

From sequencing to annotating: extending the metaphor of the book of life from genetics to genomics

IINA HELLSTEN

The Royal Netherlands Academy of Arts and Sciences, Networked Research and Digital Information, Amsterdam, The Netherlands

ABSTRACT *The article discusses how the metaphor of the BOOK OF LIFE was extended over time to cover the life cycle of the Human Genome Project from genetics to genomics. In particular, the focus is on the role of extendable metaphors in the debate on the Human Genome Project in three European newspapers, popular scientific journals and scientific and scholarly articles from 1990 to 2002. In these different domains of use, various parts of the metaphor were highlighted. The metaphor of BOOK OF LIFE was mainly used to justify the continuation of the gene research from gene sequencing to comparative genomics. Readily extendable metaphors, such as the BOOK OF LIFE, function as useful communicative tools both over time and across domains of use.*

Introduction

The Human Genome Project has often been discussed in terms of opening up the BOOK OF LIFE¹, a book that will provide a key to curing many diseases. This great promise of genetics and genomics has been boosted by the continued use of a set of core metaphors, as well as through elaborations and variants of these metaphors. Metaphor is a cross-domain mapping between two conceptual domains, such as books and genes (Lakoff & Johnson, 1980), so that genes are conceptualised as books in certain respects. The metaphor GENOME IS A BOOK can, of course, be linguistically realised in many ways such as discussing the DNA nucleotides as the *alphabet of life* and genes as *chapters* in the chromosome. In the study by Nerlich & Hellsten (2004) these linguistic realisations mostly clustered around the expression 'book of life' (see Fig. 1). This metaphor of the BOOK OF LIFE is derived from our cultural appreciation of books as the basis of civilization and it builds upon our common understandings of language and text, reading and writing.

The metaphor of the BOOK OF LIFE is widely used and has been re-formulated over and over again in the mass media as well as by scientists, politicians, NGOs and lay people (see Nerlich *et al.*, 2002; Döring, this volume; Gogorosi, this volume). Different users may, however, use the metaphor in different ways. For

Correspondence to: Iina Hellsten, The Royal Netherlands Academy of Arts and Sciences, Networked Research and Digital Information, Joan Muyskenweg 25, 1090 HC Amsterdam, The Netherlands. Email: iina.hellsten@niwi.knaw.nl

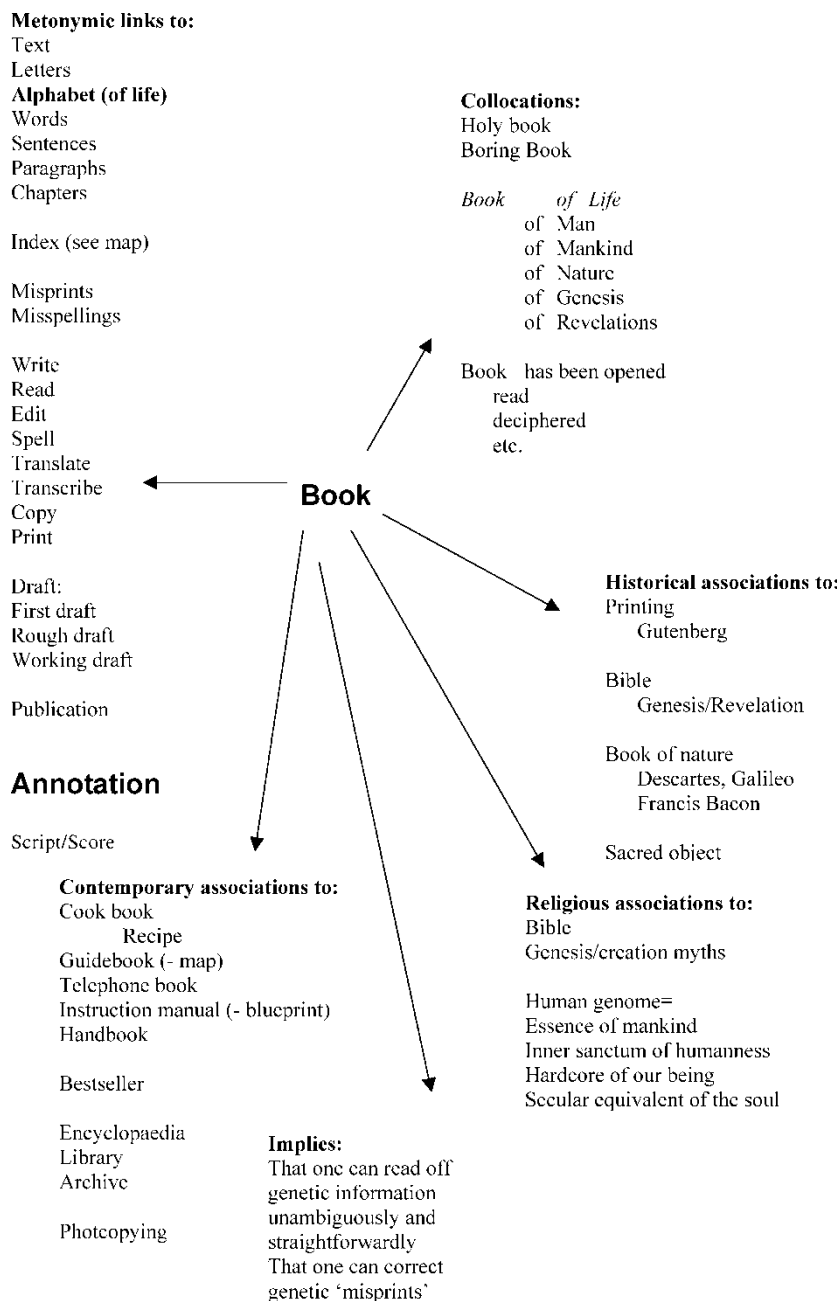


FIGURE 1. The BOOK OF LIFE.

example, different parts of the metaphor (e.g., *letters of life* vs. *annotating the book*) can be highlighted, depending on the purposes of the use. In this sense, metaphors, especially extended and extendable metaphors such as the BOOK OF LIFE metaphor, open up a 'common ground' (Maasen & Weingart, 1995; Maasen &

Weingart, 2000) for the participants engaged in a given debate; they function as communicative tools that can be modified to fit the purposes of the user. Metaphors are not only used to popularize otherwise abstract issues, such as genes, but also to open up one possible perspective on what genetics and genomics are about, and implicitly to suggest how people should approach gene research.

The meanings of metaphors differ across the various users of the metaphors, but the metaphors also change over time. Some metaphors become conventionalised in public debates while others never gain wide resonance. The metaphor of the BOOK OF LIFE dates back to antiquity and has a long history within the Judeo-Christian tradition where it refers to natural, eternal and universal texts (Kay, 2000, p. 31). It emerges in the Bible as God's record on those to be saved after the apocalypse. From the 17th century onwards, the metaphor of the *book of nature* ran in parallel with the metaphor of the BOOK OF LIFE. It was common in the history of the natural sciences, where science was perceived as an effort to *read and writethe book of nature*. For Galileo, the *book of nature* was written in the language of mathematics (Cohen, 1994).

According to Kay (1999, pp. 225–6) the metaphor of the BOOK OF LIFE gained its current scientific legitimacy in the debates on genetics when it was connected to the discourse of information: genes carry the information, *the instructions* for the formation of organisms. The connection between cellular systems and the alphabet first became popular in the 1960s when molecular biologists started using the metaphor to understand the working of DNA (Van Dijck, 1998, p. 123), as composed of the four nucleotides represented by their initial letters, adenine (A), thymine (T), cytosine (C) and guanine (G). A, T, C and G became *the alphabet of life*. In 2000, the (almost) completion of the sequencing of the genes that make up the human genome was metaphorised as the completion of the *first draft* of the human genome while two years later, in 2002, the emphasis has shifted to *annotating* the BOOK OF LIFE, i.e., from locating genes to understanding their functions.

In this article, I focus on the metaphor of the BOOK OF LIFE in the public debate on the Human Genome Project (HGP) in different domains of use and over time. The Human Genome Project was an international 'big science' project that gained wide attention in the mass media as well as in popular scientific, and scientific and scholarly journals (see Koski, this volume). Hence, the analysis focuses on mapping the uses of the metaphor in three domains of use: journalistic, popular scientific and scientific and scholarly texts. The journalistic discourse consists of articles published in the online editions of three European newspapers: *The Times* (UK), *NRC Handelsblad* (The Netherlands) and *Helsingin Sanomat* (Finland). The popular scientific discourse is represented in the texts published in *New Scientist* and news items and discussion pieces published in *Nature*. The scientific and scholarly discourses are analysed with the help of articles indexed in the *Science Citation Index* (SCI) and in the *Social Sciences Citation Index* (SSCI) between 1990 and 2002. The paper contributes to research into the dynamics of metaphors as strategic devices in science communication.

Metaphors in the communication of genomics

The Human Genome Project, the first 'big science' project in biology (Knorr Cetina, 1999) was initiated by the US Department of Energy, DoE, in the 1980s and internationally launched in 1990. The main funders were the National Institutes of Health, NIH and the DoE. It collaborated with the Wellcome Trust in the UK and is backed by France, Germany, Japan and China (Hilgartner, 1994). In June 2000, two competing projects, the publicly funded Human Genome Project and the private Celera Genomics corporation, made a joint public press briefing announcement that the *draft of the human genome* had almost been completed. The next culmination point in the public debate was the announcement, in 2001, that the human genome only contains approximately 30,000 genes instead of the expected 80,000–100,000 genes, only about twice as much as the mouse genome. In addition, over 200 of the human genes seemed not to result from vertical generation-to-generation transmission but horizontally from bacteria.

The announcement in 2000 that the first draft of the human genome had finally been deciphered was the culmination of what Van Dijck (1998) has called 'bio-phoria'. From 2001 onwards, this euphoria has been mitigated by more complex views on the functions of genes and the human genome. The focus has moved to discovering the functions of the genes in interaction with other genes as well as the interaction between the genes and their environment (functional genomics) and to comparisons between the genomes of different organisms (comparative genomics). We now have to ask how this new functional and comparative genomics is justified for the various expert and lay publics.

Genetics, in general, has been considered as an example of the change from science to techno-science (Haraway, 1997), where the distinction between science and technology has almost disappeared. In techno-science, research and technical development are intertwined in a complex actor network (Callon, 1986), involving not only scientists and technical staff but also funding agencies, industry, users, applicators, administrators, the media and the public as citizens and consumers (Michael, 1998). The techno-scientific nature of genetics has called into question not only the boundaries between scientific and technological development but also the boundaries between nature and culture. For example, the OncoMouse, a mouse that develops cancers due to genetic modification, is both natural and cultural and at the same time, neither solely natural nor cultural (Haraway, 1997).

The ethical issues surrounding the complex intertwining of the natural and the cultural, the technical and the scientific in modern biotechnology have led to a situation where sciences are also evaluated outside of the scientific community. Research and technical innovations have to be legitimised in the marketplace, in policy-making, in ethical debates and amongst the publics as citizens and as consumers (Välvirronen, 1993; Hellsten, 2003b). All these arenas of science evaluation have their own rules of conversation, and therefore, the problems have to be translated to fit the relevant contexts (Leydesdorff, 2001). Metaphors, as tools of communication, are useful in this process of translations.

In this complex communication process, the role of metaphors is important. Researchers working in fields outside of genomics as well as science journalists may easily pick up the metaphors used by geneticists but use these metaphors differently in new contexts. For scientists working in the life sciences, metaphors may be indispensable tools for popularising issues but also for promoting certain views over others and for legitimising specific scientific programmes. To justify and legitimise their scientific projects, scientists have to adjust to journalistic practices and make public appearances in the form of writing popular articles in newspapers, giving interviews for the mass media, and even organizing press conferences. In the mass media, metaphors are used as part of journalistic routines for the purposes of popularising, concretising and dramatising issues, in brief for making issues both newsworthy and interesting for the relevant audiences. The metaphor of the *BOOK OF LIFE* with its overall positive cultural implications is useful to justify and to legitimise scientific projects in public, as well as to popularise scientific activity for wider audiences. The metaphor resonates widely across the contexts of use, and can therefore be expected to be fruitful in the translation of science communication.

The mapping and sequencing of the human genome received wide attention in the mass media since the 1990s. In newspapers all over the world and in scientific and social scientific journals, for example, hundreds of articles have dealt with the project.² According to the *Google* advanced search engine, Faganfinder (<http://www.faganfinder.com/engines/google.shtml>), from January 1995 to December 2002 there were 5,350 pages where the metaphor of the *alphabet of life* was used and 115,000 pages where the metaphor of the *BOOK OF LIFE* was used on web pages that also use the term human genome. Substantially, these pages range from museum exhibitions, such as, 'The Secrets of Life—World of DNA/The Human Genome Demystified through an Exciting Interactive Exhibition', organized at the Israel National Museum of Science and Technology (<http://www.mustsee.org.il/hebrew/genom/eindex.html>) to pages discussing the origin of the bacterial genes in humans, often stating some kind of an alien aspect in humans (e.g., <http://www.karenlyster.com/genes.html>), to educational and university web pages (e.g., <http://www.techfak.uni-bielefeld.de/bcd/ForAll/Basics/welcome.html>).

For this analysis, I have selected articles that use the metaphor of *BOOK OF LIFE* within the debate on the human genome and from the change from genetics (the study on genes) to genomics (the study of genomes) and post-genomics (comparative and functional genomics). The data were gathered using the search term 'book of life' in order to keep the number of results low enough to enable qualitative analysis. The relatively small corpus of texts allows me to close-read all the texts and hence to conduct a systematic qualitative analysis of how the metaphors have been reformulated over time and across the different discourses, in particular in the communication between the mass media and the sciences. In the following, I will first take a look at the metaphors in the scientific and social scientific discourses as represented in the *Web of Science* (<http://isi4.newisiknowledge.com/portal.cgi/wos/>) database, then in the popular scientific discourses as

represented by two journals and lastly in the journalistic discourses, represented by three European online newspapers.

The book of life in the sciences and the social sciences

In the *SSCI* and the *SCI*, the metaphor of BOOK OF LIFE was used 12 and 20 times, respectively.³ The search covered only the titles, abstracts and keywords of the documents, allowed by the search machine, but the numbers are indicative of the use of these metaphors in scientific and scholarly articles. In both citation index databases, several occurrences of the metaphor can be found in book reviews (three in the *SSCI* and five in the *SCI*) of Lily Kay's seminal book, *Who Wrote the Book of Life?*, published in 2000. She has also published two articles on the same topic in the social scientific and one in the scientific journals indexed in the databases. Interestingly, three of these reviews are indexed in both citation indexes. In the *SCI*, there are several articles dealing with the publication of the 'first draft' of the human genome in 2000 (see Fig. 2).

In the *SCI*, the main tone of the items emphasizes the promises of genome sequencing and the new challenges brought about by functional genomics. The metaphors are also actively reformulated in the articles over time. In articles indexed in the *SCI*, the main metaphoric expressions are the 'human genetic code' and 'vital instruction manual' (Stephenson, 2000). Later on, this is reformulated as 'books in progress that need to be annotated' (Pennisi, 2000, p. 2304). Similarly, Streicher & Müller (2001), while discussing new 3D modelling techniques, note that, 'The current genome-sequencing projects provide 'word indices' of the BOOK OF LIFE. A central post-genomic question will be how these words are three-dimensionally deployed in the generation of organism form'. In brief, the change of focus from genes to genomes is represented as a mere continuation of the completing the BOOK OF LIFE by highlighting different parts of the metaphor.

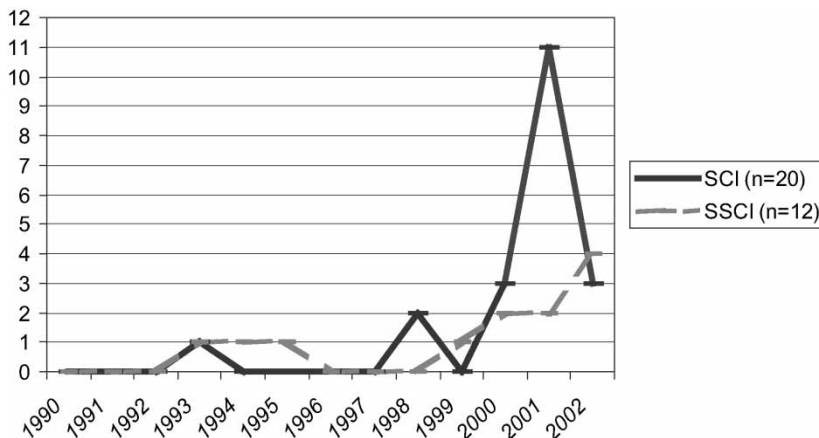


FIGURE 2. The BOOK OF LIFE in articles indexes in the *SCI* and *SSCI*, 1990–2002.

Another issue of particular interest in the scientific articles concerns the horizontal gene transfer from bacteria to the human genome and the interaction between the genomes of different species. 'The evolution of bacteria and animals appears to be like that of language: no mother tongue remains immune from corruption by useful foreign words' (Ponting, 2001). Bacterial genes in the human genome are here considered as 'corruption'. Searls (2002, pp. 211–17) discusses whether the analogy between linguistic metaphors and molecular biology could also be taken literally in the sense that methods developed for analyzing languages could also be applied to molecular biology. Here, the metaphor has become conventionalized to the extent that it is taken for granted and the language-gene analogy is not only used to inform, explain or illustrate advances in genetics but to argue for potentially new methods to be used in genetics.

In the scholarly articles indexed in the *SSCI* the first uses of the metaphor of the BOOK OF LIFE occur in the context of evolutionary history and palaeontology. The BOOK OF LIFE means here geological history and evolution. The articles that focus on genetics, often emphasize the possibly positive outcomes of the Human Genome Project. An article entitled, 'Blessings from the book of life' (Stipp, 2000), for example, highlights the project as helping to seek out 'the genetic bad actors behind our worst scourges, from arthritis to Alzheimer's, which in turn will lead to hundreds of new therapies' (*ibid.*). Here, the public are addressed as potential patients and consumers of the promised applications of the genome project which are themselves given a quasi-religious sanction. However, one of the first critical voices against the great promises of genome sequencing was published in 1994 by the science writer Kohn in the *New Statesman & Society* entitled, *The Boring Book of Life*. In the article, he criticizes the usefulness of sequencing of the nucleotides A, C, T, G that count for the 'language of genes' as not leading directly to treatments against diseases (Kohn, 1994, p. 40). Some of the articles in the *SSCI* reflect on the public uses of the metaphor. Nerlich *et al.* (2002), for example, discuss the positive connotations implied by the metaphor of the BOOK OF LIFE during the 2000 announcement.

In summary, the metaphor of the BOOK OF LIFE was re-formulated in the scientific and social scientific texts in two ways: First, the change from the process of sequencing the individual genes that constitute the human genome to *annotating* the BOOK OF LIFE shifts the focus from sequencing the nucleotides to the complex interactions between the genes in their cellular environment as well as the interaction between the genomes. Second, the analogue between the linguistic metaphors and molecular biology is extended to genomes as mother tongues that can become 'corrupted' and the methodological similarities between linguistics and genetics. The metaphor also became more conventionalized over time.

The book of life in science popularisation

The metaphor of the BOOK OF LIFE was most frequently in use in the articles indexed in the *SCI* and the *SSCI* in 2000–2002, and many of them were book reviews of Lily Kay's book. I expected that these metaphors would be more

widely and vividly in use in popular scientific and journalistic discourses. The popular scientific discourse is here constituted of the online editions of two widely read, international, online accessible, weekly science publications, the *New Scientist* and *Nature*. The *New Scientist* magazine (<http://archive.newscientist.com/>) specialises in science and technology and has, according to its own words, a circulation of over 680,000 readers all over the world. *Nature* (<http://www.nature.com>), in turn, is a high-quality science journal that also participates in the debates by publishing popular scientific texts under the sections news features, concepts, news and views and brief communications, for instance. The journal has a wide readership. According to its own statement it had over 800,000 registered online users in June 2002, and received over 2.8 million visitors to the site in November 2002.

These publications are expected to contribute to the popularization of the human genome mapping for wider, yet science-interested, readers. In the online archive of the *New Scientist* there were 19 items using the metaphor while in *Nature* there were seven items using the metaphor (Fig. 3).

The *New Scientist* used the metaphor widely in its news accounts and articles to popularize genes and the genome for wider audiences. The first feature articles appeared as early as 1990, emphasizing the great promises of 'reading from beginning to end virtually every one of the 3 billion genetic letters that make up the genome' (Lewin, 1990). The formulations of the metaphors have changed over time from 'DNA text' (Pollack, 1990) and the 'four-letter biological alphabet' (e.g., Beard, 1990) to 'genome as library' and 'chromosomes as books' (Anonymous, 1996). The metaphor is successfully expanded over time as ever new metaphorical expressions are added to the discussion. The scope of the metaphor has expanded from genes as DNA to genomes and chromosomes. In the *New Scientist*, the size of the human genome sequence is also vividly illustrated to emphasise the work that still has to be done in order to understand the function of the raw data:

The text would fill a thousand fat telephone directories. It is written in a cryptic alphabet of just four letters, in a barely understood language. It is

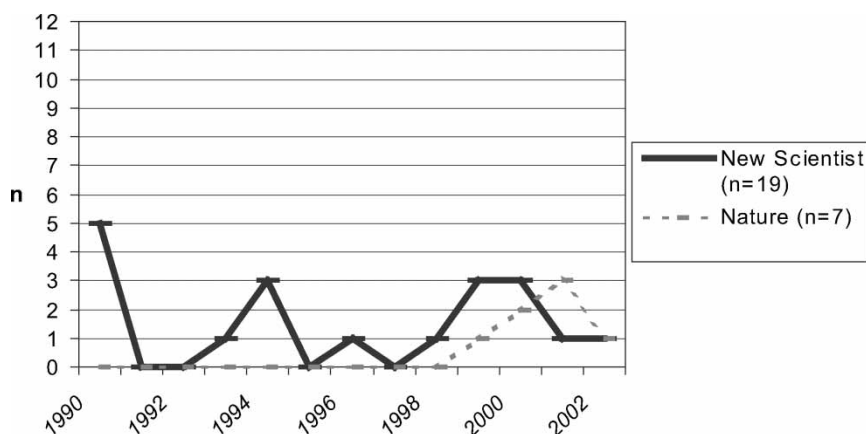


FIGURE 3. The BOOK OF LIFE in *New Scientist* and *Nature*, 1990–2002.

subtle, and self-referential and filled with allusions to other works, and it has kept an army of scholars working for years in hope of being able to read it through just once. (Voss, 1999)

The formulations of the metaphor have further changed from ‘chromosomes as chapters’ and ‘genes as sentences’ (Coghlan, 2000) to the ‘genomic alphabet’ (Furlow, 2001). The metaphor expands from gene sequencing to the complex interactions between the various genes and the interaction between the genes and their environment, i.e., genome annotating. The focus of the metaphor BOOK OF LIFE widens from sequences to manuals and instructions and from genomics, the study of genomes, to proteomics, the study of proteins and finally glycome, the study of glucose, sugar:

But there is another code out there to be deciphered—a more subtle, more complex alphabet that spells out the structures of massive molecules that subtly monitor and guide the day-to-day lives of the cells in our bodies. And surprising though it may seem, the letters of this alphabet are made of sugar. (Schmidt, 2002)

In *Nature* the metaphor of the BOOK OF LIFE was only used in the popular scientific sections such as news and views, review articles and science in context. The complete sequence of human chromosome 22 was covered in terms of ‘first chapter of the book of genes’ and the size of the human genome sequence as ‘the whole of the book will probably never be printed in its entirety—it would take about half-a-million pages of this journal to do so’ (Little, 1999). The change from genome sequencing to functional genomics is visible in *Nature* where Collins, the leader of the publicly funded genome project is quoted as saying:

The stage is set for a full scale exploration of the ways in which this disarmingly simple one-dimensional instruction book is converted into four dimensions of space and time that characterize living organisms. (quoted in Aldhous, 2001)

This critique of the early promises of the HGP is coupled with a call for new research focused on understanding the function of the genes, and the metaphor is used to justify the continuation of the project, and seems therefore an apt tool for building linkages between the past, the present and the future of the project. In this sense, metaphors may contribute to building and strengthening promises to be fulfilled in the future. The promises of the HGP are ‘sold’ to the publics as potential customers of the applications and to agencies funding the research.

In summary, the *New Scientist* elaborated the metaphor of the BOOK OF LIFE in a rich way to illustrate the Human Genome Project, while in *Nature* the metaphors were mainly used to justify the continuation of the project. In the next section I will turn to the journalistic uses of these metaphors.

The book of life in newspapers

The newspapers selected for the analysis cover three European countries with different views on biotechnology. In Finland the attitudes have been very positive while in the UK the attitudes, especially toward agricultural biotechnology, have been more critical. The Netherlands is somewhere in between these two, but closer to the UK (Gaskell *et al.*, 2001). The newspapers selected for the analysis are *Helsingin Sanomat*,⁴ (<http://www.helsinginsanomat.fi>) the biggest daily quality newspaper in Finland, with a circulation of about 1.1 million readers for the print version. In the UK, I selected for the analysis the online version of *The Times*, including the *The Sunday Times*, because the archive covers the years 1990–2002.⁵ The site has some 1.9 million unique users per month (<http://www.timesonline.co.uk>). In the Netherlands, the *NRC Handelsblad* (<http://www.nrc.nl>), a quality newspaper with an online edition was selected for the analysis. Its online archive was contacted via a newspaper archive service, LexisNexis.

In the newspapers, the metaphor of the book of life was most frequently used around the time of the announcement of the ‘first draft’ of the human genome in June 2000 (Fig. 4).

In *The Times* and *The Sunday Times*, the metaphor of the BOOK OF LIFE was used in 15 items. The uses of the metaphor changed from ‘genes as the chapters in the chromosome’, ‘the genome as a biological encyclopaedia’ and the ‘paper and print of each volume consisting of deoxyribonucleic acid’ (Hurrell, 1992) to ‘three billion chemical “letters” of the human genome’ (Hodgkinson, 1993) to ‘genes as individual portions of the single, three-billion letter sentence that makes up the book of life’ (Ahuja, 2000, 2001) further to mouse genome as ‘a crucial phrasebook for translating knowledge of the human genome’ (Henderson, 2002). Here, the metaphor is flexibly extended from genetics to comparative genomics as a way towards understanding how certain genes function as parts of different genomes, such as the human and the mouse genome.

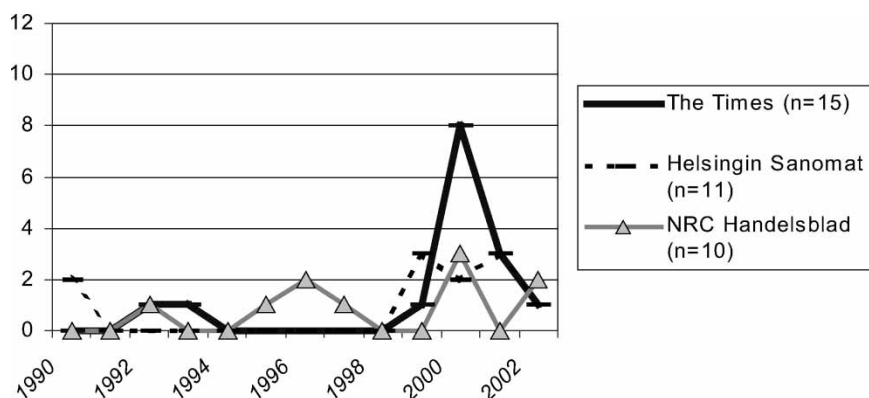


FIGURE 4. The BOOK OF LIFE in the newspapers, 1990–2002.

In *Helsingin Sanomat*, the metaphors are first in use during the launch of the Human Genome Project in the beginning of the 1990s and again in 2000–2002, i.e., the metaphor was applied at ‘strategic’ moments of the project. The formulations of the metaphor change from ‘genes as words in an encyclopaedia’ (Ropponen, 1990) to ‘nucleotides as the alphabet of the genetic language’ (Tigerstedt, 1999) and further to comparing the human genome sequence to a ‘200 parts book series’ or a ‘telephone directory’ (Paukku, 2000). Later on the metaphor is extended to fit into the post-genomic situation:

We have called the human genome the book of life, but actually it consists of three books: the book of history, the instruction manual and the catalogue of parts. (Anonymous, 2001)

The metaphor is flexible enough to allow for extensions. At the same time, the medical promises of the Human Genome Project seem to escape ever farther into the future.

In the *NRC Handelsblad* there were eight articles using the metaphor. The first, in 1992, deals with the first sequence of a complete chromosome, that of the chromosome III of yeast. The nucleotide basepairs are metaphorised as the *four letters of the DNA alphabet* (Eijgenraam, 1992). Similarly, the second article deals with the completion of the whole genome of the bacterium *Haemophilus influenzae* and emphasises how the order of the DNA letters defines the proteins and therefore the characteristics of the organism (Heselmans, 1995). This simple view of genes directly coding for certain proteins has later been redefined. This change is also visible in the formulations of the metaphors as ‘genes as chemical words that together form the instruction book for an organism’ and ‘a telephone directory’ (Pols, 1997) to ‘the book of life that is written in the language of DNA’ (van den Berg, 2000). In the Dutch newspaper, the change from gene sequencing to functional genomics does not show up in the use of the metaphors. This may have to do with the different languages used.

In summary, in the newspapers, selected parts of the metaphor are used to highlight the amount of work needed to completely decipher the human genome and the great promises that the complete sequence would bring to publics as consumers and tax-payers. At the same time, the novel formulations of the metaphor link functional genomics to the earlier phases of the Human Genome Project. Again, the new extensions of the metaphor justify the continuation (of the funding) of the project.

Conclusions

The metaphor of the BOOK OF LIFE was strategically used to celebrate the launch of the Human Genome Project, to celebrate the results of the project and to call for further research into the functions of genes. In all three domains of use studied here (sciences and social sciences, popular scientific journals and journalistic accounts) the metaphor was mainly in use at the beginning of the Human Genome Project, between 1990 and 1992, when trying to illustrate the aims of

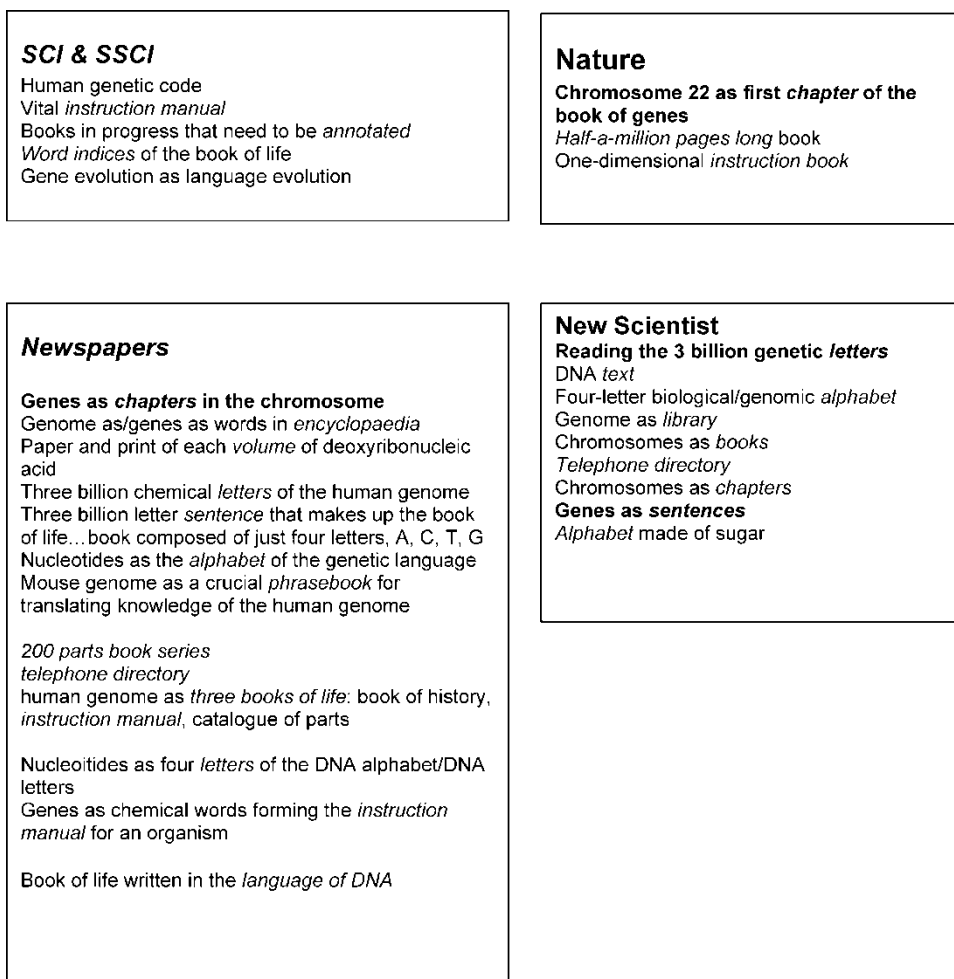


FIGURE 5. The BOOK OF LIFE in the different domains of use.

the project, then again during the announcement of the first draft of the human genome in 2000 and again in the context of the emergence of functional genomics in 2001. More importantly, it was not widely used in 2001 in the context of the announcement that the human genome had only 30,000 genes instead of the anticipated 100,000. This was a time when celebration was for a while interrupted by reflections on scientific, philosophical, ethical, and religious questions associated with the Human Genome Project and by a renewed questioning of old metaphors for the human genome such as the *map*, *book* or *blueprint* metaphors (Nerlich & Hellsten, 2004). Despite this, the single metaphor of the BOOK OF LIFE was flexible enough to be extended from genetics to genomics and further to functional genomics. The positive associations attached to the skills of reading and writing were effectively used for carrying over associations from the past to provide expectations and visions of the future.

Also, different parts of the metaphor of the BOOK OF LIFE were emphasised across the domains of use (see Fig. 5). The newspapers used the metaphor in a vivid and systematic way to discuss the Human Genome Project, widening the metaphorical image from chemical letters of the human genes to the mouse genome as a phrasebook for the human genome. In the citation indexes and in *Nature* the metaphor was used less frequently and in a more conventional way. In *New Scientist*, in turn, the metaphor was used in a systematic way to discuss the various phases of the Human Genome Project, and the metaphorical image was extended from DNA-text to the genome as a library, for example. Some formulations of the metaphor of the BOOK OF LIFE, such as illustrating the size of the gene sequence as a telephone directory or an instruction manual, or discussing the nucleotides as letters of life, were used in all the domains.

It seems that certain metaphors, such as the BOOK OF LIFE with its many associations and wide resonance, are readily extended in the debate over time. The extensions were mainly based on highlighting new parts of the metaphors in use. All in all, the metaphor of the BOOK OF LIFE has had wide resonance, first over time (the book of life from the Bible to modern sciences and to the genome; from gene sequencing to annotating, and from lexical to semantic structures), second across topics (modern biotechnology, genetics, genomics and biodiversity (e.g., Väliaverronen & Hellsten, 2002)) and thirdly across the different discourses (scientific and scholarly, popular scientific and journalistic). Metaphors that have both a long history of use and that are flexible enough to allow for new formulations may be taken as tools of communication more readily than new metaphors that do not provide such resonance. The change in the metaphors is a slow and gradual process. The metaphors of *Frankenfood* (e.g., Hellsten, 2003a) and the BOOK OF LIFE, for example, carry familiar cultural images (the Frankenstein myth and the biblical myth) that gain resonance when reformulated to fit into a new context (GM foods and genetics/genomics, respectively).

In the context of the mapping of the human genome, metaphors such as the BOOK OF LIFE have been used as strategic communicative tools to legitimate a scientific project, and they have been reformulated to justify new phase of the project. This re-formulation of the metaphor shows that the great promise of a healthier future is still quite far away, but it nevertheless, serves as a justification for the continuation of the genome project: The view promoted metaphorically and otherwise is that the directory of genome sequences would remain useless unless an annotation of the book, i.e., research into the interaction between the genes and the genomes, is funded. In this sense, the metaphor mainly drives the interests of the scientists. There is a constant need for further research on whose point of view certain metaphors promote and what the mechanisms are that make some metaphors more successful than others.

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Notes

1. Metaphorical expressions are indicated in *italics*, and conceptual metaphors in CAPITALS all through the article. Conceptual metaphor serves as a general grouping of various metaphorical expressions (Lakoff & Johnson, 1980).
2. In *The Times* and *The Sunday Times*, for instance, there were 221 items on Human Genome Project in 1990–2002, in the Sciences Citation Index (SCI) more than 1088 items and in the Social Sciences Citation Index more 236 items on the topic. Hence, the metaphors of the BOOK OF LIFE or the *alphabet of life* comprise roughly five percent of the items on the Human Genome Project.
3. The data was collected using the search term 'book of life'. This resulted in 26 hits in the SCI of which four were discarded because they deal with geriatric, geology and cosmology. In the SSCI the search terms resulted in 18 hits of which four were removed because they dealt with anthropology, parapsychology and geriatrics.
4. The data were collected from the online versions of the newspapers with the search terms 'book of life' and 'alphabet of life' together with genome, and their respective translations in Finnish 'elämän kirja', 'elämän aakkoset' and 'geenikirja' and in Dutch 'alfabet' 'boek' and genoom 'boek van het leven' and 'alfabet van het leven' together with genoom.
5. The online archive of the Guardian, for example, only covers articles published after 1 September 1998.

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