the individual on whom the book is centred.

Scientific Language: On average, the books in this category have the lowest overall level of scientific language of any category so far. Most books in this category have language that is generally non-specialist. One book, *The Map that Changed the World*, has some jargon/equations, but no books have a relatively high level of jargon/equations.

This is in line with the comments of Rabiner (Nixon, 1991), who said that biographies and autobiographies can provide an ideal avenue into science, because they are more accessible to non-scientists, whilst still allowing an insight into how science operates. "they immerse us into the world of research and ideas without a blackboardfull of equations" (p. 34).

New Scientific Ideas/Theories: This is not a feature of any of the books in this category.

Explanation/Discussion of Current Science: Explanation and discussion of current science is not a significant feature of any of the books in this category. Some books do, however, explain and discuss aspects of historical science (see below). This is the only category so far not to significantly feature explanation/discussion of current science in any book.

Advocacy/Argument: Like the previous two categories, this is not a significant feature of any of the books in this category.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: Biography is the main focus and the defining feature of all books in this category, running as a thread throughout, with all other aspects secondary to it. All books focus primarily on one individual.

Autobiography: This is not a significant feature of any of the books in this category.

Events of Science: This is a significant secondary feature of all of the books in this category. A major feature of *The Map that Changed the World* is the history of English geology, and Smith's life is used as a device to tell this history. *Charles Darwin in Australia* discusses the events on Darwin's trip. *Galileo's Daughter* covers aspects of society and scientific beliefs over the period of Galileo's life, illuminating and providing a context for Galileo's life. *The Queen's Conjuror*, as well as telling Dee's life story, also paints a picture of society and events and beliefs at the time, both 'scientific' and in society in general.

This is in line with the comments of Sapp (1995), who said that well-written biographies or autobiographies are not only about the person on whom they are focussed, but everything surrounding them, including their social and cultural world. This can help to personalise science.

Story of Science Endeavour: This is not a feature of any of the books in this category.

Explanation/Discussion of Historical Science: This is a significant secondary feature of three of the books in this sample. *The Map that Changed the World* discusses historical scientific ideas in geology. *Galileo's Daughter* contains a discussion of Galileo and his contemporaries' ideas. *The Queen's Conjuror* discusses Dees work, and also what others believed at the time. Only one book, *Charles Darwin in Australia*, made no significant mention of historical science, instead focusing on the events of Darwin's Australian journey.

This is in line with Turney's comments (1999) that biographies, although primarily aimed at telling the lives of scientists, still often involve explanations of science also. However, in light of this sample, this comment should be qualified with explanations of *historical* science – albeit historical science that was current during the subject of the biography's life.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: All books in this sample contain black and white illustrations. In addition, *The Queen's Conjuror* contains full colour illustrations. All illustrations are supplementary to the text.

Format: Again, all books in this category are medium sized.

Summary of Characteristics of Books in this Category

- Novel-like with continuous narrative thread
- Most authors are science or non-fiction writers
- Centred around a range of science topics surrounding the lives of individuals
- Language is generally non-specialist
- New ideas/theories is not a significant feature
- Explanation/discussion of current science is not a significant feature
- Advocacy/argument is not a significant feature
- Not practical science guides
- Defining feature is that books are centred around biography
- Autobiography is not a significant feature
- Events of science is a significant secondary feature
- Story of science endeavour is not a feature
- Explanation/discussion of historical science is a significant secondary feature of most books
- Elements of science fiction/fantasy is not a feature
- Regular matt paper
- Illustrated with black and white illustrations, supplementary to the text
- Medium sized

Category 8: Autobiography

Summary Of Category

This category consists of books centred around autobiographies of scientists, and all other aspects of the books hinge on this characteristic. Books in this category are very 'story rich', with discussions of events and biography interspersed into the central autobiographical thread. The books are centred around a range of science topics, and have a wider focus than stories of science endeavours or events.

Some books contain explanations and discussions of current or historical science, but new scientific ideas/theories and advocacy/argument are not a significant feature of most books. They are not practical science guides, and do not contain elements of science fiction/fantasy.

Books in this sub-genre are novel-like, with a continuous narrative thread, and most are written by scientists. The level of scientific language varies between different books. Books are medium sized, printed on regular matt paper, and most contain black and white illustrations, supplementary to the text.

This category was mentioned by Morrison and Morrison (1999); Rabiner (Nixon, 1991); Sapp (1995); and Turney (1999).

Books From Sample In Category

Seven books from the sample exemplify this category. These are:

- *Uncle Tungsten*, by Oliver Sacks
- *'Surely You're Joking, Mr Feynman!'*, by Richard P Feynman
- *Off the Planet*, by Jerry M Linenger
- *Wildlife Wars*, by Richard Leakey
- *The Common Thread*, by John Sulston and Georgina Ferry
- *Failure is not an Option*, by Gene Kranz
- *Driving Mr Albert*, by Michael Paterniti

Brief Description of Each Book

Uncle Tungsten, by Oliver Sacks: A combined autobiography, history of chemistry, and a series of explanations of chemical concepts. Sacks tells the story of his childhood, his family and their interest in chemistry. Interwoven is a history of chemistry, with explanations of a range of chemical concepts.

'Surely You're Joking, Mr Feynman!', by *Richard P Feynman:* Autobiographical stories of the life of Nobel-prize winning physicist Richard Feynman. The book is based on Feynman's conversations about his life which were recorded by Ralph Leighton, and edited into a book by Edward Hutchings.

Off the Planet, by Jerry M. Linenger: An autobiographical account of astronaut Jerry Linenger's experience of spending five months on the space station *Mir*.

Wildlife Wars, by Richard Leakey: An autobiographical account of Richard Leakey's personal experiences whilst director of the Kenyan Wildlife Service.

The Common Thread, by John Sulston and Georgina Ferry: An autobiographical account of Sulston's time as director of the Human Genome Project, with a discussion of the science and politics surrounding the project.

Failure is Not an Option, by Gene Kranz: An autobiographical account of Kranz's time working at NASA as a flight controller for the Mercury, Gemini and Apollo space programs, with a discussion of the history of the early NASA space program.

Driving Mr Albert, by Michael Paterniti: Pathologist Thomas Harvey performed a post mortem on Einstein, and in the process, took his brain home, supposedly for research purposes. Many decades later, Harvey still had the brain at his home. Journalist Michael Paterniti drove Harvey across America with Einstein's brain, to visit Einstein's granddaughter. This book is the story of the trip.

Table 3.13: Matrix of Characteristics for Books From Sample in Autobiography Category

	Uncle Tungsten	'Surely You're Joking, Mr Feynman'	Off the Planet	Wildlife Wars	The Common Thread	Failure is not an Option	Driving Mr Albert
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of neurology	Professor of theoretical physics	Astronaut	Scientist in human origins and palaeontology, former director of Kenyan Wildlife Service	Director of Human Genome Project (Sulston), science writer and broadcaster (Ferry)	NASA flight director	Journalist
Science Topic	Chemistry	Physics	Space Exploration	Wildlife Conservation	Genetics (The Human Genome)	Space Exploration	Relativity
Scientific Language	Relatively high level of jargon/equations	Language generally non-specialist	Language generally non-specialist	Language generally non-specialist	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Language generally non-specialist
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No	No

Table 3.13 continued

	Uncle Tungsten	'Surely You're Joking, Mr Feynman'	Off the Planet	Wildlife Wars	The Common Thread	Failure is not an Option	Driving Mr Albert
Biography	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Several individuals equally focussed on	Significant secondary feature. Two individuals particularly focussed on
Autobiography	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Events of Science	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature	Significant secondary feature
Story of Science Endeavour	No	No	No	No	No	No	No
Explanation/Discussion of Historical Science	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature	Significant secondary feature	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	No illustrations	Full colour illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary	No illustrations
Format	Medium: 233 x 152	Medium: 197 x 128	Medium: 227 x 152	Medium: 197 x 129	Medium: 240 x 165	Medium: 228 x 150	Medium: 197 x 126

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: All books in this category are novel-like, designed to be read in entirety, from beginning to end. All have a continuous narrative thread.

Profession of Author(s): As this category consists of books about scientists' personal experiences, the authors of most books in this category are (or were) scientists in the field that the book is written about. One exception is *Driving Mr Albert*, where the author is a journalist.

Science Topic: Again, books in this category focus on a variety of science topics, including chemistry, general physics, space exploration (two books), wildlife conservation, genetics, and relativity. Like the previous category, each book focuses on the science surrounding the individual on whom the book is centred.

Scientific Language: The level of scientific language varies between books in this category. Four have language that is generally non-specialist (*'Surely You're Joking, Mr Feynman!'*, *Off the Planet*, *Wildlife Wars* and *Driving Mr Albert*), while the remaining three books have a relatively high level of jargon/equations. This is a similar pattern to several previous categories.

This is not entirely in agreement with the comments of Rabiner (Nixon, 1991), who said that biographies and autobiographies can provide an ideal avenue into science, because they are more accessible to non-scientists, as "they immerse us into the world of research and ideas without a blackboardfull of equations" (p. 34). Although this was the case for the previous category (biography), some books in this category do have a relatively high level of scientific language.

New Scientific Ideas/Theories: Again, the author's new scientific ideas/theories do not feature significantly in most books in this category. The exception to this is *The Common Thread*, where the author's ideas on the ethics/legalities of genetic research are a significant secondary feature.

Explanation/Discussion of Current Science: The amount of scientific explanation varies from book to book in this category. Three books: *Uncle Tungsten*, *The Common Thread*, and *Failure is Not an Option* have a significant level of explanation and discussion of current science. These explanations, however, are not the main focus of the books, but instead, fit into the autobiography that the books centre around. The remaining books in this category, in contrast, have relatively little explanation and discussion of current science.

Advocacy/Argument: This is not a significant feature of most of the books in this category. Two exceptions are *The Common Thread*, where the author advocates against patenting genetic information, and *Failure is Not an Option*, where the author advocates the importance of a space program.

Practical Science Guidance: No books in this category were designed for the purpose of providing a practical guide to a scientific activity.

Biography: Biography is a significant secondary feature of all books in this category. Most books focus equally on several individuals, with the exception of *Driving Mr Albert*, where the biographical aspects focus primarily on two individuals, Einstein and Thomas Harvey.

Autobiography: Autobiography is the main focus of all the books in this category, and all other characteristics are secondary to it. Some books are about the scientists lives as a whole, whilst others focus on a particular endeavour, event, or experience that they were involved in. In *Uncle Tungsten*, the main focus of the book is the story of Sack's childhood fascination with chemistry. '*Surely You're Joking, Mr Feynman!*' is an autobiography which focuses broadly on Feynman's life. *Off the Planet* is an autobiography of Linenger and his time on the space station *Mir*. *Wildlife Wars* focuses mainly on Leakey's time in the Kenyan wildlife service, but does discuss some of his childhood, life before and personal life. *The Common Thread* focuses primarily on Sulston's involvement in the human genome project. *Failure is Not an Option* focuses mostly on Kranz's work on the Mercury, Gemini and Apollo programs. *Driving Mr Albert* is an account of journalist Paterniti's journey across America with Thomas Harvey and Einstein's brain.

Events of Science: This is a significant secondary feature of all the books in this category. *Uncle Tungsten* discusses Sack's childhood, and also discusses in quite some detail the events of the history of chemistry. '*Surely You're Joking, Mr Feynman!*' discusses the events in and surrounding Feynman's life. *Off the Planet* discusses the series of events during Linenger's time on *Mir*. *Wildlife Wars* discusses the series of events over the time Leakey was head of the Kenyan Wildlife Service. *The Common Thread* runs through the entire genome project and the peripheral events surrounding it, and *Failure is Not an Option* tells the story of the entire space program, together with Kranz's specific involvement in it.

This is in line with the comments of Sapp (1995), who said that well-written biographies or autobiographies are not only about the person on whom they are focussed, but everything surrounding them, including their social and cultural world, and this can help to personalise science.

Story of Science Endeavour: This is not a feature of any of the books in this category.

Explanation/Discussion of Historical Science: This is a significant secondary feature of three of the books in this category. *Uncle Tungsten* includes the discussion of theories throughout the history of chemistry. In *The Common Thread*, the author explains and discusses the science before and during the genome project. In *Failure is Not an Option*, the author discusses the spacecraft technology at each stage. In the remaining books in this category, explanation/discussion of historical science is not a significant feature.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: Four books in this sample: *Uncle Tungsten*, *Wildlife Wars*, *The Common Thread* and *Failure is not an Option*, contain black and white illustrations. One book, *Off the Planet*, contains full colour illustrations. All illustrations are supplementary to the text. The remaining two books in this sample are not illustrated.

Format: All books in this category are medium sized.

Note: Turney (1999) commented that the autobiography category is quite diverse, and that differences in approach depend on how much the author focuses on explaining their science, versus telling their life story, versus telling the story of their scientific work. This was indeed the case for the books in this sample.

Summary of Characteristics of Books in this Category

- Novel-like, with continuous narrative thread
- Most authors are scientists in the field the book is written about
- Centred around a range of science topics
- Level of scientific language varies
- Author's new ideas/theories is not a significant feature of most books
- Explanation/discussion of current science is a significant secondary feature of some books
- Advocacy/argument is not a significant feature of most books
- Not practical science guides
- Biography is a significant secondary feature
- Defining feature is that books are centred around autobiography
- Events of science is a significant secondary feature
- Story of science endeavour is not a feature
- Explanation/discussion of historical science is a significant secondary feature of some books
- Elements of science fiction/fantasy is not a feature
- Regular matt paper
- Most contain black and white illustrations, supplementary to the text
- Medium sized

Category 9: Practical Science Guides

Summary of Category

Books in this category are practical science guides, and all other aspects of the books hinge on this characteristic. Books are very 'science rich', with significant levels of explanation and discussion of current science. All in this sample are centred around astronomy. New scientific ideas/theories and advocacy/argument are not present to significant levels.

Books in this group contain no significant 'story' elements of biography, autobiography, discussion of events, or stories of science endeavours. They do not have significant levels of explanation/discussion of historical science, and do not have elements of science fiction.

In contrast to previous categories, these books are encyclopedia-like, with a combination of continuous narrative and short facts/explanations in non-alphabetical order. Authors are astronomers and amateur astronomy enthusiasts and the books have a relatively high level of scientific language. All are large sized, printed on intermediate semi-glossy paper, with dominant black, white and blue illustrations.

Books of this type were mentioned by Bradford and Loose (1994) and Turney (1999).

Books From Sample in Category

Four books from the sample exemplify this category. These are:

- *A Walk Through the Southern Sky*, by Milton D Heifetz and Wil Tirion
- *The Southern Sky Guide*, by David Ellyard and Wil Tirion
- *Astronomy 2000*, by Glenn Dawes, Peter Northfield and Ken Wallace
- *Astronomy 2001*, by Glenn Dawes, Peter Northfield and Ken Wallace

Brief Description of Each Book

A Walk Through the Southern Sky, by Milton D Heifetz and Wil Tirion: A beginners guide to amateur astronomy. The book begins with a discussion of how to look at the sky, how to measure distances, and how to use the rest of the book. Following this are charts of what to look for in the night sky at each stage of the year, and a 'walk' through various features of the night sky, with a discussion of one specific feature at a time, including how to find each feature, and what to look for. Finally, the book discusses some of the legends associated with various constellations.

The Southern Sky Guide, by David Ellyard and Wil Tirion: A guidebook for those who participate in amateur astronomy in the southern hemisphere. The book begins with a discussion of the night sky and basic astronomy theory, followed by a series of charts of what and when can be seen in the night sky, accompanied by explanatory text.

Astronomy 2000, by Glenn Dawes, Peter Northfield and Ken Wallace: A guidebook for those who participate in amateur astronomy in eastern Australia, this book contains data and information aimed at facilitating amateur astronomers to carry out their hobby. The book describes and diagrams what can be seen, where and when, on a month-by-month basis. The book contains a large number of charts, diagrams, maps and tables, with accompanying explanatory text. Places that amateur astronomers can go to look for more information on astronomy are also discussed, as well as information about observatories. The book contains some brief explanations of astronomy theory and practical aspects of astronomy, with accompanying line drawings, however the majority of the book is devoted to providing practical information about what to look for in the sky.

Note: *Astronomy 2001* is identical to *Astronomy 2000*, but with data relevant to astronomy in 2001.

Table 3.14: Matrix of Characteristics for Books From Sample in Practical Science Guides Category

	A Walk Through the Southern Sky	The Southern Sky Guide	Astronomy 2000 & Astronomy 2001
Arrangement of Content	In parts, out of order (encyclopedia-like). Some continuous narrative, some short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Some continuous narrative, some short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Some continuous narrative, some short facts/explanations in non-alphabetical order
Profession of Author(s)	Astronomer (Heifetz) and astronomical cartographer (Tirion)	Astronomer (Ellyard) and astronomical cartographer (Tirion)	Astronomical society members and amateur astronomy enthusiasts
Science Topic	Astronomy	Astronomy	Astronomy
Scientific Language	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Relatively high level of jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Significant secondary feature	Significant secondary feature	Significant secondary feature
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	Yes	Yes	Yes
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavours	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/Non-existent	Minor/non-existent

Table 3.14 continued

	A Walk Through the Southern Sky	The Southern Sky Guide	Astronomy 2000 & Astronomy 2001
Elements of Science Fiction/Fantasy	No	No	No
Paper Type	Intermediate semi-glossy	Intermediate semi-glossy	Intermediate semi-glossy
Illustrations	Black, white & blue illustrations. Dominant	Black, white & blue illustrations. Dominant	Black, white & blue illustrations. Dominant
Format	Large: 245 x 189	Large: 296 x 210	Large: 264 x 200

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: In contrast to all previous categories, all books in this category are encyclopedia-like, and can be read in parts, out of order. All contain some sections of continuous narrative, and some sections of short facts/explanations in non-alphabetical order.

Profession of Author(s): The authors of the books in this category are all personally involved in astronomy, either as professional astronomers or as astronomical society members and amateur astronomy enthusiasts. One is an astronomical cartographer.

Science Topic: All books in this category from this sample focus on astronomy. It is, however, possible that a wider range of topics may be found in a larger sample, such as dinosaur hunting, fossil hunting, personal disease management or computer building (Bradford & Loose, 1994; Turney, 1999).

Scientific Language: All books in this category have a relatively high level of jargon/equations.

New Scientific Ideas/Theories: This is not a significant feature of any of the books in this category.

Explanation/Discussion of Current Science: This is a significant feature of all books in this category, there to support the main focus of the books: data to assist amateur astronomers in their hobby.

Advocacy/Argument: This is not a significant feature of any of the books in this category.

Practical Science Guidance: As mentioned by Bradford and Loose (1994) and Turney (1999), all books in this category are designed for the purpose of providing a practical guide to a scientific activity – astronomy, in all books in this sample. This is the defining feature of this category, and it is the only category to contain this feature.

A Walk Through the Southern Sky is a relatively simple guide, suitable for those who wish to look at the sky and know what they are seeing. *The Southern Sky Guide* and *Astronomy 2000* and *2001* are more complex, containing instructions, data and information designed to assist amateur astronomy, describing

and diagramming month by month what can be seen, where and when, with accompanying explanatory text.

As Turney (1999) mentioned, these books are similar to textbooks, but are different in the way they relate to the reader.

Biography, Autobiography, Events of Science, Story of Science Endeavour, Explanation/Discussion of Historical Science and Elements of Science Fiction/Fantasy : These are not significant features of any of the books in this category.

Paper Type: The paper used in this category is slightly thicker and glossier than all previous categories – all books in this category use intermediate semi-glossy paper.

Illustrations: All books in this category contain black, white and blue illustrations which, in contrast to all previous categories, are dominant.

Format: In contrast to all previous categories, all books in this category are large sized.

Summary of Characteristics of Books in this Category

- Encyclopedia-like, with a combination of continuous narrative and short facts/explanations in non-alphabetical order
- Authors are professional/amateur astronomers
- Focused on astronomy
- Have a relatively high level of scientific language
- New scientific ideas/theories is not a significant feature
- Explanation/discussion of current science is a significant secondary feature
- Advocacy/argument is not a significant feature
- Defining feature is that all books are practical science guides
- Biography, autobiography, events of science, story of science endeavour, explanation/discussion of historical science and elements of science fiction/fantasy are not significant features
- Intermediate semi-glossy paper
- Dominant black, white and blue illustrations
- Large sized

Category 10: Fun Collections of Facts or Short Explanations

Summary of Category

Books in this category consist of 'fun' encyclopedia-like collections of short facts/explanations of current science in non-alphabetical order, or short essays explaining and discussing current science interspersed with short facts/explanations in non-alphabetical order. Each book in this category focuses on a variety of science topics, and all other aspects of the books hinge on these characteristics.

Books in this group are very 'science rich', concentrating entirely on the explanation/discussion of current science. They contain no significant biography, autobiography, events of science, stories of science endeavours or explanation/discussion of historical science. New ideas/theories or advocacy/argument do not feature to a significant level. They are not practical science guides, and they do not have elements of science fiction/fantasy.

Books in this sub-genre are written by professional science communicators, and have a mid-low level of scientific language. They are medium-large sized, printed on regular matt paper, and some contain dominant black and white illustrations.

This type of book was mentioned by Bowring (personal communication, October 24, 2001), who specifically mentioned books by Karl Kruszelnicki (which feature in this sample) as examples of this type of book.

Books from Sample in Category

Seven books from the sample exemplify this category. These are:

- *How Much does the Earth Weigh*, by Marshall Brain
- *Adam Spencer's Book of Numbers*, by Adam Spencer
- *Dr Karl Kruszelnicki's New Moments In Science Series*, by Karl Kruszelnicki
 - Pigeon Poo, the Universe and Car Paint (No.1)*
 - Flying Lasers, Robofish and Cities (No.2)*
 - Munching Maggots, Noah's Flood and TV Heart Attacks (No.3)*
 - Fidgeting Fat, Exploding Meat and Gobbling Whirly Birds (No.4)*
- *Q & A with Dr K*, by Karl Kruszelnicki

Brief Description of Each Book

How Much does the Earth Weigh, by Marshall Brain: Eleven chapters, each containing a series of questions on a particular theme, followed by an explanation. The questions are chosen to be 'the most interesting' of those sent in to the website 'How Stuff Works'. The result is a book of interesting science questions, with their answers explained.

Adam Spencer's Book of Numbers, by Adam Spencer: A collection of interesting science facts about numbers, from one to 100. Each number is listed in turn, and several facts about it given. There are also quiz questions for some numbers.

Dr Karl Kruszelnicki's New Moments In Science Series, by Karl Kruszelnicki:

Pigeon Poo, the Universe and Car Paint (No.1)

Flying Lasers, Robofish and Cities of Slime (No.2)

Munching Maggots, Noah's Flood and TV Heart Attacks (No.3)

Fidgeting Fat, Exploding Meat And Gobbling Whirly Birds (No.4)

A set of four books which consist of a collection of short essay-type explanations and discussions about various 'fun' topics in science. Each book has a number of chapters, each of which is focused around a different science theme. Within each chapter, a range of interesting facts and information about the theme are woven together into a short essay. The stories first appeared as a series: 'Great Moments in Science' on ABC radio.

Q & A with Dr K, by Karl Kruszelnicki: An almost identical format to Dr Karl Kruszelnicki's other books. The book consists of a collection of short essay-type explanations and discussions about various 'fun' topics in science. The book has a number of chapters, each of which is focused around a different science theme. Within each chapter, a range of interesting facts and information about the theme are woven together into a short essay.

Table 3.15: Matrix of Characteristics for Books From Sample in Fun Collections of Facts or Short Explanations Category

	How Much Does the Earth Weigh	Adam Spencer's Book of Numbers	Dr Karl Kruszelnicki's New Moments in Science Series	Q& A with Dr K
Arrangement of Content	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	In parts, out of order (like-like). Short facts/explanations in non-alphabetical order	In parts, out of order (like-like). Continuous narrative and short facts/explanations in non-alphabetical order	In parts, out of order (like-like). Continuous narrative and short facts/explanations in non-alphabetical order
Profession of Author(s)	Founder and writer for HowStuffWorks website	Ex-mathematician, radio host and comedian	Science communicator	Science communicator
Science Topic	Various	Mathematics/Various	Various	Various
Scientific Language	Some jargon/equations	Some jargon/equations	Some jargon/equations	Some jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavours	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No	No
Paper Type	Regular matt	Regular matt	Regular matt	Regular matt
Illustrations	No illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Dominant	Black & white illustrations. Dominant
Format	Medium: 214 x 131	Medium: 181 x 111	Large: 258 x 176	Medium: 266 x 168

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: Like the previous category, but in contrast to categories 1-8, all books in this category are encyclopedia-like, and can be read in parts, out of order. The five books by Karl Kruszelnicki contain chapters consisting of independent short essays, with continuous narrative interspersed with short facts/explanations. Each chapter can be read independently. The remaining two books consist entirely of short facts and explanations in non-alphabetical order.

Profession of Author(s): The authors of all books in this category are professional science communicators. Five of the seven books in this category have the same author (Karl Kruszelnicki).

Science Topic: In contrast to previous categories, a variety of science topics are covered within each individual book. In other categories, although a variety of topics are covered within the category as a whole, each individual book focuses specifically on one science branch or topic.

Scientific Language: All books in this category contain some jargon/equations, but none have a high level of scientific language. This is in line with Bowring's comments (personal communication, October 24, 2001), that these books are designed to be fun, and suitable both for children and non-scientifically educated adults.

New Scientific Ideas/Theories: This is not a significant feature of any of the books in this category.

Explanation/Discussion of Current Science: The explanation and discussion of current science is the main focus of all the books in this category. Each book focuses on a variety of areas of current science, explaining current thinking, and discussing the results and implications of current research.

Advocacy/Argument, Practical Science Guidance, Biography, Autobiography, Events of Science, Story of Science Endeavour, Explanation/Discussion of Historical Science, and Elements of Science Fiction/Fantasy: These are not significant features of any of the books in this category.

Paper Type: All books in this category use regular matt paper.

Illustrations: Three books in this category contain black and white illustrations, which are supplementary to the text in *Adam Spencer's Book of Numbers*, but dominant in all five books by Karl Kruszelnicki. The remaining book in this category, *How Much Does the Earth Weigh?*, is not illustrated.

Format: Approximately half the books in this category are medium sized (*How Much Does the Earth Weigh?*, *Adam Spencer's Book of Numbers* and *Q&A With Dr K*), whilst the remainder are large sized (*Dr Karl Kruszelnicki's New Moments in Science Series*).

Summary of Characteristics of Books in this Category

- Encyclopedia-like. Some consist of short facts/explanations in non-alphabetical order, and others of short essays interspersed with short facts/explanations in non-alphabetical order
- Authors are professional science communicators
- Each book focuses on a range of science topics
- Mid-low level of scientific language
- Authors new ideas/theories is not a significant feature
- Centred around explanations/discussions of current science
- Advocacy/argument, practical science guides, biography, autobiography, events of science, story of science endeavour, explanation/discussion of historical science and elements of science fiction/fantasy are not significant features
- Regular matt paper
- Illustrations vary from none to dominant black and white
- Medium-large sized

Category 11: Dictionary-Like Reference

Summary of Category

This category consists of encyclopedia-like 'reference' books, with short facts/explanations in alphabetical order, and all other aspects of the books hinge on this characteristic. Books in this category are very 'science rich', and are centred around explanations/discussions of science topics. They focus on a variety of areas of science. New ideas/theories and advocacy/argument are not significant features, and the books are not practical science guides.

These books contain no significant 'story' elements of biography, autobiography, events of science, stories of science endeavours or explanation/discussion of historical science. They do not contain elements of science fiction/fantasy.

Books in this sub-genre have a relatively high level of scientific language. They are small-medium sized, printed on both regular matt and intermediate semi-glossy paper, and illustrations vary from black and white, black white and blue, to several colours, and from supplementary to dominant.

This type of book was mentioned by Turney (1999).

Books from Sample in Category

Three books from the sample exemplify this category. These are:

- *Collins Gem Physics Basic Facts*, by Eric Deeson and Ken Dobson
- *Collins Gem Biology Basic Facts*, by T A McCahill
- *Weatherwise*, by David Ellyard

Brief Description of Each Book

Collins Gem Physics Basic Facts, by Eric Deeson and Ken Dobson: A pocket dictionary of physics facts, consisting of a large number of physics terms and concepts in alphabetical order, each accompanied by an explanation. The book is designed to be a handy reference on physics topics, for example for use in school projects.

Collins Gem Biology Basic Facts, by TA McCahill: A pocket dictionary of biology facts, consisting of a large number of biology terms and concepts in alphabetical order, each accompanied by an explanation. The book is designed to be a handy reference on biology topics, for example for use in school projects.

Weatherwise, by David Ellyard: A dictionary-type book of weather terminology, in alphabetical order with short explanations and discussions of each term.

Table 3.16: Matrix of Characteristics for Books From Sample in Dictionary-like Reference Category

	Collins Gem Physics Basic Facts	Collins Gem Biology Basic Facts	Weatherwise
Arrangement of Content	In parts, out of order (encyclopedia-like). Short facts/explanations in alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in alphabetical order
Profession of Author(s)	Not stated	Not stated	Science communicator
Science Topic	Physics	Biology	Meteorology
Scientific Language	Relatively high level of jargon/equations	Relatively high level of jargon/equations	Relatively high level of jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Minor/non-existent
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Minor/non-existent	Minor/non-existent
Story of Science Endeavour	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Minor/non-existent
Elements of Science Fiction/Fantasy	No	No	No
Paper Type	Regular matt	Intermediate semi-glossy	Regular matt
Illustrations	Black, white & blue illustrations. Dominant	Several separate coloured illustrations. Dominant	Black & white illustrations. Supplementary
Format	Small: 116 x 79	Small: 122 x 86	Medium: 213 x 137

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: Again, all books in this category are encyclopedia-like, and can be read in parts, out of order. Unlike the previous two categories, however, there is no continuous narrative – as Turney (1999) noted, all books consist entirely of short facts/explanations. In contrast to the previous two categories, these facts/explanations are in alphabetical order, reflecting their purpose as ‘dictionaries or primers for scientific literacy’ (Turney, 1999, p. 122).

Profession of Author(s): The professions of the authors of two of the books in this category are not stated (*Collins Gem Physics Basic Facts* and *Collins Gem Biology Basic Facts*). The author of the remaining book (*Weatherwise*) is a science communicator.

Science Topic: Like most other categories, books in this category focus on a variety of science topics, including general physics, general biology, and meteorology. Unlike the previous category, however, each book focuses on a specific area of science.

Scientific Language: All books in this category have a relatively high level of jargon/equations.

New Scientific Ideas/Theories: This is not a significant feature of any of the books in this category.

Explanation/Discussion of Current Science: The explanation and discussion of current science is the main focus of all books in this category. Each focuses on a particular area of current science, providing a series of facts and explanations.

Advocacy/Argument, Practical Science Guidance, Biography and Autobiography: These are not significant features of any of the books in this category.

Events of Science: This is not a significant feature of any of the books in this category. This is in agreement with Turney (1999)’s comments, who said that these books present the facts of an area of science, without detailed discussion of historical context, or other background information.

Story of Science Endeavour, Explanation/Discussion of Historical Science and Elements of Science Fiction/Fantasy: These are not significant features of any of the books in this category.

Paper Type: Two books in this sample use regular matt paper (*Collins Gem Physics Basic Facts* and *Weatherwise*), and one book uses paper that is slightly thicker and glossier (intermediate semi-glossy): *Collins Gem Biology Basic Facts*.

Illustrations: Illustration types vary between the different books in this category. *Collins Gem Physics Basic Facts* contains dominant black, white and blue illustrations. *Collins Gem Biology Basic Facts*

contains dominant illustrations in several colours, and *Weatherwise* contains black and white illustrations that are supplementary to the text.

Format: Two books in this category are small sized (*Collins Gem Physics Basic Facts* and *Collins Gem Biology Basic Facts*), and the third (*Weatherwise*) is medium sized.

Summary of Characteristics of Books in this Category

- Encyclopedia-like, with short facts/explanations in alphabetical order
- Conclusions about authors cannot be drawn from this sample due to lack of information
- Centred around a range of science topics
- Relatively high level of scientific language
- Authors ideas/theories is not a significant feature
- Centred around explanations/discussions of science topics
- Advocacy/argument, practical science guides, biography, autobiography, events of science, story of science endeavour, explanation/discussion of historical science and elements of science fiction/fantasy are not significant features
- Regular matt and intermediate semi-glossy paper
- Illustrations vary, including black and white; black, white and blue; and several colours, and from supplementary to dominant
- Small-medium sized

Category 12: Coffee-Table Pictorials

Summary of Category

This category consists of large books, printed on thick glossy paper, with dominant, full colour illustrations. All other aspects of the books hinge on these characteristics.

In most other characteristics, the books in this category are variable. Most are centred around the explanation/discussion of current science, and new scientific ideas/theories and advocacy/argument are not present to significant levels. They are not practical science guides.

Some books, however, are more 'story-rich', with significant levels of biography, autobiography and events of science. Most are not stories of science endeavours, and most do not contain explanations/discussions of historical science. None contain elements of science fiction/fantasy.

Some books are novel-like, with a continuous narrative thread, and others are encyclopedia-like, with short facts/explanations in non-alphabetical order. The level of scientific language varies, and authors backgrounds include scientists in related fields, science writers/publishers, illustrators/artists and museum directors/curators.

A subset of this sub-genre was mentioned by Morrison and Morrison (1999), which they called 'field guides', including atlases, illustrated guides, and field guides to birds. Another subset of this category was also mentioned by Morrison and Morrison (1999) – illustrated history of science books.

Books from Sample in Category

Nine books from the sample exemplify this category. These are:

- *A Gap in Nature*, by Tim Flannery and Peter Schouten
- *Full Moon*, by Michael Light
- *The Science Book*, by Peter Tallack (Ed)
- *Animal*, by David Burnie and Don E Wilson (Eds)
- *Water*, by Peter Swanson
- *The Universe in a Nutshell*, by Stephen Hawking
- *Evolution*, by Carl Zimmer
- *The Illustrated A Brief History of Time*, by Stephen Hawking
- *The Illustrated Longitude*, by Dava Sobel and William JH Andrewes

Brief Description of Each Book

A Gap in Nature, by Tim Flannery and Peter Schouten: A large, glossy, illustrated book about extinct animals. Each double (occasionally single) page focuses on a particular animal, and includes a discussion and a large colour illustration. The text covers aspects such as descriptions of the animal, where it lived and when it was last seen.

Full Moon, by Michael Light: A large book of photographs from the Apollo lunar missions. The majority of the book consists of large, spectacular photographs and no text. At the end is a short section containing information about the Apollo missions, and how the book was made. Following this is a section of 'thumbnail' prints of the photographs that appeared earlier in the book, with captions.

The Science Book, by Peter Tallack (Ed): A large, illustrated book on the history of science. Beginning at 35 000 BC, the book covers 250 milestones in the history of science. Each milestone is represented in the book with one page of text, accompanied by a full colour illustration.

Animal, by David Burnie and Don E Wilson (Eds): An encyclopedia-like book of the world's wildlife. The book contains descriptions of hundreds of animals, birds, fish, and insects, each accompanied by a picture.

Water, by Peter Swanson: A large, illustrated book about the importance of water. The book is divided into a series of chapters, each of which focuses on a different aspect of water, such as agriculture, rivers, pollution and industry.

The Universe in a Nutshell, by Stephen Hawking: A large, illustrated book on a similar subject matter to Hawking's first book, *A Brief History of Time*. Hawking explains and discusses aspects of the universe, such as relativity, time, and string theory, and the size and shape of the universe. The text is accompanied by large, numerous, full colour illustrations and photographs.

Evolution, by Carl Zimmer: A large, illustrated book about evolution. Beginning with Darwin's *Beagle* voyage, the book then discusses more of Darwin's life and work, before moving on to topics such as dating methods and what they reveal about the history of life, the history of inheritance research, the origins and history of life, disease, and human evolution.

The Illustrated A Brief History of Time, by Stephen Hawking: A large, glossy, illustrated version of Stephen Hawking's original *A Brief History of Time*. The text is similar to the original, but is updated and expanded in parts. The chapters follow the same order as the original, although there is an additional chapter on wormholes. The text is accompanied by a large number of full colour photographs, diagrams and illustrations.

The Illustrated Longitude, by Dava Sobel and William JH Andrewes: An illustrated version of Dava Sobel's *Longitude*, this is a large, glossy book containing the same text as the non-illustrated version, accompanied by large, full colour illustrations.

Table 3.17: Matrix of Characteristics for Books From Sample in Coffee-table Pictorials Category

	A Gap in Nature	Full Moon	The Science Book	Animal	Water	The Universe in a Nutshell	Evolution
Arrangement of Content	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	In parts, out of order (encyclopedia-like). Short facts/explanations in non-alphabetical order	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Museum director (Flannery) wildlife illustrator (Schouten)	Artist and photographer	Science book publisher	University researcher and science writer (Burnie) and museum senior scientist (Wilson)	Not stated	Professor of theoretical physics	Science writer
Science Topic	Extinct Animals	The Moon/Apollo Space Missions	General Science History	World Wildlife	Conservation Science (Water)	Cosmology	Evolution
Scientific Language	Language generally non-specialist	Language generally non-specialist	Language generally non-specialist	Relatively high level of jargon/equations	Language generally non-specialist	Relatively high level of jargon/equations	Some jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Minor/non-existent	Significant secondary feature	Main focus of book	Main focus of book	Main focus of book	Main focus of book
Advocacy/Argument	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Main focus of book	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No	No	No	No	No	No
Biography	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature. Several individuals equally focussed on

Table 3.17 continued

	A Gap in Nature	Full Moon	The Science Book	Animal	Water	The Universe in a Nutshell	Evolution
Autobiography	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent	Minor/non-existent
Events of Science	Significant secondary feature	Minor/non-existent	Main focus of book	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature
Story of Science Endeavour	No	No	No	No	No	No	No
Explanation/Discussion of Historical Science	Minor/non-existent	Minor/non-existent	Significant secondary feature	Minor/non-existent	Minor/non-existent	Minor/non-existent	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No	No	No	No	No	No
Paper Type	Thick glossy	Thick glossy	Thick glossy	Thick glossy	Thick glossy	Thick glossy	Thick semi-glossy
Illustrations	Full colour illustrations. Dominant	Black & white illustrations and full colour illustrations. Dominant	Full colour illustrations. Dominant	Full colour illustrations. Dominant	Full colour illustrations. Dominant	Full colour illustrations. Dominant	Full colour illustrations. Dominant
Format	Large: 285 x 247	Large: 295 x 299	Large: 299 x 259	Large: 313 x 261	Large: 280 x 283	Large: 256 x 198	Large: 247 x 190

Table 3.17 continued

	The Illustrated A Brief History of Time	The Illustrated Longitude
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Professor of theoretical physics	Science writer (Sobel) and museum curator (Andrewes)
Science Topic	Cosmology	Navigation (The History of Determining Longitude at Sea)
Scientific Language	Relatively high level of jargon/equations	Language generally non-specialist
New Scientific Ideas/Theories	Minor/non- existent	Minor/non-existent
Explanation/Discussion of Current Science	Main focus of book	Minor/non-existent
Advocacy/Argument	Minor/non- existent	Minor/non-existent
Practical Science Guidance	No	No
Biography	Significant secondary feature. Several individuals equally focussed on.	Significant secondary feature. One individual particularly focussed on and several individuals equally focussed on

Table 3.17 continued

	The Illustrated A Brief History of Time	The Illustrated Longitude
Autobiography	Minor/non-existent	Minor/non-existent
Events of Science	Minor/non-existent	Main focus of book
Story of Science Endeavour	No	Yes
Explanation/Discussion of Historical Science	Minor/non-existent	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No
Paper Type	Thick glossy	Thick glossy
Illustrations	Full colour illustrations. Dominant	Full colour illustrations Dominant.
Format	Large: 253 x 196	Large: 253 x 228

Discussion of Patterns of Characteristics in this Category

Arrangement of Content: The books in this category are divided approximately evenly between those that are novel-like, with a continuous narrative thread (*The Universe in a Nutshell*, *Evolution*, *The Illustrated A Brief History of Time* and *The Illustrated Longitude*), and those that are encyclopedia-like, with short facts and explanations in non-alphabetical order (*A Gap in Nature*, *Full Moon*, *The Science Book*, *Animal*, and *Water*). This is the only category to contain an equal mixture of novel-like and encyclopedia-like books.

Profession of Author(s): The authors and co-authors of the books in this category have a variety of backgrounds. Three have authors who are scientists in the field the book is written about: *The Universe in a Nutshell*, *The Illustrated A Brief History of Time*, and *Animal*. Two have authors who are science writers or publishers: *The Science Book*, *The Illustrated Longitude* and *Evolution*. Two have authors who are illustrators or artists: *A Gap in Nature* and *Full Moon*, and two have authors who are museum directors or curators: *A Gap in Nature* and *The Illustrated Longitude*. In the remaining book, *Water*, the profession of the author is not stated.

Science Topic: Again, books in this category focus on a variety of science topics, including extinct animals, space missions, general science history, wildlife, water conservation, cosmology (two books), evolution, and navigation.

Scientific Language: The level of scientific language varies between the books in this category. Five books have language that is generally non-specialist (*A Gap in Nature*, *Full Moon*, *The Science Book*, *Water*, and *The Illustrated Longitude*), one has some jargon/equations (*Evolution*), and three have a relatively high level of jargon/equations (*Animal*, *The Universe in a Nutshell*, and *The Illustrated A Brief History of Time*). This is a similar pattern to several other categories.

New Scientific Ideas/Theories: This is not a feature of any of the books in this category.

Explanation/Discussion of Current Science: This is the main focus of six books in this category, and a significant secondary feature of one, *The Science Book*. In the remaining two books: *Longitude* and *Full Moon*, explanation and discussion of current science is not present to a significant level.

Advocacy/Argument: This is not a feature of most books in this sample. One exception is *Water*, where the avocation of the idea that water and water conservation is important is the main focus of the book.

Practical Science Guidance: No books in this category are designed for the purpose of providing a practical guide to a scientific activity.

Biography: The amount of biography varies between different books in this category. Five books: *A Gap in Nature*, *Full Moon*, *Animal*, *Water*, and *The Universe in a Nutshell*, do not have biography as a significant feature. Four books: *Evolution*, *The Science book*, *The Illustrated A Brief History of Time*, and *The Illustrated Longitude*, do have biography as a significant secondary feature, focusing equally on several individuals.

Autobiography: This is not a significant feature of any of the books in this category.

Events of Science: The amount of discussion of the events of science varies between different books in this sample. Five books do not feature the discussion of the events of science, two books have this as a significant secondary feature, and two books have this as their main focus.

Story of Science Endeavour: Most books in this category do not contain this feature, with the exception of *The Illustrated Longitude* which, like the non-illustrated version, is the story of the way in which the problem of measuring longitude at sea was solved.

Explanation/Discussion of Historical Science: The majority of books in this category (six) do not feature the explanation/discussion of historical science. Three books: *Evolution*, *The Science Book* and *The Illustrated Longitude* have this as a significant secondary feature.

Elements of Science Fiction/Fantasy: This is not a feature of any of the books in this category.

Paper Type: In contrast to all other categories, the paper used in all books in this category is thick and glossy.

Illustrations: In contrast to all other categories, all books in this category contain full colour illustrations that are dominant. *Full Moon* consists almost entirely of illustrations, with a short section of text at the end of the book. *A Gap in Nature* and *The Science Book* contain one full illustrated page for each page of text. *Animal* contains many illustrations per page, *Water* contains a combination of full page and numerous smaller photos, and *The Universe in a Nutshell* contains several illustrations per page. *Evolution* contains at least one illustration on most pages. *The Illustrated a Brief History of Time* and *The Illustrated Longitude* also contain numerous illustrations. Full colour, dominant illustrations is the defining feature of this category, together with the size of the books.

Format: Like category nine, all books in this category are large sized. This, together with the illustrations is the defining feature of this category.

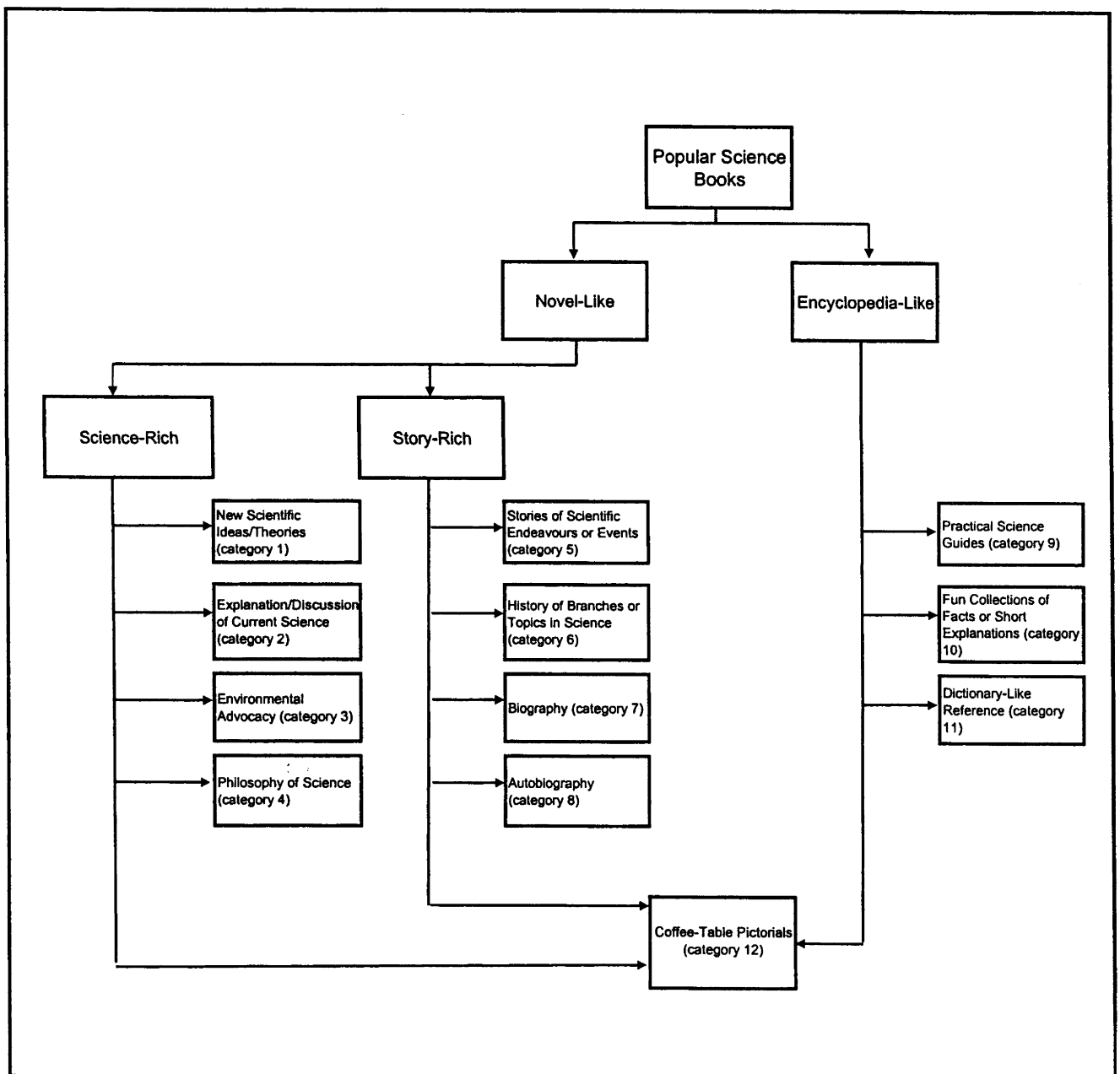
Summary of Characteristics of Books in this Category

- Some are novel-like with continuous narrative thread, others are encyclopedia-like, with short facts/explanations in non-alphabetical order
- Authors backgrounds include scientists in related fields, science writers/publishers, illustrators/artists and museum directors/curators
- Level of scientific language varies
- New scientific ideas/theories is not a significant feature
- Most are centred around the explanation/discussion of current science
- Advocacy/argument is not a significant feature of most books
- Practical science guidance is not a feature
- Biography may be a significant secondary feature
- Autobiography is not a significant feature
- Events of science may be a significant secondary or main feature
- Story of science endeavour is not a feature of most books
- Explanation/discussion of historical science is not a feature of most books
- Elements of science fiction/fantasy is not a feature
- Defining feature is thick glossy paper
- Defining feature is dominant, full colour illustrations
- Defining feature is large size

Relationships Between Categories

All 12 categories of the popular science book genre can be placed into an overall 'diagram of relationships' for the genre as outlined in Figure 3.1. This shows the pattern of relationships between all of the categories in the genre.

Figure 3.1: Relationship Between Categories of the Popular Science Book Genre



Division 1: Novel-Like and Encyclopedia-Like

The genre can be split first into two broad groups: novel-like and encyclopedia-like.

The novel-like group contains categories 1-8 (1. New Scientific Ideas/Theories; 2. Explanation/Discussion of Current Science; 3. Environmental Advocacy; 4. Philosophy of Science; 5. Stories of Scientific Endeavours or Events; 6. History of Branches or Topics in Science; 7. Biography; and 8. Autobiography). Books in this group are designed to be read in entirety, from beginning to end.

The encyclopedia-like group contains categories 9-11 (9. Practical Science Guides; 10. Fun Collections of Facts or Short Explanations; and 11. Dictionary-Like Reference). Books in this group are designed so they can be read in parts, out of order.

One category (12. Coffee-Table Pictorials) must be placed in both groups, as it contains both novel-like and encyclopedia-like books.

Division 2: Science-Rich and Story-Rich

The categories within the novel-like group can be further split into two sub-groups: science rich and story-rich.

The science-rich group contains categories 1-4 (1. New Scientific Ideas/Theories; 2. Explanation/Discussion of Current Science; 3. Environmental Advocacy; and 4. Philosophy of Science). These categories consist of books which are predominantly science focussed, concentrating on explaining/discussing current science, presenting new science ideas, advocating/arguing for and against scientific ideas/theories, and discussing the philosophy of science. 'Story' elements of biography, autobiography, events of science, stories of science endeavours or explanation/discussion of historical science may be present in science-rich books, but are always secondary to science elements.

The story-rich group contains categories 5-8 (5. Stories of Scientific Endeavours or Events, 6. History of Branches or Topics in Science, 7. Biography and 8. Autobiography). All books of this type centre around features such as biographical detail of researchers, and stories of how

discoveries were made (Bradford & Loose, 1994). Story-rich books also contain discussions of the events of science, including the “trials and triumphs of earlier scientists” (Wilford, 1997, p. 48). Science elements, when they occur, are secondary to the story elements. The story-rich group could be classed as a sub-set of the narrative non-fiction mentioned by Downes (2001).

Further General Comments

Categories are Not Mutually Exclusive

As Morrison and Morrison (1999) and Turney (1999), pointed out, categories of popular science books are not absolutely distinct, and assigning individual books to categories can sometimes be difficult. In cases like this, it is logical to assign books based on their most dominant features, and their fit with the defining features of each category.

Categories That Did Not Appear in the Sample

Buchanan (1991) discussed a type of popular science book that he calls ‘non-technical regional science books’ (p. 7). These provide scientific information for a lay audience about the flora, fauna, geology and environment in a small area. Books of this type were not seen in this sample. A possible reason for this is that being regionally relevant, they are not bestsellers, and all the books in the sample used in this study came from bestseller or most available popular science book lists from national bookstores. If a larger sample were taken, it is possible that this type of book may appear.

Conclusion

Based on the results of this study, the popular science book genre can be divided into at least 12 distinct categories. These can be divided into a ‘diagram of relationships’, with each category belonging to a specific group.

Almost all of the variables used in this study proved important in determining the various categories, and most are, individually or combined with other characteristics, the ‘defining feature(s)’ of at least one category. As the production of the list of variables was an iterative process, developed as the books were read, the final list of characteristics was chosen largely because each did help define the categories that were emerging. Some characteristics are undoubtedly more important than others, defining not just individual categories, but also higher

level groups such as the 'science-rich' and 'story-rich' groups outlined in Figure 3.1. Some characteristics, such as 'practical science guidance' are less important in the overall scheme, but are nonetheless essential in defining particular categories. Two variables; 'paper type' and 'format', are not defining characteristics on their own, but are when combined with 'illustrations' in the Coffee-Table Pictorials category. These two characteristics could possibly be combined into one in future analyses.

Most books in the sample were relatively straightforward to categorise, indicating that further variables are not necessary, for this sample at least. However, two variables that were not considered in the analysis but may be interesting are cover design and intended readership. It would be fascinating to see what effect the inclusion of these variables would have on the analysis.

One of the categories that emerged from the research is particularly large: Explanation/Discussion of Current Science. Consideration was given to dividing this category into further sub-categories and, although this idea was not followed through in this study for reasons of simplicity, this is certainly an issue that could be considered in the future. Further groupings that could be included in this category are: 'current science only', 'current science with biography/autobiography', 'current science with history', and 'current science with elements of science fiction/fantasy'. A similar approach could be taken with other categories if a larger sample was examined.

The classification scheme developed here could be tested by selecting additional books that are not part of the original sample and seeing how easily they can be fitted into the scheme. Additionally, it would be interesting for potential users such as book editors, retailers, and authors to test the scheme, to determine how easily it can be used by others.

The data set that has been developed in this analysis, and the categories themselves, could be used in the future for a variety of different analyses. For example, the categories could be used in a study of the readership of popular science books, to determine if different categories have different audiences. It would also be interesting to examine issues such as whether there is a correlation between the level of scientific language and the profession of the author, and whether there is a relationship between the science topic and the level of scientific language.

Future research may reveal more categories, more characteristics of each category, or give cause for some of the existing categories to be split further or indeed, combined. It could also involve the development of a classification scheme, outlining an algorithm for assigning books to specific

categories. This process would be aided by the ranking of characteristics into a hierarchy of importance for each category.

Chapter Four

Features of Bestselling Books in ‘Stories of Scientific Endeavours or Events’ Category

Introduction

Chapter 2 included a discussion of the role of popular science books in the field of science communication, and their place as a subset of the activities of popular science, science writing, and science books. Some books, however, may be more successful as a science communication medium than others, and the factors that lead to success may vary between the individual categories revealed in the previous chapter.

There are different ways that ‘success as a science communication medium’ could be defined, but one way is to use sales rankings. Sales success varies greatly from book to book, with some, such as Stephen Hawking’s *A Brief History of Time*, selling many copies and gaining prominence on bestseller lists, while others are less successful.

A range of opinions can be found as to the reasons why some popular science books sell more successfully than others. Little research has been conducted, however, as to whether these opinions accurately reflect the real features of bestselling popular science books, and no research has been conducted as to the features of bestselling popular science books in specific categories. This study aims to begin to address these issues.

This chapter is an investigation of the common features of a sample of bestselling popular science books in the category ‘Stories of Scientific Endeavours or Events’. Opinions outlined in the literature were used to compile a list of features which may aid success. The items on this list were then compared to a number of current bestsellers and, from the patterns that emerged, suggestions were made as to features which may contribute to the success of books in this category. Before describing this research, however, a brief review of the previous literature about features that may help popular science books sell well is presented.

Literature Review

A range of ideas exists in the literature on the features that may help popular science books sell well.

Topic

Choice of topic is considered to be an important aspect of whether a popular science book sells well. There is a general agreement amongst several authors (Bradford & Loose, 1994; Leane, n.d.b; Nixon, 1991; Tallack (Durrani, 1998)) that popular science books on aspects of physics and biology are often more successful than books on other areas of science. In particular, cosmology, astronomy, genetics, and evolution are some of the topics which are the most popular.

The reason for this is thought to be that these topics have universal appeal – they are interesting, common and fundamental to everyone. They include topics that concern ourselves, such as our evolutionary past and why we are unique in the world, and also topics concerning the greater universe, its origin and fate, and how it works (Marr (in Gibbon, 2001); Tallack (Durrani, 1998); Wilford, 1997).

Fahnestock (1993, p. 20), although discussing popular science articles, made a similar point, suggesting that successful science popularisations have to have both ‘wonder’ and ‘application’. Macmillan senior editor John Michael reinforced this idea by saying that it is ‘big’ questions that fascinate people, such as “What is the universe made of? When did it begin? Where is it going?” (Mantell, 1995, p. 42). Because of this, physics sells, but chemistry does not. Biology, for example, the Human Genome Project, has the potential to sell, as long as it, too, can be perceived as “something big and awesome” (p. 42).

Wilford (1997), and Bradford and Loose (1994) both pointed out that books on current cutting edge science, including astrophysics, biochemistry, computer science, chaos theory or particle physics, are also very interesting to the public. According to Bradford and Loose, the more groundbreaking or ‘hot’ the discovery, the more appealing to readers. Buchanan (1991) made a further point - that books on multidisciplinary topics also sell well. This is because these books appeal to a wide audience, with a range of different interests being catered for.

Finally, books with the word ‘God’ in the title often sell well, according to Tallack (Durrani, 1998), and McDonald (1993). This is interesting to note, and raises the question of why this is the case, and what the implications of this are. A possible explanation is that the relationship

between science and religion is a contentious issue, with strong feelings amongst many members of the public, on all sides of the debate. Hence, popular science books that appear to deal with this topic are likely to have a wide appeal. Few commentaries on this exist, however McDonald mentioned this effect is especially true in reference to books about astrophysics and cosmology. The reason for this is that there are many readers who are not usually interested in physics itself, but who do become interested when the discussion is about the implications for religion of discoveries in physics. A wider examination of this issue would be of interest.

Presentation of Scientific Content

Presentation of scientific content is seen as one of the major factors on which the success of particular popular science books hinges. Many authors commented on aspects of this topic, and all agreed that it is important that the science in a popular science work be presented in an appropriate fashion for a non-specialist audience. There are several facets to this issue, which are discussed below.

Jargon

Several authors commented on the need to avoid high-level technical jargon, equations, formulae and mathematics when writing for a non-specialist audience, to make the topic easily understandable (Guyer, 1998; Kenward, 1990; Sapp, 1995; Turney, 1999). Instead, the author should use clear, simple language (Rayl, 1992).

Guyer (1998) made the point that jargon is very useful to those in a particular field, because it helps those in the know to communicate quickly and precisely. The downside of this, however, is that it keeps everyone else “out of the loop” (English, not jargon section, para. 2.). So, when writing for a non-specialist audience, all jargon that is not essential should be dropped. When a technical term must be introduced, it is important to explain it in context, rather than simply provide a definition in parentheses.

Ideas

Several authors (Ben-Ari, 1999; Guyer, 1998; Rabiner, 1994; Sapp, 1995; Shermer, 2001) emphasised that in doing this, it is important not to patronise or over-simplify the science, which can also easily be done, and agreed that it is important to think of the reader as someone who is intelligent and interested, but who simply does not have specialist knowledge in the particular area of interest. Introducing difficult ideas is acceptable, as long it is recognized that the reader does not have prior knowledge of jargon and technical concepts.

In an interview with Shermer (2001), popular science author Steven Pinker put this idea eloquently by saying:

I was given good advice by one of my editors, who told me that when you write science for the general public you are writing for your college roommate who is just as smart as you. It was the best advice I ever received. A lot of academics think that when you write for the general public you have to dumb it down and condescend. I try never to do that. There's a large number of people who are as interested in ideas now as they were in college. They read these books and that's who we are writing for. (p. 3 [my numbering])

Doing this is not always easy, and there is a fine line "between explaining scientific concepts clearly, on the one hand, and oversimplifying or 'dumbing down' the material too much, on the other" (Ben-Ari, 1999, Requirements and challenges section, para. 6). Rodgers (1992) echoed this sentiment, commenting that it is easy for an editor to identify difficult passages in a piece of popular science writing, but how to remedy these is not always straightforward.

Metaphor, Analogy and Anthropomorphism

Several sources commented on the use of metaphor as an aid in presenting science appropriately to a non-specialist audience. Metaphors are useful because they "allow the writer to draw pictures in the head of the reader" (p. 14) that "will lead the reader to a 'eureka' experience" (Rayl, 1992, p. 14). Ben-Ari (1999) also commented on the usefulness of metaphor to popularise and explain science. Leane (2001) agreed, commenting that "Metaphor, in particular anthropomorphic metaphor, has long been a staple of science popularisation" (p. 418). Leane noted that analogy, a subset of metaphor, is particularly useful in explaining quantum theory because this area of science in particular is often, by its nature, difficult for people to relate to anything in their everyday experience. Turney (2001b) also believes that metaphor and analogy are important to help readers "understand new things in terms of ones which they are already familiar with" (p. 56).

Dawkins (1998) discussed in detail the use of metaphor and analogy in communicating science and, in particular, pointed out the necessity to use appropriate and useful metaphors and analogies that genuinely aid understanding, not simply sound poetic.

Carey (1995) mentioned that several popular science writers use animism in their explanations, making their material human in order to help make science intelligible for non-scientists. Richard Feynman's writing is given as an example of a great explainer of science who uses animism, for example, by saying that a "photon 'makes up its mind'" (p. xvii). Carey mentioned several other examples of popular science authors who use animism, saying that "animism is a

persistent ally in the popular science-writer's struggle to engage the reader's understanding" (p. xviii). (Note: According to dictionary definitions, it is evident that Carey actually means anthropomorphism, not animism).

Story/Narrative

Presenting the facts and explaining scientific topics are key ingredients of popular science books. It is not enough, however, said Ben-Ari (1999) to simply present a series of unconnected facts – it is vitally important to tell a good story at the same time. Bradford and Loose (1994) made a similar point, saying that “In the US, those who read popular science want a lively narrative, as well as a clear explanation of the science” (p. 41). Mantell (1995) pointed out that popular science books have to be accessible, and the key to do this is to transform “difficult but important” (p. 38) subjects into “exciting narratives that readers can relate to their own lives” (p. 38). Rodgers (1992) concurred, and explained that popular science books written like textbooks for lay readers are not likely to be appealing. Research scientist and author Robert Hazen reiterated this point, and explained that stories are successful because people like them, are entertained by them and can relate well to them. He offered an example of how this might be done:

Rather than lecturing, or writing the equation for Newton's law and describing the physics, you might offer an anecdote about what happened to your friend when he didn't wear his seatbelt. (Rayl, 1992, para. 16)

Lauber (1997) believes that a story gives a science book unity, “so that one idea leads inexorably to another, drawing the reader on and on” (para. 6), and Turney pointed out that science stories “are pretty much like stories about anything else – they involve struggles, conflicts or adventures, have heroes and villains, complication and resolution” (2001b, p. 47). Author Simon Singh said that in his own book, *Fermat's Last Theorem*, the long and interesting story allowed the mathematical explanations to begin at a relatively easy level (Durrani, 1998). In another article, Singh added that in a science book, there needs to be a balance between the science itself, and the story behind it. If this is done correctly, he said, “the science will add to the story, and the story will illuminate the science” (Singh, 2000, p. 21).

Turney (2001b) pointed out that the discoveries of some areas of science – cosmology, geology, evolutionary biology and paleoanthropology, for example, are by their very nature involved in reconstructing timelines, and those timelines can then easily be turned into stories or narratives if some of the technical detail is left out. Wilkie (Watson, 2001) made a similar point, saying that finding engaging stories in science is difficult, but that some types of science lend themselves better to becoming stories. Watson (2001) pointed out that physics and genetics are

popular because they are by their very nature sciences that are stories. Genetics, for example “is a story about beginnings (and ends)” (p. 26), but chemistry is more difficult. Watson also believes that stories about science are important in a wider sense – that if a topic in science can be told as a good story, it is more likely that it will be widely known, and accepted and established as a scientific fact.

People

A scientific subject can be greatly enlivened by introducing some interesting and articulate people, according to Wilford (1997). Bradford and Loose (1994) also believe this to be the case, and said: “The more successful popular science writers have brought their books alive with vivid descriptions of the leading researchers, combined with personal accounts of the progress of scientific work” (p. 41). Carey (1995) mentioned the importance of popular science writers including something of themselves in their writing, which gives an immediacy and personal element to the story.

Angle

Durrani (1998) and Wilford (1997) both made the point that there has to be an original angle in a new popular science book - it is important to have something new to present. “Books that plod along the main path of a discipline are doomed to failure” (Durrani, 1998, para. 9).

Opening

According to Lauber (1997), the first chapter and, in particular, the first page of a book is vitally important. The beginning of a book is where an author has the best chance of catching and holding the attention of the reader, ensuring they read on. Lauber believes that one of the best, most attention-grabbing beginnings for a popular science book is a natural disaster, and admitted using many of these in her own writing. If there is no disaster conveniently available, it is possible to create a similar effect, by creating the feeling of a story that is about to be told. The opening of a book should speak to the reader, saying: “Come with me and I will show you many wondrous things” (para. 12).

Tone

It is also important to use a conversational tone in a popular science book, said Ben-Ari (1999) and Lewis (1994). According to these authors, often, when scientists write popular science

books, they persist in using the passive voice which is the common practice in scientific literature. This is seen as a common and major problem by agents and editors of popular science books, as it is stilted and remote for readers. Carey (1995), on the other hand, mentioned Richard Feynman as an excellent explainer of science, who “saturates his writing with his individual style and personality” (p. xvii).

Readability

A factor considered to be important in the appeal of a popular science book is a high overall level of readability. Buchanan (1991) discussed one way to measure the readability of a popular science book, through the use of the ‘Flesch readability formula’, which analyses aspects of writing such as the number of words per sentence and how many syllables each word has. Buchanan applied the Flesch test to two popular science books on the current bestseller list, and found that they rated well, falling within the ‘fairly easy’ or ‘standard’ categories. Buchanan believes that these books, and others that sell well, do so largely because they are able to use simple but powerful language, without compromising the complexity of the ideas being presented. Simplicity of language does not mean simplicity of ideas.

Fiction Techniques and Attractive Writing

In popular science writing, it is essential to capture the interest of the reader, and one way of doing this is to employ fictional techniques, and to use some of the same tools that novelists use in their writing (Leane, n.d.b). Mitton agreed, and gave popular science authors the advice to read as many pieces of literature as possible to gain inspiration for how to write their own books. One key thing to be learned from this is that “each chapter in a popular-science book has to have a beginning, a middle and an end” (Durrani, 1998, para. 11). Weatherall also believes that a popular science book needs to be like a good novel, keeping the reader wanting to turn the page. However, it is important to do this without sacrificing scientific accuracy (de Bono, 2001).

Although aspects such as a good topic, story and angle are very important, it is also necessary for authors to simply be able to write well, with passion, enthusiasm and flair (Durrani, 1998). Ferrell (1992) made a similar point, saying “Stop by a bookstore or library and scan the shelves for yourself. I guarantee you’ll find something that captures your imagination, intrigues your curiosity, piques your desire to learn. That’s what good science writing does” (p. 11). Wolpert said, similarly, “People like them [science books] because they have a sense of magic. A bit like the reason why children like Harry Potter. You enter a completely different world” (Bhatiani, 2001, p. 159). Finally, Crowden (1994) said:

Our authors ... are asked to produce 200 to 300 pages of prose that must be clear, jargon-free and lightly illustrated, but which can be illuminated by anecdote, opinion and all the excitement of modern science. (p. 41)

Author and Media Attention

Several authors commented on the effect that the background of an author of a popular science book, together with marketing, can have on the book's sales. One anonymous author (*Selling science*, 2001) took the view that an author's name, along with marketing, are the only features which make the difference between a best-seller and one which does not sell well, quoting Bruce Lewenstein, professor of communication and science and technology studies at Cornell University: "An author's style and personality and the presence he or she brings to a best-selling science book are generally the main factors in making it a best seller" (*Cult of personality* section, para. 1). An example was given of Stephen Hawking's *A Brief History of Time*, a book by a very famous author, which sold phenomenally well, but is generally thought to be unfinished by many readers. A second example given was *The Hot Zone*, by Richard Preston, "a sensationalistic and poorly written tabloid account of mankind's experiences with the Ebola virus" (*Hot sales* section, para. 4). Despite this, the book sold well, because Preston and his book received much media attention at the time due to an Ebola outbreak in central Africa.

Mantell (1995) made a similar point, saying that "...even abstruse can sell, if it's by the right person" (p.39). Mantell gave the example of *The Emperor's New Mind*, by eminent scientist Roger Penrose, which sold 65,000 copies in hardcover, despite the fact that the book was "by all accounts a dense, difficult book" (p. 39). In most instances, science journalists "take a back seat to the scientists themselves" (p. 39) when explaining 'cutting edge' research to the public. von der Lippe also made the point that a scientist writing a book about their own science can have more credibility with readers than when an author writes about another's research (Kreeger, 2000).

Ben-Ari (1999) also said that books by scientists about their own research sometimes do well because they are well-known and have a popular following. Other times, however, a completely unknown scientist can write a very successful book. Bradford and Loose (1994) believe that whether or not the scientist themselves is the best person to write about science depends on the scientific field. Cutting-edge subjects are better written by top researchers in the field, although they can be assisted by collaboration with a science journalist. For basic science topics or practical guides, however, scientists or science writers who have the ability to use an engaging style are the better suited to this task.

Sapp (1995) divided authors of popular science books into several categories. First are scientists who write popular science, a category which Sapp further divides into two types. One is “practitioners in the field who are popularising general knowledge from their discipline” (p. 50). The other is famous or award-winning scientists who write about their own original work in a popular format. Scientists in the first category have solid reputations, but are not ‘superstars’ (p. 50). However, they may be very good communicators, in touch with their readers, and have a great deal of enthusiasm for their topic. Those in the second category have the ‘name appeal’ that allows their books to sell well. However, popularisation is not their main activity, and may not be what they do best. “At worst, books by famous scientists get published because they sell, pure and simple ... While their books might sell fabulously, other books available on the same subject may do a better job of teaching and explaining” (p. 50).

A second category of popular science book author is professional writers or journalists. Sapp also divided these authors into two categories, those who specialise in science writing, and “generalists who cover all fields” (p. 51). Science writing specialists:

...are uniquely trained professionals who often have some academic background in science, enjoy many contacts within scientific communities, and know the science beat thoroughly....Though they are not scientists, they nonetheless qualify as science insiders. This is often reflected positively in the quality of their work. (p. 51)

The work of generalist writers who write about science, on the other hand, should be evaluated carefully. The writers may have good intentions, but may lack resources, and may even be sensationalistic in their approach to writing about science. Finally, there are “collaborations between scientists and journalists, scientists from different fields, or scientists and humanists” (p. 51). These can be very effective.

Stephen Hawking’s *A Brief History of Time*

A Brief History of Time, published in 1988, achieved unprecedented sales figures. It spent almost 100 weeks on the New York Times bestseller list during 1988 and 1989 (Nixon, 1991), and sold 729,000 copies in its first year, and 410,000 more copies in the following year (Leane, n.d.b). In all, the book sold more than 1 million copies in hardcover (Rayl, 1992). Since then, it has sold more than 10 million copies and been translated into 40 languages (Ben-Ari 1999; Overbye, 2001).

Leane (n.d.b) discussed a number of opinions as to possible reasons for the book's success, an issue which has been the subject of much discussion. Some of the factors include Hawking's medical condition, the book's title, the subject matter, the lack of equations, and the length of the book. (Rodgers, 1992) believes that there are several reasons why the book was so successful. First, it had an intriguing title, something that Rodgers recommended to any popular science author aiming to produce a bestseller. A second reason was what the book promised to offer in terms of content, "an account...of the origin, nature and ultimate fate of the Universe in less than two hundred pages" (p. 232). Thirdly, it was attractive because it was written by a famous 'insider' in the field, something that is very desirable these days. But finally, and perhaps most importantly, was the 'Hawking effect'. The public imagination was "captured by the thought of a brilliant mind imprisoned in a paralysed body, unravelling the secrets of the Universe" (p. 232).

Overbye (2001) also commented that part of the attraction with Hawking's books is that it is information "from the horse's mouth" (p. F5). Also, the books make readers feel that they are being treated like adults, able to deal with difficult concepts. "When it comes to putting the goods on the table without condescending, Dr. Hawking is a genius" (p. F5). According to Sipchen (1990), Hawking himself attributed the book's success to the fact that people are naturally curious about the universe, and also the fact that the book does not contain complicated equations, making it accessible to nonscientists.

The book and its success, however, has not been without its critics. Lewenstein (personal communication, October 24, 2001) mentioned that "many people have questioned whether *Brief History of Time* has actually been read by many of its purchasers". This sentiment was echoed by Shurkin (1994), who commented that "no one ever finished Hawking's book..." (p. 618), and Overbye (2001), who said that according to popular and publishing lore, the book was "one of the great unread classics of our time" (p. F5). Rodgers (1992) also said there were reports that there were "more buyers than readers" (p. 232), and the reason for this may be that in reality, the book may not be very easy for a non-specialist audience to read. It contains difficult concepts and has rather a fast pace. Popular science books should stretch their readers, but this, combined with the fast pace in *A Brief History of Time*, may have been what created the problem. Overbye (2001) also pointed out that the fact that the book was not an easy read and that readers did not finish it because of this was something that Stephen Hawking himself admits in the introduction to his new book *The Universe in a Nutshell*.

Kenward (1990) made a similar comment:

I have the dubious distinction of being the person who told one paperback publisher that Stephen Hawking was unpublishable. In my defence, I should add that I saw an early version of the manuscript. In further mitigation, I have met few people who have managed to get through this best seller unscathed: on the other hand, I have met several physicists who found it hard going. But best-seller lists have never had much to do with readability. (p. 45)

Rogers (1992) commented that a number of books have been written since claiming to be for those who did not understand *A Brief History of Time*. Leane (n.d.b) also found that many sources believe that the book does not have a high level of readability, and that this cannot be considered one of the reasons for the book's massive success.

Nixon (1991), however, gave another point of view on this issue, saying that although many critics say that many people who bought the book never finished it, others, such as Hawking's editor, actually believe that there is a "highly intelligent public" (p. 32) out there, who enjoy such a challenge. "All of those PhD's, MD's and other advanced degrees aren't just diplomas hanging on the walls" (p. 32). Sipchen (1990) made a similar comment, remarking that the success of the book may in fact indicate that there is an intelligent public, who have a "growing appetite for books about hard science" (p. 1).

Jenkins (1992), on the other hand, stated that the book "has been much praised for the clarity with which it expounds twentieth-century physics for the layperson" (p. 529), and that it is widely accepted that the book is clear, and not hard to read. However, this does not mean the content is easy to understand: "most laypersons will find the content challenging" (p. 529), showing that "clear writing does not necessarily mean easy content" (p. 529). Jenkins analysed the language in four chapters of *A Brief History of Time*, based on the assumption that this is an example of clear exposition. The aim of this was to discover the factors that contribute to clear writing, by examining aspects of the language in the chapters such as text structure, paragraph structure, sentence structure, linearity and cohesion, themes, and verbal groups. The study analysed in detail what the situation is in the four chapters of *A Brief History of Time*, and what aspects led to the clarity of the language. Jenkins found that Hawking's book uses a number of methods to achieve this clarity; that it "illuminates theory with the practical" (p. 544); "is structurally and syntactically transparent" (p. 544); "logically explicit, lexically simplified" (p. 544); "not too high in information density, and cohesive and coherent" (p. 544).

In summary, despite the evidence that some consider the audience of *A Brief History of Time* to be more sophisticated than previously thought, and the comments on the book's readability (or otherwise), this book, in the end, does seem to have sold largely for the reasons given by 'the Hawking effect', an effect less available to others. It is, really, an exception to many of the other ideas about saleability.

Research Question

This research in this chapter aimed to address the following question:

- Can a list of common characteristics of successful popular science books in the category 'Stories of Scientific Endeavours or Events' be developed?

Method

The following method was used in this study:

1. A sample group of five current bestselling popular science books in the category 'Stories of Scientific Endeavours or Events' was compiled
2. From the opinions expressed in the literature review, a list of features which may aid success was compiled
3. Each book was compared with every characteristic on the list, and the patterns that emerged were noted
4. Based on the patterns that emerged, suggestions were made as to features which may contribute to the success of books in this category

Methodology

There are many different ways that 'success as a science communication medium' could be defined, but for this study, a successful popular science book is defined as one which sells well. In making this choice, the fundamental assumption has been made that to sell well also means to be read widely. This approach has the drawback that sales data does not give any information about whether the books that are bought are read by the purchasers. It is usually assumed that those willing to spend money to buy a book will be motivated to read it. However, this assumption may not necessarily be true, leading to the risk that sales data may over-represent how widely read a particular popular science book is. Equally, the opposite situation may be the

case. Sales data does not reflect additional readings of a book, for example through libraries or personal lendings and so may under-represent how many people read a particular book (Buchanan, 1991). No data appears to be available as to how accurately sales data of popular science books reflects readership levels.

There are a number of alternative ways that could be used to define a successful popular science book. A book's success can also be judged through mediums such as reviews, public recognition and reader feedback. There are, however, drawbacks with these measures also. In particular, they are subjective - reviews can vary for an individual book, and the same is true of public recognition and reader feedback. These variations make analysis very difficult (Ben-Ari, 1999).

Sales data has the advantage over reviews and reader feedback in that it conveniently allows books to be ranked in order, using the number of copies sold. Sales data therefore allows books to be compared quantitatively to one another, in a way which is not possible by using reviews, recognition and reader feedback. Therefore, bearing in mind the drawbacks of the method, for this study, presence on bestseller lists will be used as a measure of the success of a popular science book, and the assumption will be made that sales approximate levels of readership.

Results and Discussion

Compiling of Sample

A sample list of five current bestselling popular science books in the category 'Stories of Scientific Endeavours or Events' was compiled for use in this study. The books used are taken from those in this category in Chapter 3. These are as follows:

- *Longitude*, by Dava Sobel
- *The Great Arc*, by John Keay
- *Fermat's Last Theorem*, by Simon Singh
- *Flu*, by Gina Kolata
- *Rivals*, by Michael White

List of Features Which May Aid Success

From the literature review, a list of features can be identified which may aid sales of popular science books. Details of these are contained in Table 4.1.

Table 4.1: Features Which May Aid Success of Popular Science Books

Topic	<ul style="list-style-type: none"> • A focus on aspects of physics and biology with universal appeal and relevance, especially cosmology, astronomy, genetics and evolution, or on cutting edge science, such as astrophysics, biochemistry, computer science, chaos theory and particle physics. (Bradford & Loose, 1994; Fahnestock, 1993; Leane, n.d.b; Marr (Gibbon, 2001); Michael (Mantell, 1995); Nixon, 1991; Tallack (Durrani, 1998); Wilford, 1997) • A focus on multidisciplinary topics (Buchanan, 1991) • A focus on topics that involve God/religion (McDonald, 1993; Tallack (Durrani, 1998))
Scientific Content	<ul style="list-style-type: none"> • Avoidance of jargon, use of clear, simple language (Ferris (Rayl, 1992); Guyer, 1998; Kenward, 1990; Sapp, 1995; Turney, 1999) • Necessary technical terms explained in context (Guyer, 1998) • Scientific ideas not over-simplified (Ben-Ari, 1999; Guyer, 1998; Pinker (Shermer, 2001); Rabiner, 1994; Sapp, 1995; Shermer, 2001) • Metaphor, analogy and anthropomorphism used to present science (Ben-Ari, 1999; Carey 1995; Dawkins, 1998; Leane, 2001; Rayl, 1992; Turney, 2001b)
Story/Narrative	<ul style="list-style-type: none"> • Facts woven into a story/narrative (Ben-Ari, 1999; Bradford & Loose, 1994; Hazen (Rayl, 1992); Lauber, 1997; Mantell, 1995; Rodgers, 1992; Singh (Durrani, 1998); Singh, 2000; Turney, 2000; Watson, 2001; Wilkie (Watson, 2001))
People	<ul style="list-style-type: none"> • Introduction of people (Bradford & Loose, 1994; Carey, 1995; Wilford, 1997)
Angle	<ul style="list-style-type: none"> • Original angle (Durrani, 1998; Wilford, 1997)
Opening	<ul style="list-style-type: none"> • An effective opening (Lauber, 1997)

Table 4.1 continued

Tone	<ul style="list-style-type: none"> • A conversational tone, with the avoidance of the passive voice (Ben-Ari, 1999; Carey, 1995; Lewis, 1994)
Readability	<ul style="list-style-type: none"> • A high level of readability (Buchanan, 1991)
Fiction Techniques & Attractive Writing	<ul style="list-style-type: none"> • Writing which has passion, enthusiasm, flair and excitement, with use of fiction techniques such as beginning, middle and end to chapters (Crowden, 1994; Durrani, 1998; Ferrell, 1992; Leane, n.d.b; Mitton (Durrani, 1998); Weatherall (de Bono, 2001); Wolpert (Bhatiani, 2001))
Author	<ul style="list-style-type: none"> • Prominent/well-known author, eminent scientist, professional science writer, or scientist in the field (Ben-Ari, 1999; Bradford & Loose, 1994; Lewenstein (Selling science, 2001); Mantell (1995); Sapp, 1995; Selling science, 2001; von der Lippe (Kreeger, 2000))
Media Attention	<ul style="list-style-type: none"> • Significant media attention focused on the book (Selling science, 2001)
Title	<ul style="list-style-type: none"> • An 'intriguing' title (Rodgers, 1992)

Note: Turney (2001b) discussed an 'effective explanations of science' model, which outlined four stages for effective scientific explanations in popular science books. This model is intended to be a useful way to help authors be more systematic in their explanations of science. An evaluation of whether this model had been used in explanations of science in the books in this sample had potential as a useful characteristic to add into the analysis in this chapter. In practise, however, this evaluation proved difficult, as it was difficult to judge if what was seen in the books matched Turney's ideas. Therefore, this model was excluded from the analysis.

Comparison of Characteristics to Books in Sample

Each book was compared with every characteristic on the list, and the patterns that emerged were noted. The results of this analysis are summarised in Table 4.2, and discussed below.

Table 4.2: Comparison of Characteristics to Books in Sample

		Longitude	The Great Arc	Fermat's Last Theorem	Flu	Rivals
Topic	Physics/Biology or Cutting Edge Science?	No	No	No	Yes	No
	Multidisciplinary?	No	No	No	No	Yes
	God/religion?	No	No	No	No	No
Scientific Content	Jargon avoided?	Yes	Yes	No	Some jargon	Some jargon
	Technical terms explained in context?	N/A	N/A	Yes	Yes	Yes
	Ideas not over-simplified?	Yes	N/A – no significant explanation of science	Yes	Yes	Yes
	Metaphor, analogy and anthropomorphism	Yes	N/A – no significant explanation of science	Yes	Yes	Yes
	Story/Narrative?	Yes	Yes	Yes	Yes	Yes
People	People introduced?	Yes	Yes	Yes	Yes	Yes
	Original angle?	Yes	Yes	Other books exist	Other books exist	Yes
Opening	Effective opening?	Yes	Yes	Yes	Yes	Yes
	Conversational tone, passive voice avoided?	Yes	Yes	Yes	Yes	Yes
Readability	Readability level?*	55 (fairly difficult)	51 (fairly difficult)	48 (difficult)	56 (fairly difficult)	31 (difficult)
	Fiction techniques used? Passion, enthusiasm, flair, excitement?	Yes	Yes	Yes	Yes	Yes
Fiction Techniques and Attractive Writing						
Author	Prominent author, scientist in the field or professional science writer?	Professional science writer	Professional non-fiction writer	Professional science writer, film and television producer	Professional science writer	Professional science writer

Table 4.2 continued

			Longitude	The Great Arc	Fermat's Last Theorem	Flu	Rivals
Media Attention	Significant media attention?		Yes	Yes	Yes	Yes	Yes
Title	'Intriguing' title?		Short, descriptive title, intriguing subtitle	Short, descriptive title, intriguing subtitle	Short, descriptive title, intriguing subtitle	Short, descriptive title, intriguing subtitle	Short, descriptive title, intriguing subtitle

*See p.165

Discussion of Patterns of Characteristics

Topic

Physics/Biology or Cutting Edge Science? Multidisciplinary? God/religion?

Most of the books in this sample do not fit the 'topic' criteria considered to be important in the literature. Just one book, *Flu*, is focused on one of the areas named (biology), although not on an area considered to be the most popular within this discipline (genetics or evolution). The remaining books have topics that differ from those considered to be popular, including: navigation – the history of determining longitude at sea (*Longitude*); cartography/surveying – in India (*The Great Arc*); mathematics (*Fermat's Last Theorem*) and scientific rivalry (*Rivals*). Instead, the books in this sample tend to concentrate on very specific stories surrounding unusual topics in science. This suggests that although as a general rule there are certain topics that are considered to help popular science books sell, in this category, topics outside these areas can be just as, if not more, appealing and successful.

Additionally, although multidisciplinary topics are considered to sell well (Buchanan, 1991), just one book in this sample concentrates on multidisciplinary topics (*Rivals*). Finally, none deal with God or religion.

Scientific Content

Jargon avoided? Technical terms explained in context?

Although it is considered important to avoid jargon and to use clear, simple language (Ferris (Rayl, 1992); Guyer, 1998; Kenward, 1990; Sapp, 1995; Turney, 1999), this is not always the case for the books in this sample. Two books, *Longitude* and *The Great Arc*, do have language that is generally non-specialist, but a further two books, *Flu* and *Rivals*, have some jargon/equations, and *Fermat's Last Theorem* has a relatively high level of jargon/equations.

However, in these books, as Guyer (1998) suggests, when technical terms are introduced, they are usually explained in some context, rather than being in the form of a simple term and definition. For example, a technical term introduced in *Flu* is 'PCR'. The meaning of this term is explained within the context of an experiment being carried out by two scientists:

It was time to use PCR, the miraculous method that can make millions of copies of a single fragment of a gene floating in a solution. Taubenberger and Reid decided to look for a piece of a flu virus's genetic material called the matrix gene...they could use PCR to start copying a piece of it. (p. 208)

Further examples can be seen in *Fermat's Last Theorem*, which contains a relatively high level of technical terms and, in particular, equations, formulae and mathematics. When Pythagoras' theorem is explained, as well as the more mathematical aspects of the theorem, a discussion is also given of how the theorem is relevant to reader's own experiences:

What is remarkable is that Pythagoras' theorem is true for every right-handed triangle you can possibly imagine. It is a universal law of mathematics, and you can rely on it whenever you come across any triangle with a right angle. (p. 20)

And a discussion of how the theorem has been used in history:

...although this theorem will be forever associated with Pythagoras, it was actually used by the Chinese and the Babylonians one thousand years before. However, these cultures did not know that the theorem was true for every right-handed triangle. (p. 20)

Rivals, too contains some jargon, but new terms are frequently set in a historical context, with mention of who discovered the concept and when:

During the late 1940s it was discovered that DNA contained four bases, adenine (A), thymine (T), guanine (G) and cytosine (C). (p. 251)

Within another year, the New Zealander Ernest Rutherford ... discovered what he thought was a new particle he called an 'electron'. (p.182)

Edison worked almost exclusively with dynamos and generators that used a form of electricity called *direct current* (DC) and Tesla was an advocate of AC or *alternating current*. DC is a form of electricity that flows continuously whereas AC constantly changes direction, backwards and forwards. (p. 141)

These examples indicate that it is not essential to avoid all technical terms, but when used, they should not be in the form of a simple 'term and definition', but should be explained in some context – such as how a technique was used in particular experiments, how concepts relate to reader's lives and experiences, or when and by whom the concepts were discovered.

Ideas not over-simplified?

It is considered important by several authors not to over-simplify scientific ideas in popular science books (Ben-Ari, 1999; Guyer, 1998; Pinker (Shermer, 2001); Rabiner, 1994; Sapp, 1995; Shermer, 2001). It is somewhat difficult to judge if this is the case in individual books,

not least because whether an idea is 'over-simplified' depends upon each reader's level of knowledge/expertise. The consensus in the literature, however, is that books should be suitable for those who are educated/intelligent and interested, but without specialist knowledge. With this in mind, an examination of examples of the explanations of science in the books in this sample indicates that this is being achieved. Complex ideas can be found but, because of the factors outlined in the previous section (avoidance of jargon or technical terms explained in context), are written suitably for those without specialist knowledge. Some examples of this are:

Longitude: An explanation of the 'lunar distance' method of determining longitude:

As early as 1514, the German astronomer Johannes Werner struck on a way to use the motion of the moon as a location finder. The moon travels a distance roughly equal to its own width every hour. At night, it appears to walk through the fields of fixed stars at this stately pace. In the daytime (and the moon is up in the daytime for half of every month) it moves toward or away from the sun.

Werner suggested that astronomers should map the positions of the stars along the moon's path and predict when the moon would brush by each one – on every moonlit night, month by month, for years to come. Astronomers could then publish tables of all the moon's meanderings, with the time of each star meeting predicted for one place – Berlin, perhaps, or Nuremberg – whose longitude would serve as the zero-degree reference point. Armed with such information, a navigator could compare the time he observed the moon near a given star with the time the same conjunction was supposed to occur in the skies over the reference location. He would then determine his longitude by finding the difference in hours between the two places, and multiplying that number by fifteen degrees. (p. 23)

Fermat's Last Theorem: how to calculate the value of π :

The most famous irrational number is π . In schools it is sometimes approximated by $3\frac{1}{7}$ or 3.14; however, the true value of π is nearer 3.14159265358979323846, but even this is only an approximation. In fact, π can never be written down exactly because the decimal places go on forever without any pattern. A beautiful feature of this random pattern is that it can be computed using an equation which is supremely regular... (p. 50-51)

Flu: The possible origins of the 1918 'flu':

Webster proposed that the worst flu pandemics, the one in 1918 being at the far end of bad, start with a bird flu. But before it can infect a person, it has to be humanized – that is, to change in a way that would allow it to keep the birdlike features that make it so infectious and yet acquire human flu-like properties that would allow it to grow in the lung cells of a human being. That crucial step, Webster said, typically takes place in pigs. Pigs bridge the gap between birds and humans – both bird flu strains and human flu strains can grow in pigs' bodies.

An unfortunate pig that happens to be infected with both a bird and human virus at the same time can become a mixing bowl, with the genes from the two types of flu viruses recombining in its cells to form a new hybrid virus that can infect humans but has some genes from the bird flu, genes that make the newly emerging

virus more dangerous than any that had been around before. Thus the stage can be set for a worldwide pandemic. (p. 223)

Rivals: The Bohr model of the atom:

Neils Bohr was one of the first to venture ideas that formed the bedrock of this new science. He proposed the idea that atoms spent most of their time in what is called a *ground state*. The ground state is the lowest possible energy state of the atom, and using this idea Bohr was able to circumvent the problem of electrons spiraling into the nucleus and the atom decaying. In Rutherford's model, electrons could exist anywhere outside the nucleus (some described this as the 'plum pudding' model), but Bohr proposed that in all atoms electrons have to be arranged in definite locations about the nucleus and he created a set of rules that explained some of the chemical characteristics we now know are true for the elements. (p. 185)

This indicates that it is important to include complex ideas, while avoiding jargon or explaining technical terms in context.

Metaphor, analogy and anthropomorphism?

Several sources commented on the use of metaphor, analogy and anthropomorphism as an aid in presenting science appropriately to a non-specialist audience (Ben-Ari, 1999; Carey 1995; Dawkins, 1998; Leane, 2001; Rayl, 1992; Turney, 2001b). All books in this sample make use of one or all of these techniques. They do, however, differ in the extent to which they are used.

Longitude makes frequent use of these techniques. A recurring theme sees the universe and celestial bodies referred to as a clock and compass: "the clockwork universe" (p. 7); "Earth is a cog in a clockwork universe" (p. 21-22); "When mariners looked to the heavens for help with navigation, they found a combination compass and clock" (p. 22); and "the hands of the Jupiter clock" (p. 25).

The book also makes use of analogy, frequently in reference to time: "longitude shifts like the sands of time" (p. 5); "time refuses to be bottled up like a genie stuffed in a lamp" (p. 34) and "time sets its own tempo, like a heartbeat or an ebb tide" (p. 34). Finally, the book includes examples of anthropomorphism, including "fickle winds" (p. 14); instructions from the sun, which "not only gave direction, but also told them the time" (p. 22) and the movements of the moon, which "appears to walk through the fields of fixed stars" (p. 23).

Fermat's Last Theorem contains fewer examples of these techniques than *Longitude*, but there are some. For instance, subatomic particles are referred to as ingredients: "Protons, neutrons and electrons were proudly held up as the complete ingredients for the universe" (p. 23).

Flu contains examples of all techniques, including metaphor: “preserved lung tissue, a sort of Rosetta stone for the killer flu virus” (p. 28) and “In the epic sea of plagues” (p. 38), an analogy of the 1918 ‘flu’ as “like a macabre science fiction tale” (p. 6), and anthropomorphism related to the ‘flu’ virus and other diseases: “a terrifying new disease ... is poised, prepared” (p. 5); “easy prey for the flu” (p. 29); and “the fury of another terrifying infectious disease” (p. 38).

Rivals, in contrast, does not make extensive use of these techniques, but does discuss a number of metaphors and analogies that have been used by others previously for scientific concepts: neutrons as a “gluing agent” (p. 184); electrons as “orbiting the nucleus like planets around a star” (p. 183) and the “plum pudding” (p. 185) model of the atom.

This indicates that metaphor, analogy, and anthropomorphism can be useful in explaining science to a non-specialist audience, and may contribute to the success of bestselling popular science books in this category.

Story/Narrative

Story/Narrative?

The use of story/narrative is considered by several sources to be an essential factor in successful popular science books (Ben-Ari, 1999; Bradford & Loose, 1994; Hazen (Rayl, 1992); Lauber, 1997; Mantell, 1995; Rodgers, 1992; Singh (Durrani, 1998); Singh, 2000; Turney, 2001b; Watson, 2001; Wilkie (Watson, 2001)). The books in this sample indicate that this is indeed the case for this category. As discussed in Chapter 3, the presence of a central story is the main focus and the defining feature of all the books in this category. All books have a strong narrative storyline, with stories of scientific endeavours or events as the central thread. *Longitude* is the story of the way in which the problem of measuring longitude at sea was solved. *The Great Arc* is the story of the early surveying of India. *Fermat’s Last Theorem* is the story of how Fermat’s last theorem was solved. *Flu* centres around the story of the 1918 flu and the search to uncover its cause, and each chapter of *Rivals* focuses on the story of a scientific endeavour involving rivalry.

People

People introduced?

It was suggested by several sources that a scientific subject can be greatly enlivened by introducing people (Bradford & Loose, 1994; Carey, 1995; Wilford, 1997). As discussed in Chapter 3, biography is a significant feature of all books in this sample, second only to the story of the science endeavour that the book focuses on and the events of science surrounding it. Lives of individuals are told as they fit into the story of the scientific endeavour. All books focus equally on several individuals, however *Longitude* focuses particularly strongly on John Harrison, with significant attention to several others.

Angle

Original angle?

Durrani (1998) and Wilford (1997) both made the point that in a new popular science book, an original angle is important. To investigate this characteristic for the books in this sample, searches of *Bowker's Global Books in Print* database were carried out, to determine if any popular science books on the same topics (with very similar focus and range of material covered) had been published before each of the books in the sample.

For three of the books in this sample, *Longitude*, *The Great Arc* and *Rivals*, no previous popular science books with very similar focus and range of material covered existed, therefore the books can be considered to have an original angle.

For the remaining two books in this sample, there were previous popular science books with a very similar focus and range of material covered – but just one for one book and two for the other. For *Fermat's Last Theorem*, two previous books existed with very similar focus and range of material covered: *The World's Most Famous Math Problem*, by Marilyn Vos Savant, and *Fermat's Last Theorem*, by Amir Aczel. For *Flu*, one previous book existed with very similar focus and range of material covered: *Influenza 1918*, by Lynette Iezzoni. Therefore, although the books cannot be considered to have an entirely original angle, there are very few examples of similar books.

This indicates that books should have an original angle, or that topics chosen should not be the focus of large numbers of previous books.

Opening

Effective opening?

Lauber (1997) considers the beginning of a book to be very important, where the author can gain and hold the reader's interest. All books in this sample have openings that are similar in their basic structure. Most openings are personal and resemble a casual conversation, with the author discussing their experiences or interactions related to the subject matter of the book. All openings contain some history and an introduction to the topic, and a summary of the story to come. As a result, all create the feeling that Lauber mentioned - of a story that is about to be told.

Longitude begins with a personal story of the author's childhood experiences with longitude, and continues with a brief history of the longitude problem and a summary of the story that the book is centred around. *The Great Arc* begins with the story of the naming of Mount Everest, and of the early surveyors and map-makers. Included is the story of how the author came to be interested in 'The Great Arc', and a summary of the story to come. *Fermat's Last Theorem* begins with the story of the author (John Lynch for the book's foreword) meeting mathematician Andrew Wiles, and their work on a documentary series about Fermat's Last Theorem. Also included is an introduction to the problem of the solving of the theorem. *Flu* begins with a personal story of how the author came to learn of the 1918 flu, and how the pandemic affected members of her family. Included is an introduction to the epidemic, and how Kolata came to write a book about it. By nature of the subject matter, this opening uses a natural disaster, a feature mentioned by Lauber (1997). The opening to *Rivals* consists of a brief history of scientific rivalry, and an introduction to the book's content. This opening is less personal than the other books in this sample, and is longer, but is similar in other respects.

This suggests that the opening of books may indeed be important, and should be personal, include history, an introduction to the topic, and a summary of the story to come.

Note: 'opening' is defined here as the first chapter in the book – either foreword, Chapter one, or preface.

Tone

Conversational tone, passive voice avoided?

As suggested by Ben-Ari (1999), Carey (1995) and Lewis (1994), all the books in this sample have a conversational tone, making frequent use of the active voice. Examples of this for each book are:

Longitude: “In 1699, Samuel Fyler, the seventy-year-old rector of Stockton, in Wiltshire, England, came up with a way to draw longitude meridians on the night sky” (p. 45); “Harrison completed his first pendulum clock in 1713, before he was twenty years old” (p. 64); and “Halley ran the observatory with a sense of humor” (p. 75).

The Great Arc: “Meanwhile Everest and a dozen men, balancing the Survey’s cumbersome theodolite between them, crossed to the other side” (p. 5); “Lambton was able to make some important corrections to existing maps” (p. 70); “But wine was a different matter. Morton had great difficulty keeping him off it and, at the first sign of improvement, Lambton celebrated his recovery by putting himself back on it” (p. 90).

Fermat’s Last Theorem: “Pythagoras had defined the universe in terms of rational numbers, and the existence of irrational numbers brought his ideal into question” (p. 54); “Gödel had proved that trying to create a complete and consistent mathematical system was an impossible task” (p. 159) and “Wiles did his best to ignore the controversy and speculation” (p. 285).

Flu: “The group decided to make swine flu antibodies for use in laboratory tests, just in case” (p. 131); “Faced with 126 cases from six states, Finesilver did not relish his task of deciding who should be compensated and who should not” (p. 180) and “Taubenberger, in the meantime, gingerly opened his precious parcels” (p. 265).

Rivals: “With this account Priestly gave a full description of the gas, thus claiming his priority for the discovery of oxygen and then gave his explanation of how it was made and the role it played in his experiments” (p. 82); “Rutherford took his ideas and experiments further still” (p. 182) and “In 1994, Bill Gates paid \$30 million for Leonardo’s notebook, the *Codex Hammer*” (p. 339).

This suggests that the use of an active voice (and avoidance of the passive) is important for successful books in this category.

Readability

High readability?

Different measures of readability exist, but for this study, as carried out by Buchanan (1991), the Flesch readability formula (Flesch, 1979) was used as a basis by which to assess the readability of the books in this sample. The data used in the analysis, and the results are contained in the following tables:

4.3 Data for Calculation of Readability Score for *Longitude*

Sample Number	1	2	3	4	5	6	7	8	9	10
Position in book	page 2 para. 2	page 12 para. 2	page 22 para. 2	page 32 para. 2	page 42 para. 2	page 52 para. 2	page 62 para. 2	page 72 para. 2	page 82 para. 2	page 92 para. 2
Number of words	66	52	188	45	162	63	91	99	163	35
Average sentence length	8	13	19	22	16	16	30	25	20	12
Syllables per 100 words	150	137	164	156	136	165	162	174	200	137

4.4 Data for Calculation of Readability Score for *The Great Arc*

Sample Number	1	2	3	4	5	6	7	8	9	10
Position in book	page 2 para. 2	page 12 para. 2	page 22 para. 2	page 32 para. 2	page 42 para. 2	page 52 para. 2	page 62 para. 2	page 72 para. 2	page 82 para. 2	page 92 para. 2
Number of words	107	75	164	81	170	201	153	92	79	163
Average sentence length	18	15	18	13	28	20	25	18	26	18
Syllables per 100 words	170	152	138	147	180	165	153	157	182	158

4.5 Data for Calculation of Readability Score for *Fermat's Last Theorem*

Sample Number	1	2	3	4	5	6	7	8	9	10
Position in book	page 2 para. 2	page 12 para. 2	page 22 para. 2	page 32 para. 2	page 42 para. 2	page 53 para. 2	page 62 para. 2	page 72 para. 2	page 82 para. 2	page 92 para. 2
Number of words	97	67	148	52	144	100	166	132	76	95
Average sentence length	16	17	18	26	18	25	18	22	19	24
Syllables per 100 words	158	243	146	177	162	183	167	158	153	166

4.6 Data for Calculation of Readability Score for *Ftu*

Sample Number	1	2	3	4	5	6	7	8	9	10
Position in book	page 4 para. 2	page 12 para. 2	page 22 para. 2	page 32 para. 2	page 42 para. 2	page 52 para. 2	page 62 para. 2	page 72 para. 2	page 82 para. 2	page 92 para. 2
Number of words	61	97	73	182	53	61	56	137	90	79
Average sentence length	12	19	12	17	13	10	19	34	15	16
Syllables per 100 words	133	167	152	147	175	182	164	161	158	142

4.7 Data for Calculation of Readability Score for *Rivals*

Sample Number	1	2	3	4	5	6	7	8	9	10
Position in book	page 4 para. 2	page 12 para. 2	page 23 para. 2	page 32 para. 2	page 42 para. 2	page 52 para. 2	page 62 para. 2	page 72 para. 2	page 82 para. 2	page 92 para. 2
Number of words	83	40	75	57	61	145	110	63	99	81
Average sentence length	28	40	25	19	15	24	37	21	33	20
Syllables per 100 words	199	195	164	163	221	162	160	184	162	160

Table 4.8: Readability scores for books in sample

Book	Longitude	The Great Arc	Fermat's Last Theorem	Flu	Rivals
Average sentence length (all samples)	18	20	20	17	26
Syllables/100 words (all samples)	158	160	171	158	177
Reading ease score	55 (fairly difficult)	51 (fairly difficult)	48 (difficult)	56 (fairly difficult)	31 (difficult)

Table 4.8 indicates that in contrast to the books analysed by Buchanan (1991), the Flesch readability formula rates *Longitude*, *The Great Arc*, and *Flu* as 'fairly difficult', and *Fermat's Last Theorem* and *Rivals* as 'difficult'. These are translated as 'quality' and 'academic', respectively – below 'comics', 'pulp fiction', 'slick fiction' and 'digests', but above 'scientific'.

This indicates that although the language of popular science books is simpler than that of a scientific publication, it is not necessarily essential to simplify (in terms of sentence length and number of syllables) greatly.

Fiction Techniques & Attractive Writing

Fiction techniques used? Passion, enthusiasm, flair, excitement?

This is a difficult criteria to judge objectively, but many of the above ingredients, for example, story/narrative, the introduction of people, and a conversational tone, could be considered to contribute to the production of writing that has passion, enthusiasm, flair and excitement, keeping the reader interested. Therefore this can be considered to be an important characteristic.

Author

Prominent author, scientist in the field or professional science writer?

The authors of all books in this category are professional science writers, one of the backgrounds mentioned favourably by Sapp (1995). The exception is *The Great Arc*, where the author is a professional non-fiction writer.

Media Attention

Significant media attention?

The author of *Selling science* (2001) commented on the positive effect that media attention has on sales of popular science books. As a measure of the level of media attention each book in this sample received, the number of mentions it has had in newspapers and magazines was investigated through searches of *Factiva* database. This revealed that this characteristic varies greatly between books in this sample:

4.9 Media Mentions of Books in Sample

Book	Number of newspaper/magazine articles that mention book
Longitude	1495
The Great Arc	50
Fermat's Last Theorem	76
Flu	204
Rivals	14

Although it is difficult to judge what rates as 'significant' media attention, it is clear that all five books have differed in the amount of media attention they have received. *Longitude*, for example, has received more than 7 times the number of mentions than *Flu*, and more than 106 times the number of mentions than *Rivals*.

Title

Intriguing Title?

In commenting about *A Brief History of Time*, Rodgers (1992) mentioned that the book's intriguing title may have contributed to its success. The titles of the books in this sample were examined to see if any common patterns could be found. This revealed that all have main titles which are descriptive, short and straightforward, with sub-titles which are longer, describe the main story, and 'sell' the book's content. Most subtitles include words that allude to a story, such as: "The true story"; "The dramatic tale"; "The story of"; as well as words which allude to drama or difficulty, such as: "greatest scientific problem"; "dramatic tale"; "riddle that confounded"; and "great influenza pandemic".

4.10 Titles of Books in Sample

Main Title	Subtitle
Longitude	The true story of a lone genius who solved the greatest scientific problem of his time
The Great Arc	The dramatic tale of how India was mapped and Everest was named
Fermat's Last Theorem	The story of a riddle that confounded the world's greatest minds for 358 years
Flu	The story of the great influenza pandemic of 1918 and the search for the virus that caused it
Rivals	Conflict as the fuel of science

This suggests that main titles should be short and descriptive, with longer sub-titles which allude to the story the book contains, and to drama or intrigue.

Conclusion

Based on the results of this study, 12 common characteristics of successful popular science books in the category 'Stories of Scientific Endeavours or Events' can be identified. These are:

- Topics that are outside the 'mainstream' for popular science books, with an original angle
- Jargon not necessarily avoided, but technical terms explained in context
- Ideas not over-simplified
- Metaphor, analogy and anthropomorphism often used in explaining science
- Strong narrative storylines
- Significant levels of biography
- Effective openings, conversational in tone, combining autobiography, history and an introduction to the story
- Conversational tone, with use of the active voice
- Readability up to the 'fairly difficult-difficult bracket'
- Authors usually professional science writers
- Significant media attention may be an advantage, although this varies
- Short, descriptive titles, and subtitles that allude to the story of the book and to drama or intrigue

A summary of the common characteristics compared with the list of features of bestselling popular science books identified from the literature review is contained in Table 4.11.

4.11 Comparison of Features Which May Aid Success of Popular Science Books Suggested in Literature Review to Common Characteristics of Bestsellers in 'Stories of Scientific Endeavours or Events' Category

		Features Which May Aid Success of Popular Science Books Suggested in Literature Review	Common Characteristics of Bestselling Books in Category 'Stories of Scientific Endeavours or Events'
Topic	Physics/Biology or Cutting Edge Science?	Yes	No
	Multidisciplinary?	Yes	No
	God/religion?	Yes	No
Scientific Content	Jargon avoided?	Yes	Varies
	Technical terms explained in context?	Yes	Yes
	Ideas not over-simplified?	Yes	Yes
	Metaphor, analogy and anthropomorphism	Yes	Yes
Story/Narrative	Story/Narrative?	Yes	Yes
People	People introduced?	Yes	Yes
Angle	Original angle?	Yes	Yes
Opening	Effective opening?	Yes	Yes
Tone	Conversational tone, passive voice avoided?	Yes	Yes
Readability	Readability level?	High readability	Fairly difficult-difficult
Fiction Techniques and Attractive Writing	Fiction techniques used? Passion, enthusiasm, flair, excitement?	Yes	Yes
Author	Prominent author, scientist in the field or professional science writer?	Yes	No
Media Attention	Significant media attention?	Yes	Varies
Title	'Intriguing' title?	Yes	Yes

For almost all features examined in this analysis, a high correlation was found between the features which may aid success of popular science books suggested in the literature review to the common characteristics of bestsellers in the sample from the 'Stories of Scientific Endeavours or Events' category. It would be interesting to test the results of this analysis using a sample of books from the same category that have not been as successful, i.e. have achieved modest sales. Whether or not books of this type match the 'successful selling' features list developed in this study would be a good test for the validity of the list. If less successful books are found to be deficient in one or more of the criteria, then this will confirm the validity of the list. If the lower ranked books do match the majority of criteria on the list, however, then this would make the list less valid as a potential 'recipe for success'.

The initial list of 'features which may aid success' outlined in Table 4.1 is, necessarily, generic, as the literature that discussed bestselling features was not specific to particular sub genres. This means that the same methods employed in this chapter could be used to analyse other categories of popular science book. It would be interesting to do this and determine if the list of 'successful selling' features that emerges is different for other categories.

One point to note is that as sales rankings are used in this study as a measure of success, it may have been useful to have included data on the relative sales ranking of each book in the sample in the study. These rankings could have been compared with the outcomes of the success feature analysis of the books. A good correlation would have helped support the validity of the list of features. This would be particularly useful if lower ranking books had been included, to compare the correlations.

Finally, it must be recognised that the sample used in this analysis is small, meaning that the conclusions drawn here must be recognised as somewhat tentative. Future research could repeat the process with a larger sample, which would allow firmer conclusions to be drawn.

Chapter Five

Background to *Hunting the Double Helix: How DNA is solving puzzles of the past*

Introduction

In this chapter I discuss the construction of a new popular science book, *Hunting the Double Helix: How DNA is solving puzzles of the past*. I wrote the book for this PhD project as an ‘artefact of science communication’, to make an original contribution to the genre and to exemplify the results of the research conducted in Chapters 3 and 4 of this thesis. Designed to demonstrate the defining characteristics of the category ‘Stories of Scientific Endeavours or Events’ revealed in Chapter 3 and the bestselling features of it revealed in Chapter 4, the finished book is a 62,000-word collection of seven chapters of stories of scientific endeavours that have been carried out within the field of ancient DNA research. The book has been commercially published by Allen & Unwin (Sydney).

This chapter begins with a discussion of the book’s topic, including a brief overview of the field of ancient DNA research. This is followed by an explanation of the choice of category, the planning of structure and content, arrangement of publication, and the writing process. The chapter ends with a discussion of the finished book and an analysis of how it relates to the research in Chapters 3 and 4 of this thesis, followed by a short personal reflection on the project.

Topic

Choice of Topic

The topic that I chose for this book was the field of ancient DNA research - the study of genetic material preserved in the remains of deceased organisms (Wayne, Leonard, & Cooper, 1999). The main reason for this choice was the opportunity it provided for an original ‘angle’, a factor revealed in Chapter 4 to be important for success. At the time that I decided to write the book, no previous popular science books on ancient DNA existed. Just one book specifically focused on the field: *Ancient DNA*, by Bernd Herrmann and Susan Hummel (Eds.) - a specialist guidebook to ancient

DNA research, covering laboratory techniques and previous research, suitable exclusively for ancient DNA researchers.

Approximately six months into the project, a second book on ancient DNA was published: *The Molecule Hunt*, by Martin Jones. This is a popular science book. It is, however, strongly focused on the archaeological applications of ancient DNA research, leaving opportunity for the new popular science book to have an original angle.

Together with the opportunity for an original angle, my choice of topic was also based on my own educational background, experience and interests, as I have a background in genetics and previous contact with ancient DNA.

Brief Overview of Ancient DNA Research

'Ancient DNA' refers to genetic material preserved in the remains of deceased organisms (Wayne, Leonard, & Cooper, 1999). The range and age of biological samples in which ancient DNA can be found is large, from organisms that have recently died, to archaeological and paleontological specimens that are tens of thousands of years old.

Although relatively new, the field of ancient DNA research is diverse, and the body of scientific literature consists of many hundreds of articles. Detailed reviews of the field exist (for example Audic & Béraud-Colomb, 1997; Kumar, Subramanian, Walimbe, & Singh, 1999; Poinar, 1999; Wayne, Leonard, & Cooper, 1999). What follows, therefore, is a sampling of some of the main areas in which ancient DNA has been involved, with examples of some of the major papers or typical examples in each area.

Human Prehistory

Neanderthals: The Neanderthals were a human-like race who lived in Europe and western Asia from 300,000 to 30,000 years ago. Their relationship to modern humans has long been controversial, as morphologically they can be interpreted either as direct human ancestors, partial human ancestors, or close relations. DNA from several Neanderthals has been extracted and compared to present day human DNA, and the significant differences that were revealed have been taken as evidence by most researchers that Neanderthals are not human ancestors (Krings, et al.

1997, 2000; Krings, Geisert, Schmitz, Krainitzki, & Pääbo, 1999; Ovchinnikov et al., 2000; Ovchinnikov & Goodwin, 2001).

Human Migration: Ancient DNA has been used to investigate aspects of the origins, prehistory and migration patterns of prehistoric human populations in several regions, including the Pacific (Hagelberg & Clegg, 1993; Hagelberg, Quevedo, Turbon, & Clegg, 1994), Egypt (Hanni, Laudet, Coll, & Stehelin, 1994), central Asia (Ovchinnikov, Buzhilova, Mednikova, Goodwin, & Curry, 1999), Japan (Horai et al., 1991; Oota, Saitou, Matsushita, & Ueda, 1999), China (Wang et al., 2000), the Nile Valley (Lalueza-Fox, 1997) and Europe (Di Benedetto et al., 2000; Izagirre & de la Rúa, 1999).

Prehistoric Diet: The species of plants and animals that formed prehistoric diets is an area of interest to archaeologists. Analysis of the DNA in ancient human faecal remains has revealed several species of plants and animals that had not previously been known to be eaten by prehistoric humans (Poinar et al., 2001).

Tools and Art: DNA has been extracted from blood residues on stone tools, making it possible to determine what the stone tools were used for (Loy & Mattheai, 1994). DNA has also been obtained from prehistoric rock art from Texas, making it possible to determine that blood from either deer or bison had been used as a component of the paint used to make the art (Reese, Hyman, Rowe, Derr, & Davis, 1996).

The Tyrolean Iceman: A 5,000-year-old frozen body of a man, together with tools and garments, was found in the Tyrolean Alps in 1991, providing an unprecedented opportunity to study life from the Neolithic period. A range of ancient DNA studies were made on the man and his clothing: his DNA was extracted and found to be very similar to present-day Europeans (Handt et al., 1994); DNA was extracted from the grass of his cloak and shoe stuffing, to discover which plants prehistoric people used to manufacture their clothing (Rollo, Ascii, Antonini, Marota, & Ubaldi, 1994); and investigations were made of the DNA in his colon and stomach, to learn about what prehistoric humans ate, and what diseases they suffered from (Cano et al., 2000).

Sex Determination: In archaeology or forensics it is often important to know the sex of a human skeleton but, until recently, the only way to determine this was through morphological analysis, which can be ambiguous. Ancient DNA has made it possible to determine sex by examining a skeleton's DNA, and this method has been used in a variety of archaeological studies (Brown, 1998).

Human Disease

Tuberculosis: Several aspects of the history of tuberculosis have been investigated with ancient DNA. For example, the extraction of *Mycobacterium tuberculosis* DNA in pre-Columbus skeletons from the Americas revealed the previously-unproven fact that tuberculosis was present in the Americas before the arrival of Columbus (Arriaza, Salo, Aufderheide, & Holcomb, 1995; Braun, Cook, & Pfeiffer, 1998; Salo, Aufderheide, Buikstra, & Holcomb, 1994).

The Black Death: DNA from the bacteria that causes the plague, *Yersinia pestis*, was extracted from a 14th-century Black Death grave, providing evidence that the Black Death was the plague (Drancourt, Aboudharam, Signoli, Dutour, & Raoult, 1998; Drancourt & Raoult, 2002; Raoult et al., 2000).

The 1918 'Flu': The genetics of the 1918 strain of the influenza virus was examined from preserved tissue samples of 'flu' victims, giving information on the evolutionary origins of the disease (Basler et al., 2001; Gibbs, Armstrong & Gibbs, 2001a, 2001b; Reid, Fanning, Hultin, & Taubenberger, 1999; Reid, Fanning, Janczewski, & Taubenberger, 2000; Taubenberger, Reid, Kraft, Bijwaard, & Fanning, 1997).

Other Diseases: DNA has also been extracted from disease-causing organisms in a range of other historical samples, such as Leprosy (Rafi et al., 1994), Syphilis (Kolman, Centurion-Lara, Lukehart, Owsley, & Tuross, 1999), Malaria (Taylor, Rutland, & Mollleston, 1997), Lyme disease (Marshall et al., 1994; Matuschka, Ohlenbush, Eiffert, Richter, & Spielman, 1996; Persing et al., 1990) and Chagas' disease (Ferreira et al., 2000; Guhl et al., 1997).

Identification of Individuals

Josef Mengele: Auschwitz 'Angel of Death' Josef Mengele escaped to South America following WWII. A victim of a swimming accident in 1979 was buried in Brazil under another name, but it was suspected on the basis of dental and skeletal records that the man was Mengele. DNA was extracted from the skeletal remains of the man, and a comparison with that of Mengele's son confirmed this (Jeffreys, Allen, Hagelberg, & Sonnberg, 1992).

The Russian Royal Family: In 1991, a burial site was found containing what was thought to be the remains of the Russian royal family. DNA was extracted from each skeleton and compared with relatives of the family (including Prince Phillip), proving that the skeletons were indeed those of the Romanovs (Gill et al., 1994; Ivanov et al., 1996). DNA was also extracted from Anna Anderson, a long-time Anastasia claimant. Comparison to the DNA of the Romanovs showed she was not who she claimed to be (Stoneking et al., 1995).

Louis XVII: Official records say that Louis XVII (son of Louis XVI and Marie-Antionette) died of Tuberculosis as a boy in the Temple of Paris during the French Revolution – however, this version is often questioned. DNA was extracted from the heart of the boy who died, and comparison with maternal relatives showed that he was Louis XVII (Jehaes et al., 2001).

Animals

Extinct Species: An extensive area of research, the aim of most studies of DNA from extinct species is to make comparisons with DNA from present-day relatives, in order to determine the extinct species' closest living relations and their phylogenetic positions. This type of analysis has been carried out with a large number of species, including quaggas (Higuchi et al., 1987; Higuchi, Bowman, Freiberger, Ryder, & Wilson, 1984), thylacines (Krajewski, Buckley, & Westerman, 1997; Krajewski, Driskell, Baverstock, & Braun, 1992; Thomas, Schaffner, Wilson, & Pääbo, 1989), mammoths (Hagelberg et al., 1994; Hauf et al., 1995; Hoss, Paabo, & Vereshchagin, 1994; Johnson, Olson, & Goodman, 1985; Noro, Masuda, Dubrovo, Yoshida, & Kato, 1998) and moas (Bunce et al., 2003; Cooper et al., 1992; Cooper et al., 2001; Cooper, Atkinson, Lee, & Worthy, 1993; Huynen, Millar, Scofield, & Lambert, 2003).

Historical Specimens of Extant Species: A second area of research in animal-related ancient DNA involves the genetic analysis of historical or preserved specimens of present-day animals, birds and fish, such as red wolves (Roy, Geffen, Smith, & Wayne, 1996; Wayne & Jenks, 1991) and brown bears (Leonard, Wayne, & Cooper, 2000). Most studies look at genetic changes in populations over time, providing information relevant to conservation biology and evolutionary studies. Some studies use museum specimens in place of fresh specimens to determine evolutionary relationships of the species.

Evolution of Domestic Animals: A third area of animal-related ancient DNA research is in the study of DNA from historical specimens of domestic animals, such as horses (Vila et al., 2001), pigs (Watanobe et al., 2001) and cattle (Bailey et al., 1996) to learn about the history of animal domestication.

Domestic Plants

Wheat was first domesticated in the near and middle East about 10,000 years ago. The geographical range of wheat soon expanded throughout Europe and Asia, where many new varieties appeared. Ancient DNA has been used to learn more about the evolutionary history of wheat (Deakin, Rowley-Conwy, & Shaw, 1998). Ancient DNA has also been used to investigate the evolutionary history of maize (Goloubinoff, Pääbo, & Wilson, 1993; Rollo, Ascii, & Sassaroli, 1994).

Super-Ancient DNA

Over several years, DNA sequences were reported from multi-million-year-old plant fossils, insects and plants in amber, and dinosaur bones and eggs (An et al., 1995; Cano, Poinar, & Poinar, 1992; Cano, Poinar, Roubik, & Poinar, 1992; DeSalle, Gatesy, Wheeler, & Grimaldi, 1992; Golenberg, 1991, 1994; Golenberg et al., 1990; Li et al., 1995; Soltis, Soltis, & Smiley, 1992; Manen, Savolainen, de Marchi, & Rion, 1995; Woodward, Weyland, & Bunnell, 1994; Zhang & Fang, 1995; Zou, Zheng, Fang, Guangling, & Zhang, 1995). The studies were at first accepted by many as evidence that DNA can survive extremely long periods of time, but have since been criticised for several reasons, including lack of reproducibility, exceeding the theoretical limit for DNA survival, and lack of phylogenetic sense (Hedges & Schweitzer, 1995; Sidow, Wilson, & Pääbo, 1991; Wang, 1996; Wang, Yan, & Jin, 1997; Yin, Chen, Wang, Zhang, & Zou, 1996; Young, Huyen, & Allard, 1995). The conclusion is that DNA can not survive for such long periods of time. This highlights issues common to all ancient DNA research, such as reproducibility of results, control of contamination, and the limits of DNA survival.

Choice of Category

After I selected the topic and reviewed the literature in the ancient DNA field, the next stage of the project was to decide on a category (from those revealed in Chapter 3) in which to situate the book. This choice of category then aided and guided the planning of the book's structure and content.

After consideration, I made the decision to situate the book within the category of 'Stories of Scientific Endeavours or Events'. There were two reasons for this choice. First, the features of books in this category are an excellent fit with the chosen subject matter of the new book, as the field of ancient DNA contains many discrete and varied research projects that lend themselves naturally to forming stories of science endeavours. The second reason was personal preference - I most enjoy reading this type of popular science book, and favoured the idea of writing one of this type.

Planning of Structure and Content

I planned the book's structure and content, aided by the research in Chapter 3 and Chapter 4 of this thesis. Taken together, this research indicated that the following features should be taken into account when planning the book:

- The book should be novel-like with a continuous narrative thread
- It should be centred around a story of a science endeavour or event, or a series of related ones, and should have a strong narrative storyline
- It should be focused on the events of science, surrounding or related to the scientific endeavour(s)
- It should include biography
- It should include explanation/discussion of historical science
- It could vary in how much explanation/discussion of current science it contains
- It should contain black and white illustrations, supplementary to the text

As mentioned in Chapter 3, the defining feature of books in this category is that they are centred around stories of scientific endeavours or events. A review of the ancient DNA literature revealed the great diversity of the field and, as a result, I made the decision to use a similar approach to that used in *Rivals* and *It Must be Beautiful* - to focus on a number of stories of scientific endeavours or events within ancient DNA research. I compiled a list of areas where ancient DNA had been responsible for a significant and interesting discovery and, from these, designed outlines of nine chapters, with each chapter focusing on one central story. The details of each proposed chapter are contained in Appendix C (the book proposal). The aim was to cover a range of areas in which ancient DNA has been involved, including human prehistory, extinct animals, super-ancient DNA, epidemics of disease and mysteries of identity.

Arranging Publication

Before the writing of the book commenced, the decision was made to obtain a contract for publication, if possible. In order to facilitate this, I wrote a book proposal, using a structure based on that outlined by Beale (2001). A copy of this proposal is attached as Appendix C. The proposal begins with a summary of the book, including the genre, length, illustrations and predicted writing time. Following this is a short autobiographical piece. The next section, 'concept', contains an overview of the proposed topic and content of the book, a discussion of the target audience, and how the book was to be designed with this in mind. Next is a discussion of the market competitors, and the way in which the proposed book has an original angle. The final section is a summary of the book's proposed structure, and an outline of each proposed chapter of the book.

The book was given a working title: *Time Travel in a Test Tube: Discoveries with Ancient DNA* (which was later changed by the publisher to *Hunting the Double Helix: How DNA is solving puzzles of the past*) and I provided the text of the first half of Chapter 1 as a writing sample.

This book proposal was sent to Ian Bowring, science publisher at Allen & Unwin (Sydney) on 14 August 2002, together with the writing sample. The book was accepted for publication, and a contract was signed on 3 October 2002.

The Writing Process

I took 16 months to complete the first draft.

Information for the book came from three sources: primary scientific literature, secondary written sources (textbooks, popular books, articles and websites), and contact with ancient DNA researchers (phone and email). A detailed list of these sources appears within *Hunting the Double Helix*.

From the research in Chapters 3 and 4, together with the features mentioned earlier, I kept in mind the following points as I wrote the book:

- The book should have language that varies from non-specialist to relatively high levels of jargon/equations, but with technical terms explained in context
- It should contain ideas that are not over-simplified
- It should make use of metaphor, analogy and anthropomorphism in explanations of science

- It should be conversational in tone, with use of the active voice
- It should have readability up to the 'fairly difficult-difficult' bracket
- It should not include the author's ideas/theories, advocacy/argument or autobiography as significant features

During the stage from proposal to first draft, a number of changes were made to the planned structure and content:

- Chapters 2 (Russian royal family) and 3 (Louis XVII) were moved to the end of the book, to become Chapters 6 and 7. The content of the Russian royal family chapter was changed to become a story more strongly focused on Anna Anderson/Anastasia
- Chapter 4 (extinct animals) became Chapter 2 and Chapter 5 (dinosaurs) became Chapter 3
- Chapter 9 (DNA in dung) was deleted when further literature searches revealed a weaker story than had been anticipated
- Chapters 6-8 (Black Death, 1918 'flu', and Columbus and tuberculosis) were combined into one, as it was felt that the book was too strongly focussed on the diseases aspects of the field
- As the result of newly published research, an extra chapter (Chapter 4) was added on ancient DNA work on the New Zealand moa

As this list indicates, together with the changes in content, the order of the chapters was rearranged to provide a better narrative flow – a feature revealed as important in Chapter 4. Although the book is a collection of stories of essentially independent scientific endeavours, it was important that the final book be novel-like, with a continuous narrative thread, and that the order of the chapters be carefully chosen to ensure this was achieved.

The final order begins with Neanderthals and extinct animals (both success stories of the ancient DNA field), followed by a story of where ancient DNA has been less successful (dinosaur DNA), and back to another (more recent) success story with an extinct animal (the moa). Next are the stories of three deadly diseases, and finally, the more recent stories of mysteries of identity.

As I wrote, I paid particular attention to the opening of the book. The research in Chapter 4 revealed that an important feature was an effective opening, conversational in tone, combining autobiography, history and an introduction to the story. Efforts were made to ensure this was achieved.

During the writing process, regular e-mail and phone conversations were carried out with the publisher, and a meeting was held in Sydney. A first draft of the book was submitted to Allen & Unwin on 21 January 2004.

The manuscript was edited, and a number of changes suggested. Most suggestions related to details of language and grammar. One suggestion, however, was to include more explanation/discussion of the science behind the research, as it was felt that this was an area that had not been concentrated on enough. A second suggestion was to add a section in Chapter 6 on ancient DNA and victims of the *Titanic*, as this research had recently been published. The suggested changes were made, and the book was edited again with no further significant changes. Illustrations were drawn, and permissions sought for the use of photos.

The book was given a title by the publisher: *Hunting the Double Helix: How DNA is solving puzzles of the past*, and a cover was also designed by the publisher. The book was typeset in February 2005.

The book is due for release in Australia and New Zealand in May 2005, with a projected print run of 3000 copies - this may increase, however, as the book is due to feature at the London Book Fair in March 2005.

The Final Product

Hunting the Double Helix: How DNA is solving the puzzles of the past is a 62,000-word book consisting of an introduction, seven chapters and a conclusion. Each chapter focuses on a story, or related stories, within the field of ancient DNA research. Chapter 1 is the story of work to extract ancient DNA from Neanderthal bones, and what this has revealed about their relationship to humans. Chapter 2 is the story of the extraction of ancient DNA from extinct animals, and how this may one day be used to clone them. Chapter 3 is the story of 'super-ancient' DNA, which was reported to have been extracted from ancient samples such as dinosaur bones, and how this was later shown to have been an error. Chapter 4 is the story of the extraction of ancient DNA from bones of the New Zealand moa, and what this has revealed about the bird's relationship to the kiwi, and about its number of species. Chapter 5 is the story of the role of ancient DNA in helping to uncover the mysteries of three deadly historical disease epidemics: the Black Death, Columbus and tuberculosis, and the 1918 'flu'. Chapter 6 is the story of the role of ancient DNA in revealing the fate of the Russian royal family, and the identity of Anastasia claimant, Anna Anderson. Finally,

Chapter 7 is the story of the role of ancient DNA in revealing the fate of Louis XVII, and the identity of claimant Karl Naundorff.

Relationship of *Hunting the Double Helix* to the Research in This Thesis

Hunting the Double Helix was designed to embody the results of the research conducted in Chapters 3 and 4 of this thesis - the defining characteristics of the category 'Stories of Scientific Endeavours or Events' revealed in Chapter 3 and the bestselling features of it revealed in Chapter 4. An analysis of the book indicates that this has generally been achieved.

Table 5.1 shows a comparison of *Hunting the Double Helix* with the common characteristics of books in the category 'Stories of Scientific Endeavours or Events' revealed in Chapter 3.

Table 5.1: 'Category' Characteristics of *Hunting the Double Helix*

	Common Characteristics of Books in Category 'Stories of Scientific Endeavours or Events'	Characteristics of <i>Hunting the Double Helix</i>
Arrangement of Content	Beginning to end (novel-like). Continuous narrative	Beginning to end (novel-like). Continuous narrative
Profession of Author(s)	Science or non-fiction writers	PhD student in science communication, part-time science writer, background in genetics
Science Topic	Various	Genetics (ancient DNA)
Scientific Language	Variable	Some jargon/equations
New Scientific Ideas/Theories	Minor/non-existent	Minor/non-existent
Explanation/Discussion of Current Science	May be a significant secondary feature	Significant secondary feature
Advocacy/Argument	Minor/non-existent	Minor/non-existent
Practical Science Guidance	No	No
Biography	Significant secondary feature	Significant secondary feature
Autobiography	Minor/non-existent	Minor/non-existent
Events of Science	Main focus of book	Main focus of book
Story of Science Endeavour	Main focus of book	Main focus of book
Explanation/Discussion of Historical Science	Significant secondary feature	Significant secondary feature
Elements of Science Fiction/Fantasy	No	No
Paper Type	Regular matt	Regular matt
Illustrations	Black & white illustrations. Supplementary	Black & white illustrations. Supplementary
Format	Medium	Medium: 208 x 140

The information contained in Table 5.1 indicates that the finished book fits well with the common characteristics of the category 'Stories of Scientific Endeavours or Events' outlined in Chapter 3.

Arrangement of Content: In common with other books in this category, *Hunting the Double Helix* is novel-like, designed to be read in entirety, from beginning to end, with a continuous narrative thread.

Profession of Author(s): Most authors of books in this category are professional science or non-fiction writers. The author of *Hunting the Double Helix* – myself - has a similar background – I am a PhD student in science communication, and a part-time science writer. I also have a background in genetics.

Science Topic: In Chapter 3, each book in this category focussed on a different science topic, with the common feature that each focussed on specific event(s) or endeavour(s) within a wider field. This is also the case with *Hunting the Double Helix*, which focuses on a number of specific endeavours within the field of ancient DNA.

Scientific Language: Chapter 3 revealed that the level of scientific language varies between different books in this category. In common with three books in the sample in Chapter 3, *Hunting the Double Helix* has some jargon/equations.

New Scientific Ideas/Theories: This is not a significant feature of the books in this category in Chapter 3, and is not a significant feature of *Hunting the Double Helix*.

Explanation/Discussion of Current Science: Chapter 3 revealed that this is a significant secondary feature of some books in this category, however explanations fit around, and are secondary to, the historical and biographical aspects of the stories the books centre around. This is also the case with *Hunting the Double Helix*.

Advocacy/Argument: This is not a significant feature of books in this category, and is not a significant feature of *Hunting the Double Helix*.

Practical Science Guidance: Like other books in this category, *Hunting the Double Helix* is not designed for the purpose of providing a practical guide to a scientific activity.

Biography: This is a significant secondary feature of *Hunting the Double Helix*, as it is for all books in this category. Several individuals are focussed on equally, and their activities are told as they fit into the stories of the science endeavours.

Events of Science: This is a main focus of books in this category, and is also a main focus of *Hunting the Double Helix*. Each chapter includes a discussion of the events of the main story (the ancient DNA research), and the broader events surrounding it, such as historical events, and previous scientific research in the field.

Story of Science Endeavour: This is the main focus and defining feature of all the books in this category, as it is with *Hunting the Double Helix*. In a similar format to *Rivals* and *It Must be Beautiful*, each chapter of *Hunting the Double Helix* focuses on the story of a scientific endeavour (or several related ones) involving ancient DNA. Like other books in this category, the book has a strong narrative storyline, with the stories of the science endeavours as the central thread. Characteristics such as biographical detail, discussions of scientific ideas and events of science related to, but outside the main story are situated within the central story and are secondary to it.

Explanation/Discussion of Historical Science: Like most other books in this category, this is a significant secondary feature of *Hunting the Double Helix*.

Elements of Science Fiction/Fantasy: This is not a significant feature of books in this category, and is not featured in *Hunting the Double Helix*.

Paper Type: Like other books in this category, *Hunting the Double Helix* is printed on regular matt paper.

Illustrations: Like most books in this category, *Hunting the Double Helix* is illustrated with black and white illustrations that are supplementary to the text.

Format: Also like most books in this category, *Hunting the Double Helix* is medium sized.

Table 5.2 shows a comparison of *Hunting the Double Helix* with the ‘successful selling’ features of books in the category ‘stories of scientific endeavours or events’ revealed in Chapter 4.

Table 5.2: ‘Successful Selling’ Features of *Hunting the Double Helix*

		Common Characteristics of Bestselling Books in Category ‘Stories of Scientific Endeavours or Events’	Characteristics of <i>Hunting the Double Helix</i>
Topic	Outside the mainstream?	Yes	Yes
Scientific Content	Jargon avoided?	Varies	Some jargon/equations
	Technical terms explained in context?	Yes	Yes
	Ideas not over-simplified?	Yes	Yes
	Metaphor, analogy and anthropomorphism?	Yes	Minor/non-existent
Story/Narrative	Story/Narrative?	Yes	Yes
People	People introduced?	Yes	Yes
Angle	Original angle?	Yes	Yes
Opening	Effective opening?	Yes	Yes
Tone	Conversational tone, passive voice avoided?	Yes	Yes
Readability	Readability level?	fairly difficult-difficult	standard
Fiction Techniques and Attractive Writing	Fiction techniques used?	Yes	Yes
	Passion, enthusiasm, flair, excitement?		
Author	Prominent author, scientist in the field or professional science writer?	Professional science writers	PhD student in science communication and part-time science writer, background in genetics
Media Attention	Significant media attention?	Varies	N/A - has not yet been released
Title	‘Intriguing’ title?	Yes	Different format to those in sample in Chapter 4

Table 5.2 indicates that the book also matches well with most of the characteristics of bestselling books in the category ‘Stories of Scientific Endeavours or Events’ identified in Chapter 4.

Topic: All five books in chapter 4 have topics that are outside those traditionally considered to be successful for popular science books, with an original angle. As discussed earlier in this chapter, *Hunting the Double Helix* has an original angle. Its topic (ancient DNA) can also be considered to be outside the mainstream for popular science books. Although genetics is one of the ‘core’ areas

considered to be successful (Bradford, 1994; Leane, n.d.b; Nixon, 1991; Tallack (Durrani, 1998)), the specific topic of the book, ancient DNA, is not. Therefore, the choice of topic for the book does follow the pattern of topics shown in the sample in Chapter 4.

Jargon avoided, technical terms explained in context: The books in Chapter 4 varied as to the amount of technical language they contained. All that did contain jargon/equations, however, explained technical terms in context, such as how a technique was used in particular experiments, how concepts relate to reader's lives and experiences, or when and by whom the concepts were discovered. *Hunting the Double Helix* contains some jargon/equations and, here too, a range of examples can be found where technical terms are explained in context. For example, the term 'ancient DNA' is introduced over an entire chapter, within the story of a conversation with an ancient DNA researcher (p. 1-7); the terms 'DNA bases' and 'DNA sequence' are introduced within the story of an experiment that is being conducted on Neanderthal DNA (p. 30); and the term 'contamination' is introduced within the story of the extraction of DNA from insects in amber, with use of an anecdote relating the phenomenon to the reader's own experiences:

Stray DNA can be found virtually anywhere in any environment where living things have been, which of course is nearly everywhere on Earth. DNA comes from anything and everything that is, or was once alive: living animals and the remains of dead ones, skin cells, hair, plant parts, bacteria, you name it. I can pretty much guarantee that you are sitting in an invisible sea of DNA at this very moment. Scratch your hand and release a few skin cells and you'll add to it. Pluck a hair from your head and let it fall on the floor – another drop in the DNA ocean....

The vast majority of the time, this stray DNA causes no problems whatsoever for those who encounter it, which is probably why you have never before realised that this load of DNA is floating around in the environment. In ancient DNA work, however, stray DNA can be a huge problem, as it causes a phenomenon known simply as contamination. (p. 78-79)

Ideas not over-simplified: Complex ideas were found in all the books in the sample in Chapter 4 which contained explanations/discussions of science, indicating that the ideas had not been over-simplified. Complex ideas can also be found in *Hunting the Double Helix*, indicating that the science has not been over-simplified in this book either. The three examples in the previous section also serve to demonstrate instances where complex ideas have been introduced, but written suitably for those without specialist knowledge. A further example is in an explanation of why younger people were more likely to die from the 1918 'flu':

Ironically, young people may have been particularly susceptible to this new strain of flu because their immune systems were likely to have produced a particularly strong response to it, during which, as Kolata aptly puts it, 'armies of white blood cells and fluids could rush to the lungs,' leading to the pneumonia that killed so many. Their

bodies may have struck back so fiercely at the unfamiliar invader that the resulting symptoms of the fight- such as fluid-filled lungs – led to their deaths. The very old and the very young may have mounted a weaker response, so that the symptoms they developed were less severe. (p.142)

Metaphor, analogy and anthropomorphism: All books in the sample in Chapter 4 made use of one or all of these techniques, but to differing extents. An examination of *Hunting the Double Helix* reveals that the book contains very few examples of these techniques - less than most books in the sample in Chapter 4. This suggests that better use of metaphor, analogy and anthropomorphism could have been made.

Story/narrative: Like all books in Chapter 4, *Hunting the Double Helix* has, as mentioned earlier, a strong narrative storyline, with the stories of the science endeavours as the central thread. Characteristics such as biographical detail, discussions of scientific ideas and events of science related to, but outside the main story are situated within the central story and are secondary to it.

People: Also like all books in Chapter 4, biography is a significant secondary feature of *Hunting the Double Helix*. Several individuals are focussed on equally, and their activities are told as they fit into the stories of the science endeavours.

Angle: As discussed earlier in this chapter, like the books in Chapter 4, *Hunting the Double Helix* has an original angle.

Opening: All books in the sample in Chapter 4 have openings that are very similar in their basic structure. They are conversational in tone, combining autobiography, history and an introduction to the story, and are often personal. The opening to *Hunting the Double Helix* has a similar basic structure. The book begins with my first encounter with the field of ancient DNA research, followed by a brief discussion of the basics of DNA and an introduction to the field of ancient DNA research. The introduction ends with a brief introduction to the stories to come.

Tone: The books in the sample in Chapter 4 have conversational tones, with use of the active voice. *Hunting the Double Helix* has a similar tone. Examples of the active voice are contained in the following extracts: “Kriings, Paabo and their colleagues also extracted DNA from Neanderthal bones found in a cave in Croatia” (p.33); “Siberian gold miner Anatoly Logachev literally hit, with his bulldozer, the remains of a baby mammoth” (p.56); “Owen presented the bone to the Zoological society of London” (p.93); “Salo, Aufderheide and their team went on to repeat the experiment with

a second pre-Columbian mummy” (p.132); and “Peter Gill flew from England to Charlottesville to collect the samples he needed” (p.166).

Readability: *Hunting the Double Helix* rates as 61, ‘standard’ by the Flesch readability formula, and is therefore classed as a ‘digest’ - above ‘quality’, ‘academic’ or ‘scientific’, but below ‘slick fiction’, ‘pulp fiction’ and ‘comics’. This is slightly higher on the readability scale than the books in Chapter 4, all of which rate as ‘fairly difficult’ or ‘difficult’. The border between ‘standard’ and ‘fairly difficult’ is, however, set at 60, meaning that the readability score of *Hunting the Double Helix* is very close to the bestsellers. A slightly longer average sentence length and/or slightly more syllables per 100 words would have rectified this.

Fiction techniques and attractive writing: Difficult to judge objectively in the writing of others, this is almost impossible to comment on in one’s own writing. However, it was mentioned in Chapter 4 that factors such as story/narrative, the introduction of people and a conversational tone could be considered to add to the production of writing that has passion, enthusiasm, flair and excitement, keeping the reader interested. As *Hunting the Double Helix* has these same features, it is hoped that the writing in this book, too, can be considered to have these qualities.

Author: The authors of most books in the sample in Chapter 4 are professional science writers. As the author of *Hunting the Double Helix*, I am a PhD student and part-time science writer – a similar profile. I also have a background in genetics.

Media attention: Books in the sample in Chapter 4 have had differing levels of media attention. As *Hunting the Double Helix* has not been released yet, this cannot be commented on for this book.

Title: Chapter 4 indicated that main titles should be short and descriptive, with longer sub-titles which allude to the story the book contains and to drama or intrigue. The title that was chosen for the new book: *Hunting the Double Helix: How DNA is solving the puzzles of the past* (chosen by the publisher) is slightly different from this structure. The main title is less directly descriptive and is longer, following instead a more ‘intriguing’ format, with the word ‘hunting’ alluding to drama or difficulty. Conversely, the sub-title is more descriptive than most of the sub-titles in the sample in Chapter 4, and does not allude to a story. It does, however, allude to drama or difficulty, with the words ‘solving the puzzle’. It is interesting to note that the word ‘ancient’ has been omitted from the title of the book, meaning that the subject matter, ancient DNA research, is not mentioned specifically, but is instead alluded to in the phrase ‘how DNA is solving puzzles of the past’. The main reason given for this decision was one of available space on the cover.

Conclusion

Hunting the Double Helix: How DNA is solving puzzles of the past is a new popular science book on ancient DNA research, written for this PhD project. This chapter has described the book and its production, with an analysis of the finished product as it relates to the research contained in Chapters 3 and 4 of this thesis.

The book was designed to exemplify the research contained in Chapter 3 – the characteristics of the category ‘Stories of Scientific Endeavours or Events’, and in Chapter 4 – ‘bestselling features’ of books in this category. The book fits well with the characteristics of the chosen category. Most of the ‘bestselling’ features are also reflected in the book. Better use, however, could have been made of metaphor, analogy and anthropomorphism, and the book’s readability score could have been slightly lower. The title (chosen by the publisher) also has a slightly different format. Overall, however, the analysis contained in this chapter indicates that the objectives of writing this book have been achieved.

It is certainly possible that a book like *Hunting the Double Helix* could have been written without knowledge of the theoretical background developed in this thesis. The same choice of topic, for example, would probably have been made as ancient DNA is very interesting and, as mentioned earlier, matches well with my own educational background, experience and interests. It is also likely that I would have written a similar type of book, as I had read a variety of others that tell stories of scientific endeavours, and favoured the idea of writing one of this type.

However, the theoretical background in this thesis did significantly aid in the writing of the book, in a variety of ways. First, the theoretical background added validity to ideas that I had already developed based simply on personal preference; for example, the choice of topic and the introduction of people into the story. Second, the theory gave a range of entirely new insights into content and structure that undoubtedly improved the book greatly. An example of this is the concept of avoiding jargon while at the same time not over-simplifying ideas, developed in Chapter 4. I was not fully aware of this idea before conducting the research, and the book is certainly better because this has been taken into consideration. Finally, although not a direct result of the research, the experience of reading the large set of popular science books necessary for the analysis in Chapter 3 allowed me to gain a wide exposure to a range of writing styles, which was of great benefit when writing my own book.

The principles applied here could certainly be applied to other categories of the popular science book genre. In a similar way to the method used for *Hunting the Double Helix*, potential authors of books in other categories could use the features of their chosen category, and an analysis of bestsellers in that category, to guide them in the production of their books. This approach could be useful for new books in any of the categories developed in Chapter 3.

The editors and publishers of my book were aware of the research I was conducting on popular science books, but as it was not in its finished written form during the time *Hunting the Double Helix* was being produced, they did not have the opportunity to read and comment on it. An interesting next step would be for a range of audiences, including the editors and publishers of my book, to read the book and comment on how well they believe it relates to the research contained in this thesis. It would also be of interest to discuss the research with other authors, publishers and editors, to determine their opinions on its potential use as a tool in the writing of other popular science books.

A copy of the text of the finished book is included as Volume Two of this thesis.

A Personal Reflection on the Project

I first discovered the genre of popular science books by a fortunate accident. One day, a number of years ago, I was browsing in my university bookstore, when I came across *A Monk and Two Peas*, by Robin Marantz Henig, a book about the life of ‘father of genetics’, Gregor Mendel. I found it captivating reading and, upon returning to the bookstore, I was delighted to discover that there was an entire, diverse genre of books like this one. Ever since, I have been a firm popular science book enthusiast.

I have been extremely lucky in this PhD project to have been able to combine three of my greatest interests: reading, writing, and science, and I am fortunate to have been a part of an academic department and to have worked with supervisors who supported such a project. Not only have I had legitimate reason to read almost 100 bestselling popular science books on a wide spectrum of science topics (although I still cannot claim a full understanding of quantum mechanics), but I have had the opportunity to spend quality time writing a popular science book of my own.

Writing *Hunting the Double Helix* has been an enormous challenge, but it has also been a very positive experience. Although one small difficulty I encountered was in making contact with key ancient DNA researchers with whom I would have liked to have spoken, others were more than helpful in answering questions, reading drafts of chapters, and providing constructive criticism.

When I began this project, the primary aim was, of course, for the book to form a significant part of my PhD project and, although the idea of trying to have the book published was something I hoped might be possible, having this actually become a reality has been an enormous bonus. The publishers who I approached to take on this project, Allen & Unwin, have been simply superb to work with, from Ian Bowring who first signed on the project, to Emma Cotter who provided advice at various stages while the book was being written and took care of the initial rounds of editing, to Angela Handley who took over the project when Emma left, and brought it to its finished state. The whole experience of working with each of these people has been overwhelmingly positive.

After several years of hard effort, the book (and the thesis), have finally come together, and I am very proud of both.

Chapter Six

Conclusion

As stated in the introduction to this thesis, the primary aims of this study were to overcome the barrier to research that is the diversity of the popular science book genre by defining and characterising the different categories that exist within it; to analyse the features of bestselling books in a specific category; and to exemplify the results of both avenues of research in the production of an 'artefact of science communication' – a new popular science book on ancient DNA. These aims have been achieved.

As mentioned in the introduction, the results of this research will be of benefit in both the commercial and academic arenas. In the commercial world, the classification scheme and the analysis of bestsellers will benefit those involved in producing popular science books, those involved in marketing and selling, and also readers. The results, however, have not yet been made available to these potential users, and to do so – through publication and other means – would be a useful next step.

In the academic world, the work will be of interest to researchers in science communication, and could be used in a variety of ways by this group. First, the research in Chapter 3 could be expanded. A wider sample of popular science books could be examined to see if any new sub-genres emerge. The classification scheme could also be tested by selecting additional books that are not part of the original sample and seeing how easily they can be fitted into the scheme. Additionally, it would be interesting for potential users such as book editors, retailers, and authors to test the scheme, to determine how easily it can be used by others. Future research could also involve the development of an algorithm for assigning books to specific categories. This process could be aided by the ranking of characteristics into a hierarchy of importance for each category.

The data set that has been developed in this analysis could be used in the future for a variety of different analyses. For example, a significant unsolved issue is that of the readership of popular science books. The sub-genres developed in this thesis could be used as a basis for research in this area, and a study which profiles the readership of each sub-genre would, I believe, be of particular interest.

Further work could also be carried out regarding the features of bestsellers. Analysis of the features of bestsellers in other categories would be useful, and a repetition of the research in Chapter 4 using a larger sample from the Stories of Scientific Endeavours or Events category would be of benefit.

Finally, a quantitative examination of the state of popular science book publishing as it stands today would be an interesting area for future research. This could include an analysis of whether particular sub-genres identified in this thesis are more successful than others.

Popular science books are a significant science communication medium, and it is my hope that this is just the beginning of a variety of research on this interesting genre.

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Appendix A

Popular Science Books List

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Appendix B

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