

Notes for Volume Two

PART II. THE UNIFIED RELATIONSHIPS THEORY

Motto: (p. 471) Fromm, *To Have or To Be?* p. 148, cited at Schumacher, *Small is Beautiful*, p. 80, from Darwin's Autobiography.

1. (p. 472) Watson, *DNA: The Secret of Life*.
2. Extended quote given in Schumacher, *Small is Beautiful*, p. 80, shortened in Erich Fromm, in *To Have or To Be?*, p. 148.
3. (p. 472) Fromm, *To Have or To Be?*, p. 148.
4. (p. 472) Schumacher, *Small is Beautiful*, p. 79.
5. (p. 473) Bohm, *Wholeness and the Implicate Order*, pp. 3-4.
6. (p. 473) Schumacher, *Small is Beautiful*, pp. 79-80.
7. (p. 473) Osho, *Book of Secrets*, p. 141.
8. (p. 475) Maturana and Varela, *Autopoiesis and Cognition*, p. 78.
9. (p. 475) Capra, *Web of Life*, pp. 97-98.
10. (p. 475) Bergson, *Creative Evolution*.
11. (p. 476) Capra, *Tao of Physics*, p. 338.
12. (p. 476) *Ibid.*, pp. 338-339.
13. (p. 476) Russell, *History of Western Philosophy*, p. 13.
14. (p. 477) Koestler, *Ghost in the Machine*, p. 3. Proverbs 9:1 says, "Wisdom hath builded her house, She hath hewn out her seven pillars," but the Bible does not name them. For Koestler,

the citadel of orthodoxy which the sciences of life have built in the first half of our century rests on a number of impressive pillars [of unwisdom], some of which are beginning to show cracks and to reveal themselves as monumental superstitions. The four principal ones, summarized in a simplified form, are the doctrines:

- (a) that biological evolution is the result of random mutations preserved by natural selection;
- (b) that mental evolution is the result of random tries preserved by 'reinforcements' (rewards);
- (c) that all organisms, including man, are essentially passive automata controlled by the environment, whose sole purpose in life is the reduction of tensions by adaptive responses;
- (d) that the only scientific method worth that name is quantitative measurement; and, consequently, that complex phenomena must be reduced to simple elements accessible to such treatment, without

undue worry whether the specific characteristics of a complex phenomenon, for instance man, may be lost in the process.

CHAPTER 5. AN INTEGRAL SCIENCE OF CAUSALITY

Motto: (p. 483) Shortened translation of *Nam et ipsa scientia potestas est* ‘Knowledge itself is power’ from *Meditationes Sacrae* ‘Religious Meditation’s ‘De Hæresibus’ (Of Heresies), 1597.

1. (p. 484) Greene, *Elegant Universe*, p. ix.
2. (p. 485) My top priority at this first meeting in November 1980 was to find a concept that would unify the concept of data energy that I had ‘discovered’ with the material energies recognized by the physicists. So I asked David Bohm, “What is the source of data energy?” He replied, “Energy does not have a source; energy derives from *structure*.” This answer was so obvious that I wondered why I had not thought of it myself. However, as I now know, the Ultimate Source of energy is Life arising directly from the Immortal Ground of Being.
3. (p. 485) Hague, Paul, *The Thoughtful Society*, p. 29, spring 1983, unpublished.
4. (p. 487) Baleskar, *Consciousness Speaks*, p. 221.
5. (p. 488) Bell, ‘Information Society’, p. 168. In *The Coming of Post-Industrial Society*, Bell predicted a vastly different world—one that would rely upon an economics of information, as opposed to the economics of goods that had existed up to then. Bell argued that the new society would not displace the old one but rather overlay it in profound ways, much as industrialization continues to coexist with the agrarian sectors of our society. In Bell’s prescient vision, the post-industrial society would include the birth and growth of a knowledge class, a change from goods to services, and changes in the role of women. All of these would be based upon an increasing dependence on science as a means of innovation; as a means of technical and social change (from publisher’s blurb).
6. (p. 489) From the movie *The Hitchhiker’s Guide to the Galaxy*, a shortening of chapter 25 in Adams, *Hitchhiker’s Guide*, pp. 125–131.
7. (p. 489) Adams, *Hitchhiker’s Guide*, pp. 135–136.
8. (p. 489) *What is Enlightenment?* Issue 19, Spring/Summer 2001, pp. 112–114. The published replies were from Wayne Liqorman, Satyam Nadeen, and Tony Parsons.
9. (p. 489) <http://www.acadun.com/en/Academy/articles/importantspirituelquestions.doc/>.
10. (p. 490) **Moved Herschel and Milky Way Galaxy to ‘Prospects for Humanity’.**
11. (p. 492) Propp, *Morphology of Folktale*. Propp (1895–1970) was a leading member of Russian formalism movement, an influential school of literary criticism in Russia from the 1910s to the 1930s. In Morphology he analysed Russian folktales into a sequence of thirty-one functions beginning with ‘abstention’ and ending with ‘wedding’. These roughly correspond

to seventeen steps of the classical spiritual journey in myths and fairy tales, identified by Joseph Campbell in *The Hero with a Thousand Faces*. For a summary of Propp's morphology, see http://en.wikipedia.org/wiki/Vladimir_Propp.

12. (p. 492) The Great Vowel Shift from 1450 to 1750 was first studied by Otto Jespersen (1860–1943), a Danish linguist and Anglicist, who coined the term. In Middle English, long vowels had 'continental' values much like those remaining in Italian and liturgical Latin. However, during the Great Vowel Shift, the two highest long vowels became diphthongs, and the other five underwent an increase in tongue height with one of them coming to the front. Because English spelling was becoming standardized in the 15th and 16th centuries, the Great Vowel Shift is responsible for many of the peculiarities of English spelling. http://en.wikipedia.org/wiki/Great_Vowel_Shift.

13. (p. 492) OED and AHDEL.

14. (p. 493) http://en.wikipedia.org/wiki/Gestalt_psychology.

15. (p. 493) Aurobindo, *Life Divine*, p. 141.

16. (p. 493) **Gestalt psychology**, *Encyclopædia Britannica*, 2008.

17. (p. 493) **Gestalt therapy**, *Encyclopædia Britannica*, 2008.

18. (p. 493) http://en.wikipedia.org/wiki/Gestalt_therapy.

19. (p. 493) Perls, et al, *Gestalt Therapy*, pp. v–vi.

20. (p. 495) http://en.wikipedia.org/wiki/George_Bradshaw.

21. (p. 496) http://en.wikipedia.org/wiki/Traffic_light_control_and_coordination.

22. (p. 497) Morris, *Manwatching*, pp. 24–35.

23. (p. 498) Sissela Bok's parents were both Nobel Laureates, Gunnar Myrdal for Economics with Friedrich Hayek in 1974 and Alva Myrdal for Peace in 1982. So apart from the two daughters of Marie and Pierre Curie, she and her two siblings have been the only children of such distinguished parents. See relevant pages in Wikipedia.

24. (p. 498) Bok, *Lying*, pp. xv–xvi.

25. (p. 498) If I remember correctly, this statement was in the frontispiece of one of my statistics textbooks at university in the early 1960s. However, Wikipedia tells us that this saying cannot be found in Disraeli's writings.

26. (p. 499) Bok, *Secrets*, p. xv.

27. (p. 499) Underhill, *Practical Mysticism*, p. 3 (referenced at http://en.wikipedia.org/wiki/Christian_mysticism). The full quote is: "Mysticism is the art of union with Reality. The mystic is a person who has attained that union in greater or less degree; or who aims at and believes in such attainment."

28. (p. 499) **Pythagoreanism**, *Encyclopædia Britannica*.

29. (p. 499) **Eleusian Mysteries**, *Encyclopædia Britannica*.

30. (p. 500) This phrase was much used in IBM in the late 1970s as we followed the marketing slogan, “Manage data as a corporate resource.” However, there doesn’t seem to be any evidence that Disraeli actually said this. A search of the Web on 27th January 2010, returned just five sites quoting this maxim, including a British government ministry: the Department of Agriculture and Rural Development.

31. (p. 500) http://nobelprize.org/nobel_prizes/economics/laureates/1996/.

32. (p. 501) Stonier, *Wealth of Information*, pp. 18–19.

33. (p. 501) Alexander, *Gaia*, p. 14.

34. (p. 502) [http://en.wikipedia.org/wiki/Advertising and List_of_countries_by_GDP_\(nominal\)](http://en.wikipedia.org/wiki/Advertising_and_List_of_countries_by_GDP_(nominal)).

35. (p. 503) Koestler, *Act of Creation*, pp. 32–33.

36. (p. 503) Ibid., p. 35.

37. (p. 505) Aristotle, *Metaphysics*, 1012b, 34–1013a, 24, pp. 209–210.

38. (p. 506) Aristotle, *Physics*, 193b, 22–194a, 32, pp. 36–38.

39. (p. 506) Ibid., 194b, 23–194b, 36. p. 39.

40. (p. 506) Ibid., 195a16–19, p. 40.

41. (p. 506) Bohm, *Wholeness*, p. 12.

42. (p. 506) Ibid., pp. 12–13.

43. (p. 507) Aristotle, *Physics*, 195b, 31–198a, 13, pp. 42–48.

44. (p. 507) <http://www.scimednet.org/mysticsandscientists.htm>.

45. (p. 508) Conference Cassettes, ‘The Nature of Energy’, MS48.

46. (p. 509) Sheldrake, *New Science of Life*, p. 71.

47. (p. 509) Keen and Scott Morton, *Decision Support Systems*.

48. (p. 509) http://en.wikipedia.org/wiki/History_of_entropy.

49. (p. 509) In a letter of 26th January 1993 I received in reply to a letter of mine asking for the confusion around the root meaning of *entropy* to cleared up.

50. (p. 510) This meaning does not seem to be explicitly defined in The Holotropic Mind. However, Stan Grof confirmed this meaning when I have a ninety-second conversation with him in 1992 at a conference in Prague organized by the International Transpersonal Association called ‘Science, Spirituality, and the Global Crisis’.

51. (p. 510) http://en.wikipedia.org/wiki/Second_law_of_thermodynamics.

52. (p. 510) It seems that William Thomson, later Lord Kelvin, was the first to propose this hypothesis in the 1850s (http://en.wikipedia.org/wiki/Heat_death_of_the_universe). It is thus appropriate that the absolute temperature scale should be measured in kelvins, one of seven SI base units. A temperature of 0° K is -273.15° C, marking the theoretical absence of all thermal energy.

53. (p. 510) Hill & Thornley, *Principia Discordia*, quoted in http://en.wikipedia.org/wiki/Second_law_of_thermodynamics.
54. (p. 510) http://en.wikipedia.org/wiki/Origin_of_species.
55. (p. 510) http://en.wikipedia.org/wiki/Survival_of_the_fittest.
56. (p. 511) Darwin, *Origin of Species*, p. 73.
57. (p. 511) von Bertalanffy, *General System Theory*, p. 12.
58. (p. 512) Ibid., p. 15.
59. (p. 512) Weiner, *Cybernetics*, p. II.
60. (p. 512) Shannon, 'Mathematical Theory of Communication', The Bell System Technical Journal, Vol. 27, pp. 379–423, 623–656, July, October, 1948, available at <http://plan9.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf>.
61. (p. 512) Ross Ashby, *Cybernetics*, pp. 177–178.
62. (p. 512) Ibid., p. 177.
63. (p. 512) Conversation between Claude Shannon and John von Neumann in 1949 recorded in <http://en.wikipedia.org/wiki/Entropy>.
64. (p. 512) Weiner, *Cybernetics*, p.132.
65. (p. 513) Prigogine and Stengers, *Order out of Chaos*, p. 12.
66. (p. 513) Reproduced in Maturana and Varela, *Autopoiesis and Cognition*, pp. 59–123.
67. (p. 513) Ibid., Editorial preface, p. v.
68. (p. 513) Ibid., pp. 78-79.
69. (p. 513) Tarnas, *Passion of the Western Mind*, p. 45.
70. (p. 513) Capra, *Web of Life*, p. 97, quoting Maturana and Varela, *Autopoiesis and Cognition*, p. 75.
71. (p. 513) Ibid., pp. 97–98.
72. (p. 513) Gleik, *Chaos*.
73. (p. 513) Waldorp, *Complexity*.
74. (p. 514) Bergson, *Creative Evolution*, p. 87.
75. (p. 514) Teilhard, *Human Phenomenon*, p. 30.
76. (p. 514) Kapp, *Science versus Materialism*, p. 221.
77. (p. 514) Ibid., p. 179.
78. (p. 514) Ibid., p. 6.
79. (p. 514) Ibid., p. 57.
80. (p. 514) <http://www.reginaldkapp.org/>.
81. (p. 514) <http://www.scimednet.org/>.
82. (p. 515) Watson, *Double Helix* tells the story of the discovery of the structure of DNA.
83. (p. 515) <http://en.wikipedia.org/wiki/Dna>.
84. (p. 515) Watson, *DNA*, p. 55.

85. (p. 515) Watson, *Double Helix*, p. 222.
86. (p. 515) Watson, *DNA*, p. 53.
87. (p. 515) Ibid.
88. (p. 515) Ibid., p. 73.
89. (p. 515) Ibid., pp. 74–75.
90. (p. 515) Ibid., p. 75.
91. (p. 515) Ibid., p. 85.
92. (p. 516) Ibid., p. 20.
93. (p. 516) <http://en.wikipedia.org/wiki/Eugenics>.
94. (p. 516) Watson, *DNA*, p. 20.
95. '(p. 516) James Watson wants to build a better human', <http://www.alternet.org/story/16026/>.
96. (p. 516) McKie and Harris, Observer, 'Disgrace: How a giant of science was brought low', <http://education.guardian.co.uk/higher/research/story/0,,2196657,00.html>.
97. (p. 517) Dawkins, *Selfish Gene*, p. 28.
98. (p. 517) Ibid., pp. 15–20.
99. (p. 517) Ibid., p. 192.
100. (p. 517) Ibid.
101. (p. 517) Sheldrake, *New Science of Life*, p. 71.
102. (p. 517) Ibid., p. 67.
103. (p. 517) Dawkins, *Blind Watchmaker*, p. 15.
104. (p. 518) I don't know which edition this was. The article was in an edition of *Encyclopedia Britannica* that I read in the early 1980s in either my parents' rather dated edition or one of the south London libraries that I was using at the time. But they may not have had the most up-to-date edition available at the time.
105. (p. 518) Roszak, *Cult of Information*, pp. 21–33.
106. (p. 518) Ibid., p. 15.
107. (p. 518) Ross Ashby, *Cybernetics*, p. 126.
108. (p. 518) <http://www.ccrnp.ncifcrf.gov/~toms/paper/primer/>.
109. (p. 518) Ibid.
110. (p. 518) Jones, *Elementary Information Theory*, p. 13.
111. (p. 518) <http://www.ccrnp.ncifcrf.gov/~toms/paper/primer/> and http://en.wikipedia.org/wiki/Myron_Tribus
112. (p. 519) Shannon, 'Theory of Communication', p. 12.
113. (p. 519) Ross Ashby, *Cybernetics*, p. 176.
114. (p. 519) Ibid., p. 175.
115. (p. 519) Ibid., p. 122.

CHAPTER 6. A HOLISTIC THEORY OF EVOLUTION

Motto: (p. 521) Teilhard, *Phenomenon of Man*, Foreword, p. 21.

1. (p. 521) http://en.wikipedia.org/wiki/On_the_Origin_of_Species.

2. Editors of WIE, ‘The Real Evolution Debate’, *What Is Enlightenment?*, Issue 35, January–March 2007, p. 88.

3. Ibid., p. 100.

4. (p. 522) **Smuts, Jan (Christian)**, *Encyclopædia Britannica*, 2008.

5. (p. 522) <http://en.wikipedia.org/wiki/Smuts>. Einstein also said of Smuts that he was ‘one of only eleven men in the world’ who conceptually understood his Theory of Relativity.

6. (p. 522) Smuts, *Holism*, p. v.

7. (p. 522) Ibid., p. 99.

8. (p. 523) <http://en.wikipedia.org/wiki/Smuts>.

9. (p. 524) The word *hologenesis* led me to discover Teilhard’s *The Phenomenon of Man* in 1980. I was searching for a generic term for *morphogenesis*, *ontogenesis*, and *phylogenesis*, emphasizing that their common characteristic is the evolution of wholes that are greater than the sum of their preceding wholes. So I naturally coined *hologenesis* and rushed round to my local library to consult the Oxford English Dictionary to see if had been coined before. Indeed it had. As the second edition of the OED records, *hologenesis* is “The name of a theory of evolution first propounded by D. Rosa (in *Ologenesi* (1918)), and later adopted by G. Montandon (in *L’Ologènèse humaine* (1928)) to account for the origin of human races.” The OED also provided a citation from Teilhard’s book.

10. (p. 524) Wilber, *Up From Eden*.

11. (p. 524) Anne Baring, ‘The Great Work: Healing the Wasteland’, *Mystics and Scientists* 28, ‘Healing the Spilt: An Alchemy of Transformation’ (Moreton-in-Marsh, Gloucestershire: Conference Cassettes, 2005), CD.

12. (p. 524) Arnold J. Toynbee, abridge. D. C. Somervell, *A Study of History* (Oxford: Oxford University Press, 1946).

13. The name *Linnaeus* is a Latinized form of the Swedish word for the linden tree: *lind* (genus *Tilia*), sometimes confusingly called the lime tree in English, for lime is a fruit of various trees in the *Citrus* genus. Until around this time, people’s surnames in Sweden were generally patronymic, like *Andersson*. (Some people, mostly women, also have surnames like *Andersdotter* or even *Annasdotter*, a *matronymic*, from www.ratsit.se.) But some people, like the clergy, thought that such names were beneath them. So they adopted other surnames, such as the village or farmstead where they lived, or based on nature, like *Hallenberg* ‘raspberry hill’ or *Blomkvist* ‘flowery twig’. For instance, two brothers of Linnaeus’ paternal grandmother took the name *Tiliander* when they, the sons of a farmer, studied to become

clergymen, after the Latin name for the linden tree (www.linnaeus.uu.se/online/life/3_0.html). Linnaeus's father followed his uncles' example, but used Swedish as the basis for his name. When Linnaeus was ennobled in the untitled nobility, he took the name Carl von Linné.

14. The full title was *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis* 'System of nature through the three kingdoms of nature, according to classes, orders, genera and species, with characters, differences, synonyms, places' (en.wikipedia.org/wiki/Systema_Naturae).

15. **zoology**. *Encyclopædia Britannica*, 2008.

16. www.linnaeus.uu.se/online/animal/2_1.html.

17. De Candolle, *Théorie élémentaire de la botanique*, OED.

18. **fungus**. *Encyclopædia Britannica*, 2008.

19. [en.wikipedia.org/wiki/Kingdom_\(biology\)](http://en.wikipedia.org/wiki/Kingdom_(biology)).

20. en.wikipedia.org/wiki/Three-domain_system.

21. Virus article at en.wikipedia.org/wiki/Virus.

22. It is far from clear how many different species can be identified. Michael Rosenzweig has said, "Right now we can only guess that the correct answer for the total number of species worldwide lies between 2 and 100 million." (www.sciencedaily.com/releases/2003/05/030526103731.htm).

23. The power of hierarchies in evolutionary processes is well illustrated by Koestler's parable of two watchmakers called Bios and Mekhos, developing an original idea of H. A. Simon. Their watches consisted of 1,000 parts, the one that Mekhos assembled having no hierarchical order; his watches were built rather like a mosaic floor of small coloured stones. On the other hand, Bios constructed his watches with ten subsystems, each consisting of ten subassemblies of ten components. So when he needed to pause in his work, what he had done so far did not disintegrate into its elementary parts. Each level of construction was able to exist as a whole. *Ghost in the Machine*, pp. 45–47.

24. Phylogeny, OED.

25. en.wikipedia.org/wiki/Recapitulation_theory.

26. en.wikipedia.org/wiki/World_population.

27. en.wikipedia.org/wiki/Directed_Acyclic_Graph. If 7 is a man in this example, then 5 and 3 would be women. At the next generation, 11 and 8 would then be a woman and man, respectively. In this DAG, 11 has a child 9 with 8 and another child 10 with 8's mother. This would not normally happen in human society. So we would need to place further constraints on DAGs to represent this situation.

28. Such a dataflow language is used in Front Arena to customize the product, which is designed to handle trades in financial products by investment banks. I worked on the Arena

Dataflow Language (ADFL) when working as a computer consultant for Front Capital Systems in 2002 and 2004. See also Scott, *Programming Language Pragmatics*, p. 6.

29. Dawkins, *Ancestor's Tale*, p. 7.

30. Miller & Wood, *Anthropology*, pp. 73–75.

31. OED.

32. en.wikipedia.org/wiki/Mammal.

33. en.wikipedia.org/wiki/Convergent_evolution.

34. Miller & Wood, *Anthropology*, p. 81.

35. **Mendel, Gregor (Johann)**. *Encyclopædia Britannica*, 2008.

36. Dawkins, *Ancestor's Tale*, p. 193.

37. en.wikipedia.org/wiki/Clade.

38. OED.

39. Wikipedia has a number of articles on this subject, but they are not very clear.

40. www.jstor.org/pss/2446665.

41. en.wikipedia.org/wiki/Clade.

42. www.ncbi.nlm.nih.gov/mapview/maps.cgi?tax-id=9606&chr=19&MAPS=ugHs,genes,genec-r&cmd=focus&fill=40&query=uid(12719632)&QSTR=2141%5Bgene%5Fid%5D. But the gene (allele?) for brown eyes appears to be on another chromosome. It is difficult to interpret the human genome project, for it is a mass of confusion, raising more questions than it answers.

43. Dawkins, *Ancestor's Tale*, pp. 194–195.

44. Ibid., pp. 9–10.

45. (p. 538) The theory of punctuated equilibria was first presented at the annual meeting of the Paleontological Society, and the Geological Society of America, at Washington, D. C., on 2nd November 1971, along with a number of other state-of-the-art papers. Eldredge and Gould's paper, 'Punctuated Equilibria: An Alternative to Phyletic Gradualism', is published in Schopf, *Models in Paleobiology*, pp. 82–115.

At the time, the general consensus among palæontologists and biologists was that evolution progresses gradually. But this does not explain why there are large gaps in the fossil record. Eldredge gives an extended description of the theory of punctuated equilibria and how it came about in his book *Time Frames*. As he explains, "once a species evolves, it will not undergo great change as it continues its existence."

In *Ever Since Darwin*, Gould uses the theory of punctuated equilibria to explain the Cambrian explosion of about 600 million years ago, when there was a great acceleration in biotic diversity. Interestingly, on page 129 of this book, Gould uses the S-shape of the growth curve, to illustrate this phenomenon

46. (p. 538) Curiously, the abridgement of this 1116-page book by John Tyler Bonner does not contain a precis of this vitally important chapter.

47. (p. 539) I got this idea from one of Arthur Koestler's books, but cannot now find the exact reference for it. This is not to disparage the great contribution that the Arabs made to human learning during the first millennium.

48. (p. 539) Bannock, et al, *Dictionary of Economics*, article on logistic curve, p. 282–283.

49. (p. 539) Waddington, *Tools of Thought*, pp. 64–79.

50. (p. 541) Jantsch, *Self-Organizing Universe*, p. 70.

51. Victor Vinge, 'The Technological Singularity', available at <http://mindstalk.net/vinge/vinge-sing.html>.

52. Kurzweil, *Are We Spiritual Machines?*, p. 11.

53. Moore, 'Cramming more components onto integrated circuits'.

54. Moore was speaking at the 50th anniversary meeting of the International Solid-State Circuits Conference in San Francisco. Report by BBC Online.

55. Moravec, *Mind Children*, p. 1.

56. Moravec, *Robot*, pp. 125–126.

57. Rees, *Our Final Century*, p. 19.

58. (p. 534) Attenborough, *Life on Earth*, p. 20.

59. (p. 535) Russell, *White Hole in Time*.

60. (p. 535) Russell, *Waking Up in Time*, p. 4.

61. (p. 535) Russell, *Waking Up*, p. 7.

62. (p. 535) Russell, *Awakening Earth*.

63. (p. 535) Russell, *Global Brain*, p. 80.

64. (p. 536) *Money as Debt* video, <http://video.google.com/videoplay?docid=-9050474362583451279>.

65. (p. 536) Psalms, 90:10.

66. (p. 536) Rouse Ball and Coxeter, *Mathematical Recreations and Essays*, p. 317. This story was originally told by de Parville in *La Nature*, Paris, 1884, Part I, pp. 285–286. In 1883, the French mathematician Edouard Lucas invented a puzzle, called the Tower of Hanoï, based on this ancient story. There are several virtual versions of this puzzle available on the Web.

67. (p. 537) Kasner and Newman, *Mathematics and the Imagination*, p. 153 says that it would take 58,454,204,609 centuries plus a little over 6 years to complete this task. Curiously, this is 10 times longer than the calculation I did in Mathematica.

68. (p. 537) Kasner and Newman, *Mathematics and the Imagination*, p. 33. They devote a few pages (pp. 30–35) to the problems even scientists have in understanding very large numbers. Larry Page and Sergey Brin, the founders of Google, tell us that Kasner's nephew's name was Milton Sirota. They named their search service after this number, to reflect "the com-

pany's mission to organize the immense, seemingly infinite amount of information available on the web". (<http://www.google.com/intl/en/corporate/history.html>).

69. (p. 538) James Robertson is a leading advocate for an increase of seigniorage, reducing the influence of the banks on all our lives. See <http://www.jamesrobertson.com/article/free-lunches.htm> for a speech he gave on this subject in Mansion House in London in 2000, printed in *Resurgence*.

70. (p. 538) Paul Grignon, *Money as Debt*, film at <http://video.google.com/videoplay?docid=5352106773770802849>.

71. (p. 543) See, for instance, Knight, *Blood Relations*.

72. (p. 543) http://en.wikipedia.org/wiki/Gregorian_calendar.

73. (p. 543) http://en.wikipedia.org/wiki/Julian_calendar.

74. (p. 543) http://en.wikipedia.org/wiki/Roman_calendar.

75. (p. 543) http://en.wikipedia.org/wiki/Common_Era.

76. (p. 543) http://en.wikipedia.org/wiki/Buddhist_calendar.

77. (p. 544) http://en.wikipedia.org/wiki/Islamic_calendar.

78. (p. 544) http://en.wikipedia.org/wiki/Chinese_calendar.

79. (p. 544) http://en.wikipedia.org/wiki/Jewish_calendar.

80. (p. 544) White, *History of the Warfare of Science with Theology*, Vol 1, Part I, p. 8.

81. (p. 544) http://en.wikipedia.org/wiki/Ussher_chronology.

82. (p. 544) Fischer-Schreiber, *Encyclopedia of Eastern Philosophy and Religion*, article on yuga, p. 435.

83. (p. 545) Ibid., In *Bhagavad Gita*, p. 124, Eknath Easwaran refers to the four yugas together as one yuga, not mentioning the term *mahayuga*.

84. (p. 546) Ibid., article on *kalpa*, p. 171. This article says that a kalpa is a day and a night in the life of Brahma, while the Bhagavad Gita clearly indicates that this is actually two kalpas.

85. (p. 546) <http://en.wikipedia.org/wiki/Mahabharata>.

86. (p. 546) Easwaran, *Bhagavad Gita*.

87. (p. 546) See, for instance, <http://www.mayacalendar.com/description.html>, and many other sites.

88. (p. 547) Calleman, *Theory of Everything*, p. 25.

89. (p. 547) Calleman, *Mayan Calendar*, p. 76.

90. (p. 548) Calleman, *Everything*, p. 25.

91. (p. 549) http://en.wikipedia.org/wiki/Maya_calendar.

92. (p. 549) <http://edj.net/mc2012/fap9.html>.

93. (p. 550) Calleman, *Mayan Calendar*, pp. 233–238.

94. (p. 550) You can calculate the correlations between the Mayan and the Gregorian calendars on the Internet at <http://www.pauhtun.org/Calendar/tools.html>.

95. (p. 550) Whatever dates we choose for the end of the Mayan calendar, they all correspond very closely to the vision I have had since 1979. For when I was then engaged in marketing decision support systems and personal computing for IBM (UK), I saw quite clearly that the invention of the stored-program computer is incompatible with both capitalism and communism and both would self-destruct within about thirty years, when my children would be in their late thirties, presumably bringing up children of their own.

96. Russell, 'Singularity in Time', pp. 20–21.

97. McKenna, *Invisible Landscape*, pp. 95–99.

98. T. McKenna, *True Hallucinations*, p. 165.

99. McKenna, *Invisible Landscape*, p. 121.

100. H. Wilhelm, 'Time in the *Book of Changes*', pp. 214–216.

101. http://en.wikipedia.org/wiki/Shao_Yung.

102. H. Wilhelm, 'Time in the *Book of Changes*', pp. 216–218.

103. McKenna, *Invisible Landscape*, pp. 141–143.

104. *Ibid.*, pp. 144–143.

105. *Ibid.*, p. 126.

106. *Ibid.*, p. 154.

107. *Ibid.*, pp. 171 and 179–180.

108. *Ibid.*, p. xxv. The software plus extensive documentation is available from <http://www.fractal-timewave.com/>.

109. *Ibid.*, pp. 146–149.

110. Matthew Watkins, 'Autopsy for a Mathematical Hallucination?' <http://www.fourmilab.ch/rpkp/autopsy.html>.

111. Peter Meyer, 'The Mathematics of Timewave Zero', Appendix in McKenna *Invisible Landscape*, pp. 211–220.

112. Using DOSBox (<http://www.dosbox.com/>)

113. 'Dynamics of Hyperspace: A Dialog between Ralph Abraham and Terence McKenna', 1983.

114. John Sheliak, 'A Mathematical and Philosophical Re-Examination of the Foundations of TimeWave Zero and Novelty Theory'.

115. Peter Meyer, 'History of the Timewave Zero Software' and 'The Four Number Sets'.

116.

117.

118.

119. (p. 550) <http://sundin.web.surftown.se/mayacal/content/articles/differences.htm>.

120. (p. 559) I met Nick in April 2000, when we both gave a talk at the continental meeting of the Scientific and Medical Network in Växjö in southern Sweden.

121. (p. 559) Long, *Origins of Man and the Universe*, 'Genesis of the gods', pp. 26–32.
122. (p. 562) Lane, *Industrial Revolution*.
123. (p. 562) http://en.wikipedia.org/wiki/Small-Scale_Experimental_Machine.
124. (p. 562) <http://en.wikipedia.org/wiki/EDSAC>.
125. (p. 562) <http://en.wikipedia.org/wiki/Berners-Lee>.
126. (p. 563) Gleick, *Chaos*, p. 174.
127. (p. 563) Turchin, *Phenomenon of Science*.
128. (p. 563) Elisabet Sahtouris, 'A New Model for a Living Universe: Evolution as Creative Response to Crisis', *Mystics and Scientists* 28, 'Healing the Spilt: An Alchemy of Transformation' (Moreton-in-Marsh, Gloucestershire: Conference Cassettes, 2005), CD
129. (p. 563) Teilhard, *Human Phenomenon*, pp. 216–218.
130. (p. 565) Russell, *The Global Brain Awakens*.
131. (p. 565) Teilhard, *Human Phenomenon*, p. 172.
132. (p. 565) *Ibid.*, p. 173.
133. (p. 565) *Ibid.*, p. 174.
134. (p. 565) *Ibid.*, p. 214.
135. (p. 565) *Ibid.*, p. 265.
136. (p. 566) *Ibid.*, p. 181.
137. (p. 566) The Alliance for a New Humanity is one of many organizations seeking to fulfil its mission: "To Connect people, who, through personal and social transformation, are committed to creating a just, peaceful, and sustainable world, reflecting the unity of humanity." <http://www.anhglobal.org/>.
138. (p. 566) http://en.wikipedia.org/wiki/Homo_habilis.
139. (p. 566) http://en.wikipedia.org/wiki/Homo_erectus.
140. (p. 566) http://en.wikipedia.org/wiki/Homo_neanderthalensis.
141. (p. 566) http://en.wikipedia.org/wiki/Homo_sapiens.
142. (p. 566) http://en.wikipedia.org/wiki/Homo_sapiens_idaltu.
143. (p. 566) http://en.wikipedia.org/wiki/Cave_drawing.
144. (p. 566) <http://www.evolve.org/pub/doc/index2.html>.
145. (p. 566) <http://barbaramarxhubbard.iampify.com/>.
146. (p. 566) Barbara Marx Hubbard, 'One with the Process of Creation'.
147. (p. 567) Wilber, *Up from Eden*, p. 12.
148. (p. 567) Wilber, *Sex, Ecology, Spirituality*, pp. 203–208.
149. (p. 568) Toynbee, *Brief Study of History*, abridged by D. C. Somervell, Table I, 'Universal States', p. 561.
150. (p. 568) *Ibid.*, p. 246.
151. (p. 568) Capra, *Turning Point*, p. 8.

152. (p. 569) Ibid., p. 466.

153. (p. 570) Willis Harman, 'Charting Paradigm Shifts'

154. (p. 570) http://oneminuteshift.com/videos/marilyn_schlitz_video/next_scientific_revolution.

155. (p. 570) Titmuss, *Gift Relationship*.

CHAPTER 7. THE GROWTH OF STRUCTURE

Motto: (p. 571) Teilhard, *Human Phenomenon*, p. 183. This is an edited quotation. The full section is: "Evolution is an ascent towards consciousness, as we have seen and acknowledged. This is no longer contested, even by the most materialistic, or at least agnostic, of humanitarians. Evolution must culminate ahead in some kind of supreme consciousness."

1. (p. 572) Ibid., p. 216–218.

2. **abacus**, *Encyclopædia Britannica*, 2008.

3. (p. 573) **History of Computing**, *Encyclopædia Britannica*, 2008.

4. (p. 573) Ibid.

5. (p. 573) Pratt, *Thinking Machines*, Chapter 5 'Leibniz: Mechanizing Reason', pp. 70–80.

6. (p. 573) **History of Computing**, *Encyclopædia Britannica*, 2008.

7. (p. 573) Babbage was the Lucasian professor of mathematics from 1828 to 1839 (*Encyclopædia Britannica*), although he never resided at the college nor taught there. Nevertheless, he received between eighty and ninety pounds a year, quite a tidy sum in those days (Morrison, *Charles Babbage*, p. xv).

8. (p. 574) This conversation is recorded in Morrison, *Charles Babbage*, p. xii. However, what Babbage actually wrote was somewhat more prosaic: "We [Herschel and I] met one evening for the purpose of comparing the calculated results, and finding many discordances, I expressed to my friend the wish, that we could calculate by steam, to which he assented as to the thing being within the bounds of possibility." (Hyman, *Charles Babbage*, p. 49) John Herschel was the son of William Herschel, the man who discovered the planet Uranus. John, who had been a student friend of Babbage ten years earlier, went on to have distinguished career in astronomy himself.

9. (p. 574) The method of differences is based on the fact that in any polynomial of degree n , the n th order of differences is constant. For instance, to use an example that Babbage gave in his autobiography, if we want to construct a table of squares of the integers, we first take the differences between the squares and then take the differences between these differences, as Table N.1: shows.

This table then gives the starting values for each column, which can be set into the machine. It then becomes possible to calculate squares indefinitely simply by the process of ad-

Number	Square	First difference	Second difference
1	1		
		3	
2	4		2
		5	
3	9		2
		7	
4	16		2
		9	
5	25		

Table N.1: *Method of differences*

dition. Babbage’s prototype had provision for just two levels of differences, so was very limited in its capabilities.

10. (p. 574) Moore, *Ada, Countess of Lovelace*, pp. 43–44.

11. (p. 574) A Swedish engineer Georg Scheutz and his son, Edvard, did manage to construct a Difference Engine with four levels of differences and fifteen decimal places, which could also print results. It was completed in October 1853 after some twenty years of effort and was well received by Babbage, who by that time had long left work on his own Difference Engine.

It was not until 1991 that the Science Museum in London built a Difference Engine with seven levels of differences to Babbage’s specifications using construction techniques available to Babbage at his time. The purpose was to demonstrate that this machine could have been built and to celebrate the bicentenary of Babbage’s birth. Doron Swade, who masterminded this project, tells the story in Swade, *Difference Engine*, pp. 221–307.

12. (p. 574) Pratt, *Thinking Machines*, p. 93

13. (p. 575) Ada Byron married Baron King on 8th July 1835 at the age of nineteen. (p. 72) She became Ada Lovelace when her husband was elevated to the Earldom of Lovelace on 30th June 1838 to celebrate Queen Victoria’s coronation. The reason for this honour does not appear to be because of any merit on his part. It was just that Ada’s first cousin once removed, Viscount Melbourne, happened to be prime minister at the time

14. (p. 575) Morrison, *Charles Babbage*, p. 252. This book contains a reproduction of the memoir that Ada Lovelace wrote in 1843 (pp. 225–297).

15. (p. 575) Moore, *Ada, Countess of Lovelace*, p. 363.

16. (p. 575) See Carroll and Tober, *Indigo Children*.

Ada suffered from both mental and physical disorders throughout her life, some of which, at least, were probably not unconnected. She had periods of both mania and depression, what today would be called a bipolar disorder. This was not helped by the fact that her parents were utterly incompatible, separating when she was just one or two months old. She was then brought up by a domineering mother and forbidden to know anything about her illustrious father, aided and abetted by a coven of her mother's closest friends, who Ada called the Furies. Ada, a free spirit, found their surveillance intolerable (Wooley, *Bride of Science*, p. 119).

There is also evidence of mental disorders in the rest of the family. Her father's maternal grandfather committed suicide, her paternal grandfather was known as 'mad Jack', and her father, the poet, was a mad genius, who may have had an incestuous relationship with his half-sister. Ada would clearly have been a classic case study for one of Bert Hellinger's family constellation sessions, which look deeply into how our family relationships affect the way we behave and view the world (Hellinger, *Love's Hidden Symmetry*).

Ada was very well aware of her genius, that she could see a whole that even Babbage could not see. This led her to write what Doran Swade calls "her sometimes imperious notes" (*Difference Engine*, p. 165). She also got quite cross with Babbage for mislaying what she called "this first child of mine" and for making changes to her style of writing. See Woolley, *Bride of Science*, pp. 265-277 for a most understanding description of how Ada saw these notes and herself in relationship to her contemporaries.

17. (p. 575) Hyman, *Charles Babbage*, pp. 181-182.

18. (p. 575) Menabrea, 'Notions sur la machine analytique de M. Charles Babbage'. Menabrea went on to become prime minister of a united Italy.

19. (p. 575) Woolley, *Bride of Science*, p. 278.

20. (p. 575) Morrison, *Charles Babbage*, p. 254.

21. (p. 576) Kurzweil, *Spiritual Machines*, p. 294

22. (p. 576) Morrison, *Charles Babbage*, p. 252.

23. (p. 576) *Ibid.*, p. 243.

24. (p. 576) *Ibid.*, p. 284.

25. (p. 576) Dorothy Stein, who wrote a biography of Ada in 1985, found the error. The original French said, "*le cas n = ∞*" instead of "*le cas n = ∞*". Ada translated this as "when the cos of $n = ∞$ ", which does not make sense, instead of "in the case of $n = ∞$ " (Wooley, *Bride of Science*, p. 276).

26. (p. 576) Babbage's son, Henry, built a prototype of the mill, which is now in the Science Museum in London. See Pratt, *Thinking Machines*, p. 114, for a photograph of this device.

27. (p. 576) Swade, *Difference Engine*, pp. 308-310.

28. (p. 576) Method for Automatic Execution of Calculations with the Aid of Computers', patent application, dated 11th April 1936, translated and reprinted in Randell, *Origins of Digital Computers*, pp. 163–170.
29. (p. 576) Ibid., p. 160.
30. (p. 577) Ibid., pp. 191–210.
31. (p. 577) Ibid., pp. 359–373 contains a description of this machine
32. (p. 577) Ibid., pp. 299.
33. (p. 577) Pratt, *Thinking Machines*, p. 167.
34. (p. 577) Morrison, *Charles Babbage*, p. 250.
35. (p. 577) Randell, *Origins of Digital Computers*, p. 376.
36. (p. 577) Ibid., p. 376.
37. (p. 577) Ibid., pp. 383–292.
38. (p. 577) Pratt, *Thinking Machines*, p. 169. A brief description of this machine is given in Randell, *Origins of Digital Computers*, pp. 415–416. It seems that the machine, experimental as it was, could perform divisions to 39 significant binary places, calculate the highest common factor of two numbers, and factorize an integer.
39. (p. 578) Ibid., p. 169. This machine is described in Randell, *Origins of Digital Computers*, pp. 417–429.
40. (p. 578) <http://www.cl.cam.ac.uk/UoCCCL/misc/EDSAC99/>.
41. (p. 578) **History of Computing**, *Encyclopedia Britannica*, 2008.
42. (p. 578) <http://edition.cnn.com/TECH/computing/9904/30/1952.idg/>.
43. (p. 578) **History of Electronics**, *Encyclopedia Britannica*, 2008.
44. (p. 578) **transistor**, *Encyclopedia Britannica*, 2008. The engineers were John Bardeen, Walter H. Brattain, and William B. Shockley.
45. (p. 579) Gordon E. Moore, 'Cramming more components onto integrated circuits', *Electronics*, Volume 38, Number 8, April 19, 1965.
46. (p. 579) Kurzweil, *Spiritual Machines*, pp. 20–25.
47. (p. 580) Moore was speaking at the 50th anniversary meeting of the International Solid-State Circuits Conference in San Francisco. Report by BBC Online.
48. (p. 580) Martin, *After the Internet*.
49. (p. 581) Baron, *Computer Languages*, p. 203.
50. (p. 581) Ibid., p. 170.
51. (p. 581) By the early 1970s, the mainframe business was known as IBM and the seven dwarfs, because IBM held something like 80% of the market share at one time. The seven dwarfs were Burroughs, Control Data, General Electric, Honeywell, RCA, NCR, and UNIVAC.
52. (p. 581) Ibid., p. 106–108.

53. (p. 581)

http://en.wikipedia.org/wiki/History_of_IBM_mainframe_operating_systems.

54. (p. 582) Böhm, Corrado and Giuseppe Jacopini (May 1966). 'Flow Diagrams, Turing Machines and Languages with Only Two Formation Rules'. *Communications of the ACM* 9 (5). Actually, this paper was published in Italian the previous year (Yourdon, *Program Structure and Design*, p. 146).

55. (p. 582) Yourdon, *Program Structure and Design*, p. 146.

56. (p. 582) Ibid., p. 147.

57. (p. 582) Ibid.

58. (p. 583) Dijkstra, 'Letters to the editor: Go To Statement Considered Harmful', *Communications of the ACM* March 1968, Vol. 11, No 3, pp. 147–148.

59. (p. 583) Wirth, Niklaus, 'Program Development by Stepwise Refinement', *Communications of the ACM* April 1971, Vol. 14, No. 4, pp. 221–227.

60. (p. 584) Baron, *Computer Languages*, p. 346.

61. (p. 584) Stein Krogdahl, 'The Birth of Simula', <http://heim.ifi.uio.no/~steinkr/papers/HiNC1-webversion-simula.pdf>.

62. (p. 585) Winston, *On to C++*, p. 49.

63. (p. 585) McGregor and Sykes, *Object-Oriented Software Development*, p. 18.

64. (p. 585) Alexander, et al, *Pattern Language*, and Alexander, *Timeless Way of Building*.

65. (p. 585) See, for instance, Gamma, et al, *Design Patterns*.

66. (p. 587) **Encyclopædia Britannica**.

67. (p. 587) http://en.wikipedia.org/wiki/Decision_table.

68. (p. 587) Co-author with Larry Constantine and Glenford Myers of one of the seminal papers on structured design: W. Stevens, G. Myers, L. Constantine, 'Structured Design', *IBM Systems Journal*, 13 (2), 115–139, 1974.

69. (p. 587) Developer of the Soft Systems Methodology.

70. (p. 587) Authors of *Structured Systems Analysis: Tools and Techniques*.

71. (p. 588) Downs, et al, *SSADM*, pp. 17–89.

72. (p. 588) <http://en.wikipedia.org/wiki/SSADM>.

73. (p. 588) National Institute of Standards and Technology, 'Federal Information Processing Standard (FIPS) for IDEF0', 21st December 1993, p. 7.

74. (p. 588) Ibid., p. 5.

75. (p. 589) Ibid., p. 10.

76. (p. 589) <http://en.wikipedia.org/wiki/IDEF>.

77. (p. 589) http://en.wikipedia.org/wiki/Peter_Coad.

78. (p. 589) Coad & Yourdon, *Object-oriented Analysis*.

79. (p. 589) Coad & Yourdon, *Object-oriented Design*.

80. (p. 589) Booch, Object-Oriented Design.
81. (p. 589) Rumbaugh, et al, *Object-Oriented Modeling and Design*.
82. (p. 589) http://en.wikipedia.org/wiki/James_Rumbaugh.
83. (p. 589) Ibid.
84. (p. 589) http://en.wikipedia.org/wiki/Ivar_Jacobson.
85. (p. 589) Jacobson, et al, *Object-Oriented Software Engineering*.
86. (p. 589) http://en.wikipedia.org/wiki/Objectory_AB.
87. (p. 589) http://en.wikipedia.org/wiki/Rational_Software.
88. (p. 589) Booch, et al, *UML User Guide*, pp. 449–456.
89. (p. 590) **History of Publishing**, *Encyclopædia Britannica*, 2008.
90. (p. 590) **papyrus**, *Encyclopædia Britannica*, 2008.
91. (p. 590) **History of Publishing**, *Encyclopædia Britannica*, 2008.
92. (p. 591) **papyrus**, *Encyclopædia Britannica*, 2008.
93. (p. 591) **History of Publishing**, *Encyclopædia Britannica*, 2008.
94. (p. 591) **parchment**, *Encyclopædia Britannica*, 2008.
95. (p. 591) **History of Publishing**, *Encyclopædia Britannica*, 2008.
96. (p. 591) **paper**, *Encyclopædia Britannica*, 2008.
97. **papermaking**, *Encyclopædia Britannica*, 2008.
98. **Herman Hollerith**, *Encyclopædia Britannica*, 2008.
99. **Jacquard Loom**, *Encyclopædia Britannica*, 2008.
100. (p. 591) **History of Computers**, *Encyclopædia Britannica*, 2008.
101. (p. 592) *Think*, September 1989, pp. 41 and 44. (This was a special edition of *IBM's* house magazine, celebrating 75 years of the company's existence.)
102. (p. 593) These initials are as follows: HFS (Hierarchical File System), FAT (File Allocation Table), NTFS (NT File System), HPFS (High Performance File System), and UFS (UNIX File System).
103. (p. 593) For a description of data independence, both physical and logical, see Date, *Database Systems, Seventh Edition*, pp. 19–20 and pp. 295–295, respectively.
104. (p. 594) Bachman, Charles W., 'Software for Random Access Processing', *Datamation*, April 1965, pp. 36–41.
105. (p. 595) These two DBTG reports for the CODASYL Programming Language Committee were published in October 1969 and April 1971. Interestingly, there were thirty-eight members of the two committees, of which only four were on both. One wonders how they could have maintained any continuity in these circumstances.
106. Date, *Database Systems, Fourth Edition*, (1986), Chapter 23, pp. 541–583 describes IDMS, as an example of the network approach.
107. Date, *Database Systems, First Edition*, (1975), p. 240.

108. Engles, R. W., 'An Analysis of the April 1971 Data Base Task Group Report', pp. 69–91 in E. F. Codd and A. L. Dean, *1971 ACM SIGFIDET Workshop*.

109. Date, *Database Systems, First Edition*, (1975), p. 228.

110. Finkelstein, *Information Engineering*, p. 17. BOMP stands for Bill of Materials Processing.

111. Date, *Database Systems, Fourth Edition*, (1986), Chapter 23, pp. 541–583 describes IMS, as an example of the hierarchical approach.

112. (p. 596) Finkelstein, *Information Engineering*, p. 17.

113. (p. 596) Koestler, *Ghost in the Machine*.

114. Wilber, *Sex, Ecology, Spirituality*.

115. Capra, *Web of Life*.

116. Date, *Database Systems, First Edition*, (1975), p. 144.

117. (p. 598) *Ibid.*, p. 145.

118. (p. 598) Codd (1969).

119. Codd (1970).

120. (p. 599) COURSE # and TITLE and EMP # and NAME are repeating groups.

121. (p. 600) In particular, there was a tendency to view the relational model as just another approach, like the network and hierarchical ones. This gave the impression that the three approaches were the same kind of thing, which they are not, as Chris Date points out on page 166 of his *Relational Database Writings* (1991–1994).

122. The 'Great Debate' is documented in *ACM SIGMOD, Workshop on Data Description, Access and Control*, Volume 2 called *Data Models: Data-Structure-Set versus Relational*, edited by Randal Rustin. The event, which was attended by more than 160 participants, was held in Ann Arbor on 1–3 May 1974.

In essence, Charles Bachman argued that the network and relational approaches are simply a matter of style, like two sides of the same coin. Ted Codd refuted this by saying that there is a fundamental difference between the two approaches. However, as the debate focused attention on technical details rather than on foundational matters, this point does not come out clearly. See <http://www.sigmod.org/publications/dblp/db/conf/sigmod/sigmod74-2.html>.

123. Ashenhurst, Robert, 'A Great Debate', *Communications of the ACM*, June 1974, Volume 17, Number 6, p. 360.

124. Finkelstein, *Information Engineering*, p. 17.

125. Ted Codd, in particular, had a great struggle with IBM management in getting the relational model accepted. In 1975, he wrote to an IBM manager suggesting that the company should seriously consider the relational model as part of the company's long-term database strategy. He received a reply, given on page 167 in Chris Date's *Relational Database Writings*

for 1991-1994, that showed that the manager had very little understanding of the foundational significance of relational technology.

Codd showed the frustration he had endured over many years when he dedicated his book on the Relational Model in 1990 “To fellow pilots and air crew in the Royal Air Force during World War II and the dons at Oxford” for “These were the source of my determination to fight for what I believed was right during the ten or more years in which government, industry, and commerce were strongly opposed to the relational approach to database management.”

126. http://en.wikipedia.org/wiki/Oracle_Corporation.

127. http://en.wikipedia.org/wiki/Oracle_Database.

128. In 2006, the last year I have the figures, Oracle was 196 in the Fortune 500 list, not far behind Apple Computer, as it was called then, which was no. 159. In terms of profits, assets, and stockholders’ equity, it was nos. 55, 168, and 92, respectively, well ahead of Apple Computer on all counts. (Fortune, Europe Edition, April 17, 2006, Vol. 137, No. 7.)

129. http://en.wikipedia.org/wiki/IBM_DB2.

130. <http://en.wikipedia.org/wiki/Sybase>.

131. (p. 601) As the relational model of data became the ‘flavour of the month’ in the 1980s, Ted Codd was led to question whether DBMSs were really relational, as many claimed. In 1985, he specified twelve basic rules that a DBMS should follow if it is to be truly relational (‘Is your DBMS really relational?’ *ComputerWorld*, pp. ID/1-9, October 14, 1985 and ‘Does your DBMS run by the rules?’ *ComputerWorld*, pp. 49–60, October 21, 1985). He concluded, “No existing DBMS product that I know of can honestly claim to be fully relational.”

Five years later, in *The Relational Model for Database Management*, Codd listed no fewer than 333 characteristics of the relational model, not all of which were even agreed by his fellow mathematicians, including his closest associate, Chris Date.

132. (p. 601) Codd, ‘Relational Model of Data’, p. 379.

133. Date, *Database Systems*, seventh edition, p. 123.

134. This obvious example is given in Date and Darwen, *Foundation for Future Database Systems*, Second edition, p. 15.

135. (p. 602) The fact that a database can be seen as a repository of true propositions in logic is not generally the way that databases are presented to students. One exception to this is Hugh Darwen, who teaches this approach to his Open University students in the UK. See Chapter 1 in Date’s *Relational Database Writings*, 1994–1997, pp. 279–287.

136. (p. 603) Chris Date emphasized that relation-valued attributes do not violate a fundamental principle of the relational model provided they are encapsulated in Chapter 6 in his *Relational Database Writings* from 1989–1991. Since then, this notion has been further devel-

oped in the attempts to unify the relational model of data with object-oriented modelling methods.

137. Rather confusingly, entity types are sometimes referred to as entities in the literature, with entities then being called occurrences of an entity.

138. Date and Darwen, *Foundation for Future Database Systems*, pp. 371–375.

139. http://en.wikipedia.org/wiki/Sql#Data_definition.

140. SQL was initially called Structured English Query Language (SEQUEL) to manipulate and manage data stored in System R, a database system built as a research project at IBM San Jose Research. The acronym SEQUEL was later changed to SQL because ‘SEQUEL’ was a trademark of the UK-based Hawker Siddeley aircraft company.

141. Sowa, ‘Semantic Networks’, *Encyclopedia of Artificial Intelligence*, p. 1493.

142. Ibid., p. 1494.

143. (p. 604) Reproduced in Heijenoort, *From Frege to Gödel*, pp. 1–82.

144. Chen, ‘Entity-Relational Model’, *ACM Transactions on Database Systems*, Vol 1. No. 1, March 1976, pp. 9–36.

145. Sowa, ‘Semantic Networks’, *Encyclopedia of Artificial Intelligence*, p. 1496.

146. Martin and Finkelstein, *Information Engineering*.

147. Federal Information Processing Standard (FIPS) for IDEF1X, 21st December 1993.

148. Barker, *CASE*METHOD™: Entity Relationship Modelling*.

149. (p. 606) Ibid., p. 4–6.

150. (p. 607) Ibid., p. 3–4.

151. (p. 607) Hay, *Data Model Patterns*, p. 14.

152. Booch, et al, *UML User Guide*, p. 106.

153. (p. 610) Halpin, *Information Modeling*, pp. 106–107.

154. Ibid., p. xxiv.

155. Ibid., p. 409.

156. (p. 612) http://en.wikipedia.org/wiki/IBM_Generalized_Markup_Language.

157. Goldfarb, *SGML Handbook*, back dust cover.

158. Ibid., p. xiv.

159. Ibid.

160. <http://en.wikipedia.org/wiki/HTML>.

161. <http://en.wikipedia.org/wiki/XML>.

162. Barker, *CASE*METHOD™: Entity Relationship Modelling*, p. H-1.

163. (p. 614) Hay, *Data Model Patterns*, p. 256.

CHAPTER 8. LIMITS OF TECHNOLOGY

Motto: See note 13.

1. Pratt, *Thinking Machines*, p. 1.
2. Gardner, *Mind's New Science*, p. 37.
3. Turing, 'Computing Machinery and Intelligence' (*Mind*, LIX, No. 236, 1950), reprinted in Hofstadter & Dennett, *The Mind's I*.
4. Turing, 'Computing Machinery', 53.
5. Turing, 'Computing Machinery', 57.
6. Haugeland, *Artificial Intelligence*.
7. Birnbacher, 'Artificial Consciousness', pp. 489–503.
8. Levy, *Artificial Life*.
9. Swade, *The Difference Engine*.
10. Woolley, *Bride of Science*, p. 267.
11. Turing, 'Computing Machinery', p. 63.
12. Lovelace, notes on 'Sketch of the Analytical Engine', p. 284.
13. Charniak and McDermott. *Introduction to Artificial Intelligence*.
14. Keen and Scott Morton, p. 87.
15. See Nagel and Newman, *Gödel's Proof*, for a simplified description of Gödel's theorems.
16. Lucas, *Minds, Machines, and Gödel*.
17. Searle, 'Minds, Brains and Programs'.
18. See, for example, Hofstadter, *Gödel, Escher, Bach*, Hofstadter and Dennett, *Mind's I*, and Dennett, *Consciousness Explained*.
19. Penrose, *Emperor's New Mind*, p. 581.
20. Apple, *Human Interface Guidelines*.
21. IBM, *CUA Guidelines*.
22. Open Software Foundation, OSF/Motif™ Style Guide. Perhaps there is also a design guide to the UNIX Common Desktop Environment (CDE), which encompasses Motif design principles.
23. *Visual interface design for Windows*, by Virginia Howlett, leader of user interface team for Windows 95 seems to be one of the first. Today, a search on the Internet will find many more.
24. Later, Babbage's son had a cut-down version of the central mill of the Analytical Engine constructed. This is now in the Science Museum in London. (See Pratt, *Thinking Machines*, p. 124.)
25. See, for example, Weizenbaum, *Computer Power*, pp. 51–59.
26. This diagram is taken from Weizenbaum, *Computer Power*, p. 80. In turn, this was derived from figures 3.2–3.5 in D. C. Evans, 'Computer Logic and Memory', Copyright © 1966 by *Scientific American*, Inc., all rights reserved.

27. Whitehead and Russell, *Principia Mathematica*, pp. 91–97.

28. Sheffer, 'A Set of Five Independent Postulates for Boolean Algebras', pp. 486–488.

29. Nicod, 'A Reduction in the Number of Primitive Propositions of Logic'.

30. http://en.wikipedia.org/wiki/Sheffer_stroke.

31. Kilmister, *Language, Logic and Mathematics*, p. 55. If I had known about the Sheffer stroke in 1980, when I began to integrate all knowledge into a coherent whole, I might never have developed relational logic. For I began by experimenting with the various dyadic operators in Boolean logic. Most particularly, I was attempting to create asymmetrical patterns from symmetrical ones. This turned out to be impossible, leading me eventually to the Principle of Duality and the Principle of Unity. Although I still have most of my early writings, I did not keep these very first attempts at creating a universal logic. This is a pity, for it would have been most interesting to see exactly what was going on in my mind at that time.

32. Hofstadter, *Gödel*, pp. 285–288.

33. Tanenbaum, *Structured Computer Organization*, p. 10.

34. A description of the way that APL, a high level programming language, was amazingly implemented in microcode was described in 'An APL Emulator on System/370' by A. Hassitt and L. E. Lyon in *IBM Systems Journal*, No. 4, 1976, pp. 358–378.

35. Vanhelsuwé, et al, *Mastering Java*, p. 16.

36. Tanenbaum, *Structured Computer Organization*, p. 10. This is one of the most elementary principles of computer science, yet it is ignored by virtually all scientists working in the field of artificial intelligence.

37. Baron, *Computer Languages*, p. 127.

38. Rose, *APL: An Interactive Approach*. This book seems to be out of print and so I don't have the exact page reference.

39. Functional programming languages, the most mathematically pure languages, such as ML and Haskell, beloved of academics, could possibly be included here. But I have not studied these in any detail as they do not anything to the reasoning.

40. REXX has many of the characteristics of a dynamically active language, but it does not have some of the characteristics of the other four languages described here. I have therefore left it out of consideration here.

41. An exception was HyperTalk, which has an edit script command which can be used within utility programs for helping the programmer to find scripts quickly rather than searching through cards in stacks. This is necessary because scripts are properties of various types of object and can sometimes be difficult to find in a large and complex system. Another exception is REXX, which can stack XEDIT editing instructions on the CMS stack, and then dynamically invoke the editor.

42. Ryle, *Concept of Mind*, pp. 28–32.

43. Aristotle, *Metaphysics*, Book XII, viii, 4, 1073a4, p. 153.

44. Aquinas, *Summa Theologiae*, p. 12–14.

CHAPTER 9. AN EVOLUTIONARY CUL-DE-SAC

Motto: Koestler, *Ghost in the Machine*, p. 165

1. Aristotle, *Metaphysics*, Book XII.

2. There are several translations of Heraclitus' fragments on the Web. The only one I have found that translates the Greek word *logos* as 'Logos', rather than 'account' or 'word', is by William Harris at <http://community.middlebury.edu/~harris/Philosophy/Heraclitus.html>. This translation is almost identical to the fragments that Osho used in his discourses on Heraclitus, published as *The Hidden Harmony*.

3. Kahn, *Heraclitus*, p. 85 and Osho, *Hidden Harmony*, p. 70.

4. Osho, *Hidden Harmony*, p. 147.

5. Kahn, *Heraclitus*, p. 35.

6. *Encyclopedia of Philosophy*, article on 'Heraclitus of Ephesus', p. 477.

7. Aristotle, *Metaphysics*, p. 163.

8. *Ibid.*, p. 161.

9. Osho, *Hidden Harmony*, p. 147.

10. Kilmister, *Language, Logic and Mathematics*, p. 15.

11. Aristotle, *Prior Analytics*, p. 197.

12. Euclid, *Elements*, pp. 153–155.

13. Kline, *Mathematics*, 'Preface'.

14. Stewart, *Modern Mathematics*, p. 286.

15. Schumacher, *Guide for the Perplexed*, p. 15.

16. Boole, *Laws of Thought*, p. 1.

17. Leibniz, *Logical Papers*.

18. MacHale, *George Boole*, p. 19.

19. George Boole, 'On a General Method in Analysis', *Philosophical Transactions of the Royal Society of London*, Vol. 134, pp. 225–282, 1844.

20. Kline, *Mathematics*, pp. 90–91.

21. Boole, *Mathematical Analysis of Logic*, Slater introduction, p. v.

22. MacHale, *George Boole*, pp. 51, 57, and 64–66.

23. *Ibid.*, pp. 52–54.

24. *Ibid.*, pp. 2–3.

25. *Ibid.*, pp. 17–22.

26. *Ibid.*, pp. 61–62.

27. Boole, *Mathematical Analysis of Logic*, Slater introduction, p. vii.

28. MacHale, *George Boole*, pp. 105–106.
29. Ibid., pp. 252–276.
30. MacHale, *George Boole*, p. 68.
31. Boole, *Laws of Thought*, pp. 27–29.
32. Ibid., p. 33.
33. Ibid., p. 238.
34. Ibid., pp. 31–32.
35. Ibid., pp. 47–51.
36. Boole, Mary, ‘Indian Thought’, p. 952.
37. MacHale, *George Boole*, pp. 131–132.
38. Boole, ‘Indian Thought’, pp. 947–967.
39. MacHale, *George Boole*, p. 105.
40. Boole, ‘Indian Thought’, p. 950.
41. Ibid., p. 954.
42. Ibid., pp. 953–954.
43. Ibid., p. 950.
44. Ibid., p. 948.
45. Ibid., p. 951.
46. Ibid., pp. 952–953.
47. Ibid., p. 948.
48. Ibid., pp. 954–955.
49. Ibid., p. 959.
50. Ibid., p. 956.
51. Rota, *Indiscrete Thoughts*, p. 4.
52. Dummett, *Frege: Philosophy of Language*, p. xii.
53. Russell, B. ‘Experiences of a Pacifist’, p. 33.
54. Monk, *Bertrand Russell: Spirit of Solitude*, pp. 12–13.
55. Monk, *Bertrand Russell: Ghost of Madness*, pp. 500–502.
56. Hodges, *Alan Turing*, pp. 487–492.
57. Houser, et al, *Studies in the Logic of Charles Sanders Peirce*.
58. Brady, *Contributions of Peirce etc. to First-Order Logic and From Peirce to Skolem*.
59. De Morgan, *On the Syllogism*, introduction by Heath, pp. vii–viii.
60. Ibid., pp. ix and xxiv.
61. De Morgan, *Formal Logic*, p. 1.
62. De Morgan, *On the Syllogism*, introduction by Heath, p. xxiv.
63. *The Penny Cyclopædia of the Society for the Diffusion of Useful Knowledge*, Vol. XII, 466/1, 1838, article on **induction (mathematics)**. Wikipedia says that De Morgan wrote this ar-

ticle, using the term *mathematical induction* for the first time in English: “An instance of mathematical induction occurs in every equation of differences, in every recurring series, &c.,” from OED.

64. Pólya, *How to Solve It*, p. 114.
65. De Morgan, *Formal Logic*, pp. 243–244.
66. Euclid, *Elements*, Volume 2, Book IX, proposition 20, pp. 412–413.
67. Brent, *Peirce*, pp. 209–211.
68. Peirce, *Writings of Charles S. Peirce*, introduction by Fisch, pp. xv–xvii.
69. Brent, *Peirce*, p. 35.
70. *Ibid.*, pp. 60–63.
71. *Ibid.*, pp. 36–37.
72. <http://www.universetoday.com/77525/nebular-theory/>.
73. Brent, *Peirce*, pp. 131–132, quoted from Peirce, B., *Ideality in the Physical Sciences*, p. 9.
74. Peirce, B., *Ideality in the Physical Sciences*, p. 7.
75. Peirce, *Writings*, Volume 1, 1857–1866, pp. 1–3, ‘My Life’, 1859.
76. *Ibid.*, p. 163.
77. *Ibid.*, pp. 163–167.
78. Brent, *Peirce*, p. 100.
79. Peirce, *Collected Papers: Simplest Mathematics*, ¶¶ 4.12–4.20, with editors’ note p. 13, and Peirce, *Writings*, 1879–1884, pp. 218–221, MS 535.
80. Peirce, *Collected Papers: Simplest Mathematics*, ¶¶ 4.264.
81. *Ibid.*, ¶¶ 4.227–4.322, MS 429.
82. *Ibid.*, ¶ 4.229.
83. *Ibid.*, ¶¶ 4.258–4.261.
84. Clark, ‘Peirce’s Iconic Notation for the Sixteen Binary Connectives’ p. 305.
85. Peirce, *New Elements of Mathematics: Mathematical Miscellanea*, pp. 272–275.
86. Post, ‘General Theory of Elementary Propositions’, pp. 267–269.
87. Wittgenstein, *Tractatus Logico-Philosophicus*, ¶ 4.31, p. 38.
88. http://en.wikipedia.org/wiki/De_Morgan%27s_laws.
89. http://en.wikipedia.org/wiki/Modus_ponens.
90. Nagel and Newman, *Gödel’s Proof*, pp. 48–49.
91. *Ibid.*, p. 49.
92. De Morgan, *On the Syllogism*, p. 208. De Morgan’s two references to the first mention of relations are on pages 56 and 107.
93. *Ibid.*, p. 119.
94. Kline, *Mathematics*, p. 186.
95. De Morgan, *On the Syllogism*, p. 119.

96. Brent, *Peirce*, p. 242.
97. Ketner, et al., *Bibliography of the Published Works of Charles Sanders Peirce*, p. 7.
98. Peirce, 'Description of a Notation for the Logic of Relatives'.
99. Peirce, *Writings*, 1867–1871, p. xlii.
100. Brady, *From Peirce to Skolem*, p. 23.
101. Brent, *Peirce*, p. 79.
102. <http://www.lib.noaa.gov/noaainfo/heritage/coastandgeodeticsurvey/index.html> .
103. Brent, *Peirce*, pp. 120 and 366.
104. *Ibid.*, pp. 120–121.
105. *Ibid.*, pp. 121–125.
106. Peirce, 'On the Algebra of Logic', 1880.
107. Members of Johns Hopkins University, *Studies in Logic*.
108. Peirce, 'On the Algebra of Logic', 1885.
109. Brady, *From Peirce to Skolem*, p. 113.
110. Peirce, 'The Logic of Relatives'.
111. Peirce, *Writings*, 1879–1884, p. xl, Introduction by Nathan Houser.
112. Brent, *Peirce*, pp. 153 and 151.
113. *Ibid.*, pp. 150–151.
114. *Ibid.*, p. 197.
115. Peirce, *Writings*, 1879–1884, p. xli, Introduction by Nathan Houser.
116. Brent, *Peirce*, pp. 279–289.
117. *Ibid.*, p. 249.
118. *Ibid.*, pp. 306–307.
119. *Ibid.*, p. 223.
120. http://en.wikipedia.org/wiki/Paul_Carus, Tweed, *American Encounter with Buddhism*, pp. 65–67.
121. Brent, *Peirce*, p. 231.
122. *Ibid.*, pp. 228–230.
123. Peirce, *Essential Peirce*, 1893–1913. note 15, p. 505.
124. *Ibid.*, p. 30.
125. Peirce, *Collected Papers: Bibliography*, pp. 287–288.
126. Peirce, *Reasoning and the Logic of Things*, p. 2.
127. *Ibid.*, p. 141.
128. *Ibid.*, p. 26.
129. Brady, *From Peirce to Skolem*, p. 9.
130. http://en.wikipedia.org/wiki/Finitary_relation.

131. Weisstein, Eric W. 'Relation'. From *MathWorld*—A Wolfram Web Resource. <http://mathworld.wolfram.com/Relation.html>.
132. Weisstein, Eric W. 'Cartesian Product'. From *MathWorld*—A Wolfram Web Resource. <http://mathworld.wolfram.com/CartesianProduct.html>.
133. http://en.wikipedia.org/wiki/Cartesian_product.
134. http://en.wikipedia.org/wiki/Relational_algebra.
135. http://en.wikipedia.org/wiki/Relation_algebra.
136. Codd, 'A Relational Model of Data for Large Shared Data Banks', p. 383.
137. http://en.wikipedia.org/wiki/Relational_algebra.
138. Ibid.
139. <http://en.wikipedia.org/wiki/Begriffsschrift>.
140. Brady, *From Peirce to Skolem*, pp. 2 and 6.
141. Ibid., p. 7.
142. van Heijenoort, *From Frege to Gödel*, p. 1.
143. Ibid., p. 2.
144. Hintikka, *Lingua Universalis vs. Calculus Ratiocinator*, p. ix
145. van Heijenoort, *From Frege to Gödel*, pp. 1–2.
146. Pratt, *Thinking Machines*, pp. 9–90.
147. Van Heijenoort, *Frege to Gödel*, pp. 124–125.
148. Ibid., p. 127.
149. Ibid., pp. 127–128.
150. Russell, *Principles of Mathematics*, p. 523.
151. Gray, *The Hilbert Challenge*.
152. The first of these problems was concerned with proving that the continuum—the set of the infinitely many real numbers—is the next infinite cardinal after the countable set of natural numbers, \aleph_0 . In mathematical symbolism $c = \aleph_1 = 2^{\aleph_0}$. This was known as the continuum hypothesis: there is no infinite cardinal between \aleph_0 and \aleph_1 . As a natural extension of this, the generalized continuum hypothesis states that no infinite cardinal exists between \aleph_n and \aleph_{n+1} . In the event, in 1940, Gödel proved that the generalized continuum hypothesis is consistent with the axioms of set theory. That is, the generalized continuum hypothesis cannot be disproved whether the axiom of choice is used or not. (Gödel, K. (1940). *The Consistency of the Continuum-Hypothesis*. Princeton University Press.) Then in 1963, Paul Cohen proved that this hypothesis could not be proved either. In other words, the generalized continuum hypothesis is independent of the axioms of set theory. (Cohen, P. J. (1966). *Set Theory and the Continuum Hypothesis*. W. A. Benjamin.)
153. http://en.wikisource.org/wiki/Mathematical_Problems.
154. Whitehead and Russell, *Principia Mathematica*, p. 360.

155. Ibid., pp. 205–215.

156. Russell, B., ‘Reflections on My Eightieth Birthday’, p. 53.

157. Russell, B., ‘Why I Took to Philosophy’, pp. 19–21.

158. Kline, *Mathematics*, p. 221.

159. Whitehead and Russell, *Principia Mathematica*, p. 37.

160. Kline, *Mathematics*, p. 260.

161. Gödel, *On Formally Undecidable Propositions of Principia Mathematica*, p. 37.

162. Ibid., p. 45.

163. Nagel and Newman, *Gödel’s Proof*, pp. 72–73.

164. Ibid., pp. 73–74.

165. Kline, *Mathematics*, p. 262.

166. Ibid., pp. 262–263.

167. Lucas, ‘Minds, Machines and Gödel’, pp. 43–45.

168. Hofstadter and Dennett, *Mind’s I*, p. 470.

169. <http://en.wikipedia.org/wiki/Church-Turing>.

170. <http://en.wikipedia.org/wiki/Entscheidungsproblem>.

171. http://en.wikipedia.org/wiki/Halting_problem.

172. Perhaps the simplest example of a noncomputable function is one introduced by Tibor Radó in 1962 in a paper called ‘On Noncomputable Functions’. In what has come to be known as the Busy beaver problem, Radó defined an n -state Turing machine whose purpose is to write as many 1s on a blank tape consisting only of 0s and then halt. Surprisingly, there is no algorithm that can prove what the maximum number of 1s is for a particular n -state machine. I first explored this function using Turing’s World, a program developed by Jon Barwise and John Etchemendy of the Center for the Study of Language and Information at Stanford University. Unfortunately, this program does not work under Mac OS X, so it is now defunct. However, you can try out the Busy beaver problem and other Turing machines at <http://ironphoenix.org/tril/tm/>.

173. Alonzo Church, ‘An unsolvable problem of elementary number theory’, *American Journal of Mathematics* (58, 1936), pp. 345–363.

174. A. M. Turing, ‘On Computable Numbers, with an Application to the Entscheidungsproblem’, *Proceedings of the London Mathematical Society*, (Series 2, Volume 42, 1936), pp. 230–265.

175. http://en.wikipedia.org/wiki/Busy_beaver.

176. <http://www.logique.jussieu.fr/~michel/ha.html#tm52>.

177. Kline, *Mathematics*, 216–257.

178. Kilmister, *Language, Logic, and Mathematics*, p. 120.

179. Gray, *Hilbert Challenge*, p. 10.

180. Derbyshire, *Prime Obsession*.
181. <http://www.claymath.org/millennium/>.
182. <http://mathworld.wolfram.com/PowerSum.html>.
183. http://en.wikipedia.org/wiki/Johann_Faulhaber.
184. http://en.wikipedia.org/wiki/Faulhaber%27s_formula.
185. http://www.trans4mind.com/personal_development/mathematics/series/sumsBernoulliNumbers.htm.
186. http://en.wikipedia.org/wiki/Bernoulli_number.
187. <http://mathworld.wolfram.com/BernoulliNumber.html>.
188. Woolley, *Bride of Science*, p. 269.
189. Derbyshire, *Prime Obsession*, p. 105.
190. http://en.wikipedia.org/wiki/Prime_number_theorem.
191. http://en.wikipedia.org/wiki/Riemann_zeta_function.
192. <http://mathworld.wolfram.com/RiemannZetaFunction.html>.
193. Derbyshire, *Prime Obsession*, p. 216.
194. du Sautoy, *Music of the Primes*, p. 85.
195. *Ibid.*, p. 99.
196. Derbyshire, *Prime Obsession*, pp. 190–191.
197. *Ibid.*, p. 233.
198. Hugh L. Montgomery in *The Cosmic Code Breakers: The Struggle to Prove the Riemann Hypothesis*, television programme produced by NHK, 2011.
199. Freeman Dyson in *Cosmic Code Breakers*.
200. Commentator in *Cosmic Code Breakers*.
201. Derbyshire, *Prime Obsession*, p. 321.
202. **Roger Bacon**, *Encyclopædia Britannica*, 2008.
203. Quinton, *Francis Bacon*, p. 30.
204. Bacon, *Major Works*, pp. 120–299.
205. Bacon, *New Organon*, p. xii.

206. The OED does not attempt to improve on the definition of mathematical induction given in the seventh edition of *Algebra*, published in 1875, by Todhunter: “We prove that if a theorem is true in one case, whatever that case might be, it is true in another case which we may call the next case; we prove by trial that the theorem is true in a certain case; hence it is true in the next case, and hence in the next to that, and so on; and hence it must be true in every case after that with which we began”.

For instance, suppose we want to find a formula for the sum of the first n integers. We first sum the first few integers, obtaining this series of numbers: 1, 3, 6, 10, 15, 21. We can observe a pattern in this series. Each term is half the product of two numbers: 1×2 , 2×3 , 3×4 ,

4x5, 5x6, 6x7. We therefore surmise that the general formula for the sum of the first n integers is $n(n+1)/2$. We then add $n+1$ to this formula, and obtain $(n^2+3n+2)/2$, which equals $(n+1)(n+2)/2$, which satisfies the general formula. We then observe that the formula is correct for $n=1$. It must therefore be correct for all values of n .

207. Chalmers, *What is This Thing Called Science?*, p. 5.

208. George, *Precision, Language and Logic*, p. 72.

209. Popper, *Objective Knowledge*, p. 4. Hume's scepticism about the principle of induction is given in Hume, *Human Understanding*, pp. 108–118.

210. Davies, *God and the New Physics*, pp. 200–201.

211. Popper, *Objective Knowledge*, p. 4.

212. *Ibid.*, p. 4.

213. Russell, *Western Philosophy*, p. 646.

214. Chalmers, *Science*, p. 63.

215. Popper, *Conjectures and Refutations*.

216. Chalmers, *Science*, p. 55.

217. Kuhn, *Scientific Revolutions*, p. 10.

218. The Copernican revolution of the sixteenth and seventeenth centuries is well known (see, for instance, Koestler, *Sleepwalkers*). However, the story of the discovery of oxygen is less well known. Although C. W. Scheele, a Swedish apothecary, was probably the first to prepare a reasonably pure sample of oxygen, as he did not immediately publish his work, it was an Englishman, Joseph Priestley, who is generally credited with the discovery of oxygen in 1775. Priestley's work greatly influenced that of the Frenchman, Antoine-Laurent Lavoisier, who created the concept of oxygen.

However, Priestley could never accept Lavoisier's oxygen theory of combustion. To Priestley, oxygen was dephlogisticated air. He was not able to make the fundamental paradigm change that was to lead to the chemical revolution, begun by Lavoisier (Kuhn, *Scientific Revolutions*, pp. 53–56).

A similar situation holds today. There are many scientists who are mystics, who know the Divine in their own direct experience. Yet they are not yet able to free themselves of familiar paradigms that would enable them to see Reality as a complete Whole.

219. Kuhn, *Scientific Revolutions*, p. 112.

220. A relativist is one who adheres to the doctrine that there are no absolutes, that knowledge is only of relationships, relative to particular situations and contexts.

221. Chalmers, *Science*, p. 80.

222. *Ibid.*, p. 81.

223. Feyerabend, p. 19.

224. *Ibid.*

225. Chalmers, *Science*.

226. Wilber, *Marriage of Sense and Soul*, p. 18.

227. An essay on these three eyes was first published in *ReVision*, vol. 2, #1, 1979, republished in *Eye to Eye* (1983). This theme was then further developed in *The Eye of Spirit* (1997) and *The Marriage of Sense and Soul* (1998).

228. Wilber, *Marriage*, pp. 155–156.

229. de Tocqueville, *Democracy in America*.

230. Mill, *On Liberty*.

231. <http://public.web.cern.ch/Public/Content/Chapters/AboutCERN/WhyStudyPrtcles/WhyStudyPrtcles-en.html>.

232. <http://www.telegraph.co.uk/core/Content/displayPrintable.jhtml?xml=/news/2006/11/30/uhawking130.xml&site=5&page=0>.

233. It was for this reason that I abandoned physics as a sixteen year old. On the wall of the physics laboratory at school, there was a poster showing the subatomic particles that had been discovered until that time. But I could see that we could never know when we had reached the end of this quest because the human mind is capable of analysing structures ad infinitum. So it was quite clear to me that physics could not form the basis of all science. I therefore studied economics rather than physics as the required subsidiary subject at university, which was an even greater disaster.

234. <http://origins.jpl.nasa.gov/about/index.html>.

235. <http://www.seti.org/site/pp.asp?c=ktJ2J9MMIsE&b=178899>.

236. Bohm, *Implicate Order*, p. xi.

237. *Ibid.*, p. 11.

238. *Ibid.*, pp. 14–15.

239. *Ibid.*, pp. 148–149.

240. *Ibid.*, p. 149.

241. *Ibid.*, p. 150.

242. *Ibid.*, p. 150.

243. *Ibid.*, p. 149.

244. *Ibid.*, p. 145.

245. *Ibid.*, p. 146.

246. *Ibid.*, p. 198.

247. *Ibid.*, p. 176.

248. *Ibid.*, p. 187.

249. Osho, *Hidden Harmony*, p. 208.

250. Whitehead, *Process and Reality*.

251. *Ibid.*, p. 48.

252. Ibid., p. 178.

253. Zohar, *Quantum Self*, p. 124.

254. Ibid., p. 207.

255. <http://harmoniccontinuum.50megs.com/custom3.html>.

256. Mark Comings, 'The Courage to Change: An Exploration into Time, Space, Light and Mind', DVD (Sirius Media, 2005).

257. Private conversation with David Bohm in Prague in April 1992 at a conference organized by the International Transpersonal Association called 'Science, Spirituality, and the Global Crisis'.

258. These fonts were distributed with the CorelDraw program that I used when working for IBM in a software development laboratory on a beautiful island in the Stockholm archipelago in the early 1990s.

259. John I, 4:16.