Science in the Nursery

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The Popularisation of Science in Britain and France, 1761-1901

Edited by

Laurence Talairach-Vielmas

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To F. D., of course, for teaching me what popularisation was
and to all those who believe in the dissemination of knowledge

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All the papers included here are original publications, with the exception of James A. Secord's essay in Chapter 1, "Newton in the Nursery: Tom Telescope and the Philosophy of Tops and Balls, 1761–1838", which originally appeared in the *Journal of History of Science*, 23 (1985): 127–51. I wish to thank the editors for permission to re-use that material here.

INTRODUCTION

LAURENCE TALAIRACH-VIELMAS

> During the progress of the last fifty years, more than in any other similar period of her history, England has become in an eminent degree a refined and intellectual nation. While the wonders of modern science have engaged her men of genius, educational institutions have so popularized science and the politer arts, that a love of knowledge for its own sake may be said to be one of the distinguishing characteristics of the age.[1]

From the seventeenth century onwards, scientific advances and the complexification of scientific discourse have opened a gap between scientists and "the people". As a consequence, by the end of the seventeenth century, there was a growing sense that more democratic attitudes towards knowledge were required if this gap was to be bridged. Though the word "scientist" was not coined before 1833, when it appeared in William Whewell's anonymous review of Mary Somerville's *On the Connexion of the Physical Sciences*,[2] the emergence of a scientific discourse which was more and more difficult for nonprofessionals to decode may be traced back to when *Le Journal des sçavans* was published in France on 5 January 1665, quickly followed by *The Philosophical Transactions* in London two months later. It is not coincidental, therefore, that the first works of science popularisation appeared at that time. More were published throughout the eighteenth century, but in the nineteenth century the market for such publications exploded, benefitting from the expansion of print culture. Because science became professionalized and research highly specialized, nineteenth-century nonprofessionals felt the need to popularise the latest scientific and technological discoveries in order to make them known to the growing reading public.[3] Gradually, scientists interested in disseminating their own scientific discipline competed with popularisers eager to tap into the commercial potential of popularisation. Popular science publications and events then became more and more sensational and spectacular, especially in the second half of the nineteenth

century, and they took a variety of forms. They ranged from museums and travelling exhibitions to public lectures and, of course, mass-marketed books. With the industrial revolution, the boom in the book industry and the lower costs of publication made books available to people from different social classes.[4]

The focus on science was boosted further in the 1870s after the passing of the Education Act which aimed to educate the workers and increase the literacy rate of the newly enfranchised urban working class after the Reform Act of 1867. Scientific education was believed to teach the working classes how to exercise their reasoning powers and hence ensure the health, competitive power and dominance of England over Europe, becoming thereby "a national service performed by practitioners rather than a private pursuit for commercial gain".[5] Be it in specialist journals, like *Nature*, or advice and etiquette books, like Mrs. Ellis's *The Daughters of England*, the popularisation of science permeated nineteenth-century culture. Moreover, because scientific work became progressively located in laboratories, when research was being carried out using new technological aids, such as microscopes, it became more exclusively masculine. As Mary Hilton notes, "[t]he focus of biology, entomology and mineralogy had shifted away from taxonomy, a process to which women and amateurs could contribute with specimens and observations, and had moved towards the structures of living and inert materials".[6] As a consequence, in England, women, who were excluded from universities and scientific societies, became both involved in popularisation and targetted by popular science publications. In *The Daughters of England*, for instance, Mrs. Ellis regards science as a good means to render women more companionable to men. Though she does not recommend the attendance of public lectures (women did, in fact, attend scientific lectures), Ellis encourages "a slight knowledge of science":

> Certainly not to give public lectures, nor always to attend them, unless you go, with your understanding prepared by some previous reading, or acquaintance with the subjects, which in the lecture-room are necessarily rather illustrated, than fully explained. Neither is it necessary that you should sacrifice any portion of your feminine delicacy by diving too deep, or approaching too near the professor's chair. A slight knowledge of science in general is all which is here recommended….[7]

Ellis's advocacy of science for women, if moderate, was also linked to the educational role women played at home. Indeed, scientific subjects were absent from most school curricula in the nineteenth century (science teaching did not appear in French school curricula before 1880–82), and

popular works were the sole means of access to scientific knowledge for children. By the end of the eighteenth century, children's education had nevertheless to include some science. In addition to books, "instruments of 'rational entertainment'"[8] for parlour games invaded middle-class homes. These expensive toys, "cleverly advertised under the guise of education",[9] provide evidence that science belonged to the nursery, being supervised and selected by women, who not only read but also wrote popular science books within the safe precincts of the home. In the literary field, as shall be seen in this collection, book formats varied, using dialogue or more sensational narrative methods, gradually moving away throughout the nineteenth century from moralising parables towards adventurous expeditions offered to juvenile and older readers to discover the marvels of science.

As the essays in this collection show, such transformations of the formats and narrative techniques of works of popularisation revealingly went hand in hand with the development of children's literature. Children's literature was to emerge over a long period as a fully distinct genre. Throughout the eighteenth century, children's literature had been designed to purvey religious lessons, and the children's book industry was mostly limited to such books as conformed to prevailing moral standards. Though more and more chapbooks (popular pamphlets aimed at the masses) suggested that literature for children could be entertaining, books such as Isaac Watts's *Divine Songs, Attempted in Easie Language for the Use of Children* (1715) still prominently figured on the bookshelves of the nursery.[10] Thus, dry didacticism and moralising had branded eighteenth-century publications for children which saw amusement and education as being poles apart. Nurtured by didactic stories in the vein of Maria Edgeworth's narratives and sermons,[11] children were protected from the dangers of the imagination and trained to become industrious and responsible citizens. It is certainly when the publisher John Newbery (1713–1767) started to merge amusement and instruction in his publications for children that the market for children's literature was launched.[12] Though his *Lilliputian Magazine* (1751–52) was a failed commercial venture, many of his books sold well, illustrating the expansion of the children's literature market.[13] Newbury's first *Little Pretty Pocket Book* (1744), often regarded as the first children's book, undoubtedly marked the invention of children's literature. However, the book was perhaps, as Mary Hilton argues, less influential than Newbery's *The Philosophy of Tops and Balls; or, The Newtonian System of Philosophy, adapted to the capacities of young gentlemen and ladies, and familiarized and made entertaining by objects with which they are intimately acquainted: being*

the substance of six lectures read to the Lilliputian Society, by TOM TELESCOPE, A. M. and collected and methodized for the benefit of the youth of these kingdoms, by their old friend, MR. NEWBERY, in St. Paul's Church Yard (1761)—an adaptation of Locke's treatise, *Elements of Natural Philosophy*[14], which fully exploited the pattern of the conversation between teacher and child still to be found in mid-nineteenth-century works such as Charles Kingsley's *Madam How and Lady Why* (1869) or John Ruskin's *Ethics of the Dust* (1865).[15] In addition, Newbery's publications for children, if entertaining, often retained some reference to the naturalistic, a practice which later characterised most of the popular science publications by women. As Hilton contends, moreover, Newbery's conversational style in *Tom Telescope* "both enacts and describes the excitement of teaching and learning of scientific principles, proving a source of new ideas for the participants to play with", and which the subsequent popular science books by women would fully capitalize on.[16]

Among the most famous authors of works of science popularisation directed at a juvenile audience were Anna Lætitia Barbauld (1743–1825), Sarah Trimmer (1741–1810), Priscilla Bell Wakefield (1751–1832), Margaret Bryan (1780–1818) (on physics, magnetism or astronomy) and Jane Marcet (1769–1858). Wakefield's popularisation of botany for girls in her *Introduction to Botany in a Series of Familiar Letters* (1796), offering an overview of Linnean taxonomy (albeit desexualizing Linnaeus's system), or Marcet, whose *Conversations on Chemistry* (1805) inspired Michael Faraday, just like Barbauld, Trimmer or Bryan were key figures involved in children's instruction and the development of children's literature. If many of their publications remained highly didactic and moralising, using science more to mould children's minds to bourgeois standards of behaviour than to actually transmit knowledge, their popular science books typify the evolution of children's literature from the mid-eighteenth century on, as entertaining tales appeared more and more alongside moral stories. John Aikin's and Anna Lætitia Barbauld's *Evenings at Home; or, the juvenile budget opened* (1792–96), a collection of narratives combining natural history and more "scientific" topics, such as chemistry or astronomy, with poetry and moral stories, increased the importance of amusement. Though still rather instructive and repressive of fancy, Aikin's and Barbauld's method was, however, disapproved of by the religiously more orthodox Sarah Trimmer, whose periodical, *The Guardian of Education* (1802–1806), reviewed children's literature for the first time. Deeply involved in education, Trimmer founded several Sunday schools and charity schools, writing textbooks and manuals for women to start their own schools.

As an influential children's book reformer, Trimmer remains most famous today for her strict condemnation of the use of imagination in children's literature such as fairy stories. Her methods and tastes position her poles apart from educationalists advocating Rousseauist approaches to children's literature. Her writings closely tied science to revealed religion, rather than seeking to develop rational faculties in children's minds.[17] Yet, Trimmer's works for children, despite their moralising tone, are paradigmatic instances of women's knowledge and enthusiasm for natural history in the mid-eighteenth century. Indeed, most textbooks and guides dealing with natural philosophy were written by women and aimed at girls and women.[18] As Mary Hilton underlines, throughout the eighteenth century, women writers were leaders in the educational market and authored many a popular text. Defining themselves as the "nations's teachers", they "reached out from the literary world to construct a variety of intellectual and pedagogical practices, propagating culture through a variety of educational formats, from treatises and popular guides, to conduct books, stories and handbooks.[19] This important link between women and education and the construction of women as repositories of culture or agents in the dissemination of knowledge underlie some of the articles gathered in this collection. Following Aikin and Barbauld, women gradually moved away from didactic literature to propose popular science texts which played upon narrative strategies and highly visual rhetoric to redefine science as no longer dry and boring. The populariser Arabella Buckley (1840–1929) is a case in point, as shall be seen in Chapters 4, 5 and 8. Indeed, at the beginning of the nineteenth century, the booksellers Benjamin Tabart and John Harris (Newbery's successor)[20] started publishing animal tales which avoided didacticism, and promoted a new view of children's literature as visual and entertaining rather than instructive. Sarah Catherine Martin's *The Comic Adventures of Old Mother Hubbard and Her Dog* (1805), William Roscoe's *The Butterfly's Ball* (1807) or Catherine Dorset's *Peacock "At Home"* (1807)—a few of them collected in John Harris's *Harris's Cabinet of Amusement and Instruction* (1807–1809)—, figured animals, birds or insects, anthropomorphized them humorously and offered fantasies poles apart from earlier dry didactic works. These new tales paved the way for Victorian popularisers of science and publishers who attempted to capture the interest of their young readers and who fully exploited the narrative quality of certain scientific topics.

As the essays in this collection emphasize, by combining studies of fictional and nonfictional narratives popularising science, nineteenth-century popular science texts, whether written by men or by women, constantly

look at science from a literary point of view. To a certain extent, in so doing, these texts show that eighteenth and early nineteenth-century works of popularisation for children were indebted to earlier fables written for children, in which stories of the natural world were merged with moral lessons aimed to educate children. Indeed, before the eighteenth century, the one category of fiction which was generally accepted in the nursery were tales in the vein of Aesop's *Fables* (first translated into English in 1484).[21] Aesop's *Fables* and bestiaries provided children with a little knowledge in natural history until Buffon's *Histoire Naturelle* was adapted for children or the publication of Oliver Goldsmith's (1728–1774) eight-volume *A History of the Earth and Animated Nature*. At the end of the eighteenth century, Dorothy Kilner's *Life and Perambulation of a Mouse* (1783) or Sarah Trimmer's *Fabulous Histories: Designed for the Instruction of Children Respecting Their Treatment of Animals* (1786), later published as *The History of the Robins*, for instance, which used talking animals to teach children about social mores, exemplify the way plants and animals, creatures belonging to the natural world, became significant educational objects to inculcate morality and respect in children's minds. Simultaneously, as stressed by Trimmer's title, these books interestingly taught children to behave with Christian benevolence towards the natural world. As Trimmer and many others contended, man's position and power over all living beings at the head of creation should not give man the right to kill or torment inferior creatures. Trimmer's *Fabulous Histories* placed side by side a family of humans and a family of robins, the robins standing as a representation of proper human behaviour. Likewise, as shall be seen, many nineteenth-century popular science works, as well as fantasies, condemned the exploitation and mistreatment of animals, a theme which gained even more significance with the rise of anti-vivisectionism in the last decades of the century—paving the way for Anna Sewell's *Black Beauty* (1877).

With the expansion of urbanization in England and the growing mechanization of life, women popularisers of science mostly turned towards the natural world, as exemplified by the numerous works by Sarah Bowdich (1791–1856), Mary Roberts (1788–1864), Agnes and Maria Catlow, Elizabeth (1823–1873) and Mary (1817–1893) Kirby, or Eliza Brightwen (1830–1906). In the field of botany, following in the footsteps of Priscilla Bell Wakefield, Ann Pratt (1806–1893), Jane Loudon (1807–1858), Phebe Lankester (1825–1900), Elizabeth Twining (1805–1889), Lydia Becker (1827–1890), or Sarah Tomlinson all authored significant examples of popular science books. Geology was also tackled, as Rosina Zornlin's (1795–1859) *Outlines of Geology for Families and Schools* (1852)

exemplifies[22], and even astronomy, as shown by the works of Agnes Clerke (1842–1907) and Agnes Giberne (1845–1939). Such a variety of popular science books aimed at different classes of readers illustrates nicely the way in which nineteenth-century popularisers gradually moved away from Buffon and Linnaeus (or Newton in physics and astronomy and Franklin in electricity) and revamped popularisation. These popular science books also benefitted from the advances in printing technology which enabled publishers and popularisers to offer ever more attractive books, including images (from wood-engraved illustrations to colour plates), thereby radically transforming popular culture.[23]

Natural history was also a key topic in many of the children's weeklies and monthly magazines which boomed in the 1850s as the lower costs of production and distribution opened the market of juvenile literature even further. From Samuel Beeton's *Boy's Own Magazine* (founded 1855), W. H. G. Kingston's *Magazine for Boys* (founded 1859) and the *Boy's Own Paper* (founded 1879) to Margaret Gatty's *Aunt Judy's Magazine* (founded 1866), more exclusively intended for girls and probably influenced by the French children's magazine *Le Magasin d'Education et de Récréation*,[24] children's magazines toned down religious material in order to entertain children with a mix of fiction and secular instruction, not unfrequently using nature studies or featuring explorers and scientists as a means of merging instruction and entertainment.[25] Richly illustrated, these publications typified the increasing dependence on pictures in multiple forms of popularisation. But the use of visual images in such publications and books metamorphosed representational practices. At a time when science itself was becoming increasingly material there was an urge to make science more visible and tangible. These visual images went hand in hand with rhetorical images, nineteenth-century scientific discourse being frequently interwoven with figurative language, creating narratives poised between science and literature, especially in the publications which followed Charles Darwin's *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (1859), as shall be seen, which attempted to popularise natural selection and evolution.

Recent studies have illuminated the significance of eighteenth- and nineteenth-century popularisers of science, rehabilitating, in so doing, long-neglected yet very important cultural figures and the role they played as "authoritative guides", disseminating knowledge to the masses.[26] However, if scholarly analyses of popularisation and its meanings have been published over the last decades,[27] the cultural dimension of science has rarely been studied through the lens of children's literature, since

children's literature criticism generally tends to examine imaginative fiction. Thus, the comparison of children's fiction and non-fiction will attempt to evaluate theories of the knowledge-generating function of literature. Furthermore, this collection addresses the ways in which the popularisation of science, whether in non-fictional or in fictional children's literature, engages with wider debates and issues, concerning such topics as gender or religion. It focusses on works between the middle of the eighteenth century, when children's literature emerged as a genre, to the very end of the Victorian period and the beginning of the twentieth century. Revealingly, each individual essays brings home how in the nineteenth century, as science was becoming more and more secular, children's literature emphasized its imaginative potential, revealing the contemporary tensions confronted by professional scientists. Hence, this collection aims to contribute to the larger body of scholarship on Victorian science popularisers, from the works of Bernard Lightman on Victorian science and popularisers of science to Ann B. Shteir's or Barbara T. Gates's studies of women popularisers.[28] It also seeks to develop the approaches to eighteenth and nineteenth-century popularisation of science for children pioneered by Aileen Fyfe, Alan Rauch, Tess Cosslett, and Harriet Ritvo.[29] More significantly, it attempts to compare and contrast the popularisation of science for children in Britain and France during the same periods, in order to illuminate the tensions and show how they were dealt with in the two countries. In so doing, the collection highlights the circulation of popular science works across the Channel, suggesting how this influenced scientists and cultural practices alike in both countries. This wide-ranging exploration of children's literature thus seeks to offer a cultural framing of science and its development(s) in France and Britain and examines perceptions and understandings of science and their communication in language and visual images.

The collection starts with a chapter on one of John Newbery's works for children. In Chapter 1 ("Newton in the Nursery: Tom Telescope and the Philosophy of Tops and Balls, 1761–1838"),[30] James Secord looks at the way in which Newbery popularised eighteenth-century natural philosophy, generally known as the Newtonian philosophy or Newtonianism. Tom Telescope's lectures at the "Lilliputian Society"—Newbery's innovation in the field of juvenile publishing aimed at presenting Enlightenment science to a young audience—points out Newbery's efforts to make science entertaining. As Secord contends, Newbery's text was revised successively in 1794, 1806, 1827 and 1838. Each new version of Newbery's work not only aimed to compete with new titles in the field of juvenile science, but also reflected the need to constantly adapt publication

to the audience and to the changing view of scientific knowledge. Secord's focus on how the "wonders of science" found and maintained a place in the domestic privacy of the nursery is of capital importance for our understanding of the evolution of science for children from the mid-eighteenth century to the end of the Victorian period. Secord's essay examines the social meaning of science stressed in Tom Telescope's lectures and its reception in the early nineteenth century, recalling, for instance, how Mrs. Trimmer reviewed the 1806 edition, and illuminating the ways in which Newbery's blend of moral instruction and entertainment influenced later popular science works for children.

The following chapter, by Alan Rauch ("The Pupil of Nature: Science and Natural Theology in Maria Hack's *Harry Beaufoy*"), deals with Maria Hack's popularisation of William Paley's *Natural Theology; or, evidences of the existence and attributes of the Deity* (1802). Unlike other women popularisers, such as Jane Marcet and Priscilla Wakefield, who popularised general ideas in science, Maria Hack worked specifically with one text and one writer. Paley's *Natural Theology* played a significant role in the development of nineteenth-century British biology, deeply influencing an emerging movement in the British biological and geological sciences, led by figures such as Charles Lyell (1797–1875), Richard Owen (1804–1892), and, of course, Charles Darwin (1809–1882). Paley's works, including *Natural Theology*, continued to be taught at universities, especially his own *alma mater*, Cambridge, up until the early twentieth-century. As Rauch argues, although Paley died only three years after the publication of *Natural Theology*, his work found an energetic and enthusiastic populariser in Maria Hack (1777–1844). Hack's works for children, from *First Lessons in English Grammar* (1812), *Winter Evenings* (1818), *Grecian Stories* (1819) to *English Stories* (1820–25), had already sealed her fame as a children's writer before the publication of *Harry Beaufoy; or, the pupil of nature*. In 1821, and so less than two decades after the original "source" work appeared, Hack published *Harry Beaufoy; or, the pupil of nature*, which revamped Paley's arguments for the consumption of children. Hack subsequently published several works featuring the ever-curious Harry Beaufoy, but *The Pupil of Nature* has, from its publication to the 5th and last edition in 1845, been associated specifically with William Paley's *Natural Theology*. In this essay, Rauch examines *Harry Beaufoy* in an effort to understand the ways in which Hack attempted to extract the elements of Paley that she felt would be most salient and most compelling to a generation of young readers who would, as adults, find themselves reading and evaluating a new approach to "creation" and "design" in Charles Darwin's *On the Origin of Species*.

Paley's work epitomises the idea that the credibility of religion depended upon being made visible and required science. This was even more significant, perhaps, in nineteenth-century children's literature, a genre intended to ensure religious conditioning above all. Interestingly, Darwin actually borrowed from Paleyan natural theology—a book which Darwin had read and which was taught at Cambridge. In his study of the development of Darwin's thought in the context of the naturalists with which he worked, Dov Ospovat explains that Darwin may even have first been introduced to the tradition of the natural theological interpretation of the principle of population before he read Thomas Malthus (1766–1834) in 1838. Indeed, Paley may have been his first introduction to Malthus, as Paley's optimistic view of superfecondity (a principle of population as partaking of the harmonious view of nature) may well have given Darwin "an explanation of the good consequences that follow from the principle of population".[31] In addition, Darwin's representation of the relations of interdependence governing the natural world and its ecosystems owes a lot to the natural theologians' emphasis on the natural world's unity and coherence. As several chapters in the present volume contend, nineteenth-century children's literature popularising natural history and new perceptions of the natural world frequently refused to draw a sharp line between natural theology and Darwin's presentation of ecosystems, sometimes leading to ambivalent or unstable visions of evolution. The critical examination and reconciliation of works of popularisation and children's fiction in this collection thus brings together contemporary (and sometimes conflicting) definitions of the natural world.

More particularly, by examining science books for children rephrasing natural theology alongside others mediating evolutionary theory, this book demonstrates how nineteenth-century educationalists and popularisers improved children's knowledge of nature and gradually contributed to the children's awareness of environmental issues. In the late eighteenth century, women writers involved in children's literature and education raised issues especially related to man's mistreatment of animals. Anna Lætitia Barbauld's poem, "The Mouse's Petition to Dr Priestley, Found in the Trap where he had been Confined all Night" (1773), published in reaction to Joseph Priestley's laboratory experiments on air, is a case in point. Though Barbauld's animal-rights manifesto aimed to denounce the atrocities of modern science, more and more popular science publications for children encouraged them to protect the natural world. In Chapter 3 ("Tiny Humanitarians? Children as Proactive Nature Conservationists in Late-Nineteenth Century Britain"), Frederick Milton reevaluates existing interpretations of the nineteenth-century humanitarian movement, moving

away from studies which argue that a close-knit circle of establishment society members and middle-class charity workers constantly harangued a supposedly brutal working class with a stream of punitive legislation, moralistic tracts and hectoring lectures. To do so, he contrasts eighteenth-century children's literature with didactic publications such as Sarah Trimmer's and the children's magazines of the 1820s, which encouraged children to protect the natural world within the framework of nineteenth-century culture. In the second half of the nineteenth century, children were invited to collect birds' eggs as a healthy outdoor activity. It was the Sunday schools and the animal welfare movement (Royal Society for the Protection of Animals [RSPCA]) that paved the way for the formation of Bands of Mercy, children's societies whose meetings were intended to teach children to be kind to animals. As Milton underlines, the periodical press also got involved in conservation. When the Dicky Bird Society of the *Newcastle Weekly Chronicle* was founded in 1876, similar press societies were created, and by 1914, 1.3 million children had been enrolled. Milton's essay focusses precisely on the Dicky Bird Society and the way in which its members took a genuine proactive interest in nature and its conservation. The majority of these societies printed their readers' letters and essays which addressed the full range of the contemporary conservation debate. This included the use of feathers in millinery, the impact of birds on agriculture, blood-sports and egg-collecting. Revealingly, this correspondence also highlights nineteenth-century children's environmentalist activities, whether children fed the birds during the winter, erected bird boxes, actively stopped egg-collecting, or condemned many of the blood-sports of the day as cruel.

The type of Christian morality promulgated by the publications and societies involved in the treatment of animals is even more evident in the children's literature dealing with the issue of evolution and natural selection after the publication of Darwin's *On the Origin of Species.* This is why the following three chapters consider the changing perception of the natural world in the second half of the nineteenth century. They examine the issue of evolution, the popularisation of Darwin's theory and the representation of natural selection in children's literature after 1859. In France, the popularisation of science in the second half of the nineteenth century raised issues concerning the narrative methods suitable for children. The construction of science as "fairy-like" or "wonderful" spurred debates among educationalists, publishers and popularisers. Chapter 13 looks at the debate raised by the work of Pierre-Jules Hetzel (1814–1886), who created the children's magazine *Le Magasin d'Education et de Récréation* in 1864 with Jean Macé (1815–1894),[32] in an attempt to

educate the young French citizens through the popularisation of scientific and historical knowledge. Yet French popularisers of science argued amongst themselves whether to use fairies and trope science as "marvellous".[33] While Macé praised the narrative quality of fairy tales used to explain scientific phenomena, Louis Figuier (1819–1894) discarded myths, legends, folk and fairy tales in favour of dry realism and was eager "to throw Perrault's tales on the fire".[34] The debate about how to teach science and educate children went on throughout the second half of the nineteenth century in France. In many publications which included fairies and praised the magical qualities of science, however, the narrative methods differed from those of British popularisers. As a matter of fact, fairies and fairyland in French popular science books for children were more often than not used merely to dissimulate the scientific lesson, functioning as simple hooks to attract the readers' attention. In Samuel-Henri Berthoud's *Aventures des os d'un géant, histoire familière du globe terrestre avant les hommes* (1863), Jean Macé's *Histoire d'une bouchée de pain* (1861),[35] Zulma Carraud's *Les Métamorphoses d'une goutte d'eau* (1865), Arthur Mangin's *Les Mémoires d'un chêne* (1886), or later Augustin Galopin's *Excursions du Petit Poucet dans le corps humain et dans les animaux : physiologie, hygiène, médecine et chirurgie usuelles* (1928), allusions to fairies and fairy tales are used to camouflage the science lesson: for instance, the human body is compared to "an enchanted machine" or a "magic place"[36] and fossils become giant's bones, as in Berthoud's work. Still, the fairy tale and the lesson never really interweave—they remain two distinct modes which never interrelate.[37] The fairy tale is soon relegated to the margins of the narrative; science remains entertaining but the resort to the marvellous potential of science remains distinct from the way in which Victorian popularisers use fairies and their narrative potential.

Indeed, as Chapter 4 emphasizes ("From the Wonders of Nature to the Wonders of Evolution: Charles Kingsley's and Arabella Buckley's Nursery Fairies"), many British popularisers' stress on the "narrative quality of science"[38] did not merely aim to capture the interest of their readers. Of course, in the second half of the nineteenth century, science books for children reworked the popularisation of natural history through entertaining storytelling, the changes resulting from commercial strategies. Science had become "sensational"[39] or "commercial".[40] Spectacular shows and gigantic exhibitions were being staged with the London Zoo and the British Museum welcoming new specimens brought from across the Empire. As a result, popularisers often appealed to the readers' eyes, either by using verbal images or colourful visual images or by inviting their

readers to observe the natural world. As Bernard Lightman contends, Victorian popularisers sensationalised natural history through shifting the point of view towards plants and animals (as opposed to the activity of the scientist) aimed at triggering "the emotional response of the observer". Furthermore, though both men and women developed "a rich visual dimension in popular science … women popularisers tended to draw even more than their male counterparts on the ornamental aspect of the narrative of natural history".[41]

The naturalist Margaret Gatty (1809–1873), who edited the popular middle-class magazine *Aunt Judy's Magazine* between 1866 and 1874, stands out as a significant figure involved in children's literature and the popularisation of science. Her works are good examples of the significance of visual culture in popular science, as the appeal of her *British Sea-Weeds* (1863) with its colourful illustrations, suggested.[42] Arabella Buckley's use of the visual, however, was more deeply marked by the scientific authority that informed her works. For Barbara T. Gates, Buckley "strove to present science as visually apprehensible,[43] all the more so because Buckley, unlike Gatty, attempted to mediate evolutionary theory. One of the new narrative formats that the Victorian popularisers increasingly used was what Bernard Lightman terms the "evolutionary epic".[44] Following in the footsteps of Robert Chambers, who "reshaped the evolutionary cosmogony of the Enlightenment by adopting the epic conventions of historical fiction … in order to domesticate what had been seen as a dangerous scientific theory",[45] Arabella Buckley, alongside Grant Allen (1848–1899), David Page (1814–1879) and Edward Clodd (1840–1930), was one of the most significant exponents of the evolutionary epic in the second half of the nineteenth century. As Chapter 4 highlights, a few years before Buckley's popularisation of evolutionary theory, Charles Kingsley, writer and populariser of natural history, attempted to deal with the mid-nineteenth-century redefinition of nature caused by the advent of evolutionary theory and to reconcile science with religion. Indeed, Kingsley used the wonders of nature to trope a divinely ordered nature in children's imaginations; but his fairies highlighted as well how the scientific method could be articulated with natural theology to illustrate evolutionary theory.

Thus, Chapter 4 shows how in both Kingsley's and Buckley's writings, the world of nature is filled with wonderful creatures still unknown to man, illustrating the extent to which, for mid-nineteenth-century popularisers (and writers), wonder and religion were not only compatible with science but essential to the scientific method. In fact, like Darwin, and Charles Lyell before him, science popularisers called for the use of both reason and imagination to "picture" the natural world, since the geological

processes of the Earth—as uniformitarianism posited—could not be visualised. Because Lyell's theory, and later Darwin's, claimed that some hypotheses were not observable to the naked eye and could therefore not be verified, the scientific method gradually changed: Darwin's abandonment of omniscience for a narrative characterised by "misprision, illusion, and limitation" aimed to foreground "the optical illusions and visual failures to which the physical eye is prone, the formal instability of evolutionary nature".[46] Darwin did not use such representations of nature to make up for the fallibility of human vision, however. The perceptual dysfunctions of the eye figured "as the model for an imagined evolutionary nature; the abundant complexity of Darwinian vision is born out of the powerlessness and the limitation of the evolving human eye beholding nature".[47] In addition to making the invisible visible, therefore, the "mixture of science and fiction" expands the reader's imagination "beyond the visually verifiable without sacrificing any scientific authority. … Once we have imagined nature from the gnomish and amphibian perspectives we are able to form more scientifically accurate theories than our limited vision would otherwise allow".[48] As Gillian Beer has shown, Darwin's use of such "literary and imagistic techniques"[49] to envision evolutionary theory influenced many popularisers of science who belonged to the "tradition of re-imagined science",[50] such as John Tyndall (1820–1893), T. H. Huxley (1825–1895), James Clerc Maxwell (1831–1879), Richard Proctor (1837–1888) and W. K. Clifford (1845–1879). Significantly, such techniques marked children's literature as well. Thus, Chapter 4 argues that Kingsley's popular science works for children, like those of Arabella Buckley a few decades later, foreground the use of the imagination not only to mediate new scientific methods and conceptions of the natural world, but also to reconcile evolutionary science and religion.

In Chapter 5 ("Bringing (Anti-)Evolutionism into the Nursery: Narrative Strategies in the Emergent 'History Of Life' Genre"), Richard Somerset explores further Arabella Buckley's narrative methods in order to foreground how they reflected bourgeois morality. To do so, Somerset compares Buckley's popularisation of evolutionary theory with Louis Figuier's anti-evolutionary prose. First published in 1880 and 1882, Arabella Buckley's key works in natural history for children, *Life and Her Children* and its sequel *Winners in Life's Race*, were important for their capacity to present evolutionary theory to a young middle-class readership in terms that would be both clear and unthreatening. To achieve this goal, she chose to adopt a radically different narrative strategy from that which had been used with great success by the French anti-evolutionary populariser, Louis Figuier whose *World Before the Deluge* (first translated

in 1865) was presented as an empirical and chronological résumé of the palaeontological history of Life. In her works, Buckley avoided highlighting the chronological sequence, but approached it instead through the concept of typological series. From this admixture resulted an apparently common-sense progressivism that owed much to a sense of natural hierarchy. By adding a strong moral orientation to this typological-chronological narrative, Buckley was able to produce a text that promoted a certain type of evolutionary thought that did not strongly advertise itself as such, and that was not openly threatening to mainstream middle-class values. Somerset's essay contrasts Buckley's narrative strategies to Figuier's, showing how, while the former claimed to offer a pleasing narrative of purely empirical derivation, the latter offered an empirical narrative that reassuringly naturalised bourgeois moral values.

In Chapter 6 ("'One Universal Family': John George Wood, Charles Darwin, and the Visual Re-ordering of Nature") Nicola Gauld examines further the reception and mediation of natural history after the impact of the publication of Darwin's *On the Origin of Species*. Two aspects of Darwin's thought were important for subsequent compilers of natural histories. One was his genealogical approach to taxonomy—his belief that relationships could only be understood in terms of an evolutionary basis; species were descended from common ancestors, and developed from varieties rather than being created in their present form. The other, equally important aspect, was his sense of the interdependence of all living things in given habitats—ecology, in other words. As Diana Donald asserts in *Picturing Animals in Britain*,[51] visual imagery provides one of the primary and most powerful expressions of the new world view. This is why Gauld's essay tackles the meaning of Darwinian theories for illustrated zoologies published after 1859 and, more specifically, those aimed at younger audiences, questioning whether the order of contents within such publications was affected by Darwinian notions of species and whether the arrangement of animals changed, as the debate over "descent with modification" intensified. Moreover, if, as has been argued elsewhere, *On the Origin of Species* did not reach the broader public,[52] then what sort of information about the natural world was available to a lay readership? Gauld's essay addresses these questions using the work of the Rev. John George Wood (1827–1889), a natural historian and microscopist at the peak of his popularity in the 1860s, who was well-known for his contributions to the popularisation of science of children, as in the *Boy's Own Paper*, and for the moral and religious tone of his scientific writing. Indeed, the acclaimed populariser's numerous articles on natural historical topics stressed Wood's concern to reveal the presence of divine power in

the natural world, hence his prominent role in children's weeklies and monthly magazines of the second half of the nineteenth century. His Christian conception of the natural world is well illustrated in his late 1870s pedagogical series "On Killing, Setting, and Preserving Insects" published in the *Boy's Own Paper*,[53] in which scientific knowledge is combined with theological preoccupations, inviting children to care about the creatures he was teaching them how to dissect.[54] It is to Wood's *Illustrated Natural History*, first published in 1851 but re-issued throughout the 1850s and 1860s, each edition with an increasing number of illustrations, that Gauld pays particular attention, as she tries to gauge the representations of the natural world that reached Victorian readers in the years that followed the publication of *On the Origin of Species*.

Chapter 7 ("Ice Bears, Ice Boys and Ice Men: Arctic Explorations and the Popularisation of Science in Victorian Children's Fiction") turns toward children's imaginative fiction and the way in which it disseminated science in the nineteenth century. Helen Reddick addresses the influence of nineteenth-century polar exploration on children's literature. As she argues, the early nineteenth-century British Admiralty-led searches for the North-West Passage and the North Pole stirred the Victorian imagination with the resultant heroic tales of bravery and the romance of unknown, frozen lands. In the name of God, country and scientific truth, the likes of Captains John Ross (1777–1856), William Parry (1790–1855), and most famously Sir John Franklin (1786–1847), undertook voyages to the icy regions of the Arctic. These exciting and dangerous (often fatal) adventures in mysterious settings had a huge impact upon nineteenth-century consciousness—the explorers were viewed as "heroes" and their journeys were followed avidly by the public back home even if they failed in their missions. Reddick's study focusses on how these Arctic voyages were retold in fictions by children's authors such as R. M. Ballantyne, Gordon Stables and W. H. G. Kingston, examining how they were narrated to the child reader and to what purpose. In particular, it discusses how such tales contributed to the popularisation of science in novels and children's periodicals such as *The Boy's Own Paper* in the latter part of the century. Ships' crews that travelled and overwintered in the arctic regions did so in the harshest conditions. Many died (sometimes whole companies) in this extreme climate, or at the very least suffered terribly from the cold and sicknesses such as scurvy from lack of fresh meat, fruit or vegetables. Accounts of these journeys sometimes overlooked that they were usually wholly scientific expeditions, planned in advance by the Admiralty down to the smallest detail. As Reddick suggests, these journeys were not to the "Arctic Sublime" that is depicted so enthusiastically in Victorian art and

literature, but instead were very practical, strenuous and often extremely boring. In fact, although it is true that the children's fictions of the time often treat rites of passage, both romantic and pious in nature, Reddick looks at children's fiction as being equally replete with detailed, practical information about carrying out scientific experiments and endeavours. Learning how to survive the cold by building igloos and hunting bears and foxes, how to identify any new species of plant or animals, and the correct approach for trading with native Inuits in the Arctic regions form an inherent part of all such texts. Thus, Reddick's chapter argues that these children's texts fostered a great interest in science and nature, even suggesting that it is perhaps in such children's literature that the reader gets the closest representation of the true experience of exploring the Arctic in the nineteenth century.

The following chapter ("La double vie des contes : Invraisemblables métamorphoses, espaces parallèles ou leçons de sciences ?"), by Françoise Besson, prolongs the study of the way in which science was popularised in imaginative fiction. The chapter deals with the relationships between works of popularisation and fairy tales, analysing the pedagogical messages lurking beneath fantasy, as in Lewis Carroll's *Alice's Adventures in Wonderland* (1865) and J. M. Barrie's *Peter Pan* (1904). Besson looks at the way in which Victorian fairy tales and fantasies define and explain the natural world and its laws to children, often playing with the boundaries between the natural and the supernatural. Questioning space, time and the real, Victorian fantasies and fairy tales, as Besson contends, function in ways similar to works of popularisation, enabling their readers to have access to knowledge—albeit through the looking glass.

Chapter 9 ("Les 'jeunes gens' et les 'dames', destinataires privilégiés d'un discours de vulgarisation de l'astronomie aux XVIII^{e} et XIX^{e} siècles") then turns to France and French popularisation of science. Colette Le Lay's essay focusses on the popularisation of astronomy from its beginnings in the eighteenth century to the end of the nineteenth century. As Le Lay explains, not only did the identity of popularisers change throughout the nineteenth century, scholars and teachers gradually being replaced by professional popularisers such as Camille Flammarion (1842–1925), for instance, but their rhetorical and narrative strategies also evolved, as the book industry boomed and works of popularisation gradually set themselves apart from school manuals. Science popularisers targetted different readers, switching from "ladies" in the eighteenth century to younger children, or "misses", as the child was being redefined and editors offered more and more entertaining books which no longer regarded children as young adults. While tracing the rise of astronomy as a science

and the popularisers' quests for new audiences, Le Lay also underlines how French popularisers of astronomy influenced British and Italian popularisers, demonstrating the impact of Bernard Le Bouyer de Fontenelle's *Entretiens sur la pluralité des mondes* (1686) on John Harris's *Astronomical Dialogues between a Gentleman and a Lady* (1719) and Francesco Algarotti's *Newtonianismo per le dame* (1737).

While some scientists tried to see farther, others researched smaller worlds and creatures, attempting to give shape (and reality) to the invisible world which science and technology were daily revealing to the public. Microbiology/bacteriology, for instance, which emerged in the mid-1860s and was pioneered by the work of Joseph Lister (1827–1912), was regarded by unconvinced scientists as a "fairy tale". German Sims Woodhead, the director of laboratories at the Royal College of Physicians and Surgeons and first editor of the *Journal of Pathology and Bacteriology* argued that bacteria theories "appeared to be more like fairy tales than … the result of sober scientific invention and thought".[55] Likewise, Robert Mackray and Arthur J. Browne compared the "marvellous" story of the human body's fight against "an innumerable host of living, sentient, militant creatures" to fairy tales.[56] Many popular science books capitalized on the narrative power of microbiology. P. H. Gosse's *Evenings at the Microscope* (1859) or William Henry Olley's *The Wonders of the Microscope, Photographically Revealed* linked scientific writings and microscopy to fairy-tale worlds. Yet, the presence of unseen and invisible creatures, from germs to insects, was also of concern to the Victorians at a time when technological advances provided more and more means to investigate what was beyond the threshold of human vision. Microscopic life and the existence of micro-organisms "tapped into a broader cultural anxiety about the materialism of the living world and the nature of the relation between the living and nonliving world".[57] As a result, works of popularisation brought to light the anxieties related to microscopy and the microscope.

Chapter 10 turns towards the reception of new scientific theories and instruments and the discourses concealed beneath the politics of observation. Muriel Louâpre's essay ("Infiniment petits : Le parti-pris de la myopie dans la vulgarisation pour la jeunesse") underlines how, especially after 1860, the spectacularisation of science prompted popularisers to experiment with perspective, taking their viewers into invisible realms beyond the reach of human perception. This chapter contrasts works of popularisation for children and adults in nineteenth-century France by examining the presence, use and role of optical technology. Revealingly, as Louâpre shows, the microscope—and often