



# The Alexandrian Library of Life

## A Flawed Metaphor for Biodiversity

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**Abstract** In the last quarter-century many scientific, environmental, and popular publications have used a metaphor comparing species extinction and the loss of biodiversity in the modern era to the destruction of the ancient Library of Alexandria in Egypt more than 1,500 years ago. The rhetorical figure is characteristic of the environmental humanities, for it invokes the value of cultural and literary treasures to reinforce the importance of biological diversity. This article traces the origins of the metaphor to related figures of The Book of Life and to the figure of genetic information as a textual code. The Alexandrian Library of Life caught hold in the late 1980s and early 1990s, when concern about biodiversity and the destruction of tropical rainforests coincided with developments in gene sequencing, the Human Genome Project, and the growth of Internet communications and electronic library collections. Scientists and environmentalists at that time sensed both the promise of unprecedented access to bio-information and the threat of lost knowledge through species extinction. The popularity of the metaphor conceals several weaknesses, however. Living species, even using the methods of gene sequencing, cannot be archived or copied like texts, and the impulse to do so reflects imperialist efforts to appropriate and control knowledge, as several empires attempted to do at Alexandria during the library's long history. The metaphor of a species as a book, represented in the library by one specimen or copy, obscures the fact that the Alexandrian library consisted of manuscripts, not print books. In essence, species may be more like manuscripts than books after all.

**Keywords** species extinction, biodiversity, information science, genomics, classics, book history, library studies

The loss of biological diversity in our time has been likened to the burning in 272 AD of the Great Library of Alexandria. In truth, that ancient conflagration pales to a candle flame beside the present one. Measured in bits, the genetic information in the chromosomes of just twenty randomly selected creatures would fill some 400,000 scrolls, which is a good estimate of the library's entire holdings. No one knows exactly how many species we are losing daily; but if we accept the fairly conservative figure of eighty, it follows that we are torching four Great Libraries every day.

—Evan Eisenberg, *The Ecology of Eden*

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The conflagration of the tropical rain forest threatens not only countless species of plants but also the cultures and individuals who know their properties and use them in their daily lives. What we are witnessing makes the burning of the library of ancient Alexandria look insignificant by comparison. It is as if the greatest medical library in the world is burning faster than we can read its contents, which we have just begun to catalog.

—David Maybury-Lewis, *Millennium: Tribal Wisdom and the Modern World*

The burning of the ancient Egyptian Library of Alexandria millennia ago resulted in the permanent and irretrievable loss of accumulated knowledge and wisdom. Today, there is another library that contains far more information than all other conventional libraries, past and present, combined. It has the accumulated wisdom of literally billions of years, and is unquestionably Earth's most valuable resource, and one we cannot afford to lose. The library I am talking about is global biodiversity.

The information is not written as words in books; it is encoded in the genetic material of all living things on the planet. Genetic information changes through evolution.

Every species on Earth is like a unique book, with its own unique story to tell.

—Richard L. Pyle, *Ka 'Elele*, Newsletter of the Bernice Pauhi Bishop Museum of Honolulu

The epigraphs collect three of many passages in recent scientific and environmental writing comparing Earth's biological diversity to the intellectual productions collected at the library in Alexandria, Egypt, which flourished under the Ptolemaic dynasty from around 300 BCE until the Roman conquest in 30 BCE, and endured, despite several episodes of burning and destruction, until the rise of Islam in the seventh century CE. The ancient library has not been located or excavated by archaeologists, and its collections and uses are variously described in extant sources. These mysteries only enhance the appeal, however, of this analogy between biological organisms and literary texts, along a narrative that leads from imperial collection to iconoclastic destruction. The Alexandrian Library of Life metaphor has a powerful rhetorical appeal and has been used to emphasize both the importance of protecting species and ecosystems against the threat of extinction, and the urgency of collecting specimens from those habitats and preserving them in herbaria, museum collections, seed banks, or genomic databases.<sup>1</sup>

This article examines the presuppositions and implications of the Alexandrian library as a figure for biodiversity, and the significance of the metaphor for the environmental humanities. I argue that the figure arose in the early 1990s due to the concurrent development of gene sequencing and the Internet, of genomic databases and digital

1. The metaphor has spread widely enough to qualify as a meme, an idea that repeats and spreads through many discourse communities, somewhat like a microorganism spreads through infection and mutation. Richard Dawkins coined the term in *The Selfish Gene* (1978; rev. ed., 2006). The eleventh chapter of the book is entitled "Memes: The New Replicators."

books, and I explore how the metaphor suggests powerful relationships between genetic biodiversity, extinction, information storage, and cultural patrimony.

To compare the burning of the ancient Library of Alexandria to the loss of biodiversity is a complex cross-disciplinary metaphor, embraced by both biologists and humanists.<sup>2</sup> It is effective because it summons the prestige of ancient and profound knowledge in support of new scientific techniques in microbiology and genomics, even as the content of that ancient knowledge is unknown or inaccessible. Rhetoric and metaphor in literary texts are the research domains of scholars of literary humanities, such as this author, but writings in the natural sciences, whether for a specialized audience or for a wider public, have also always relied on metaphors to explain or illustrate complex ideas. As David Harvey has argued, metaphors are “the primary means whereby the human imaginary gets mobilized to gain understandings of the natural and social worlds.” Historians of science have examined the use of metaphor in the early modern period, while sociologists of science explore the power that metaphors carry today in shaping research methods and attracting funding.<sup>3</sup> Natural scientists who want the widest possible impact for their research, whether measured by a citation index or by appearances in the news media, seek imaginative metaphors to illustrate complicated phenomena that often take place on a microscopic or macroscopic scale beyond the range of human sensory experience. Ecologists and environmental scientists who wish to call attention to the threat of extinction or climate change have built the new field of environmental communications in part to help craft more persuasive metaphors, and the Alexandrian Library of Life is a notable success in this vein.<sup>4</sup>

The simile comparing the Alexandrian Library of Life to global biodiversity builds upon two earlier metaphors in biology: first, of genes (or nucleotide base pairs) as texts made up of letters, chapters, or books; and second, of diverse little-known species—for example unstudied tropical plants with potential pharmacological applications—as a library or encyclopedia of valuable information.<sup>5</sup> Edward O. Wilson, the Harvard University biology professor and two-time Pulitzer Prize winner who has been called “the Father of Biodiversity,” wrote in *The Diversity of Life* in 1992: “all living species are . . . living genetic libraries, composed of nucleotide sequences, the equivalent of words and sentences, which record evolutionary events. . . . Organisms . . . contain between 1 and

2. To describe the loss of biodiversity as being *like* the burning of the Ancient Library of Alexandria is a simile, but I will use the broader term metaphor to encompass other versions of the rhetorical figure.

3. Harvey, *Justice, Nature, and the Geography of Difference*, 163. Of many studies in the history of science I have drawn upon James Bono, *Word of God and the Languages of Man*, and Bronwyn Parry, *Trading the Genome*.

4. See Valiveronen and Hellsten, “From ‘Burning Library’ to ‘Green Medicine’”; and Larson, *Metaphors for Environmental Sustainability*.

5. See Schultes, “Burning the Library of Amazonia.” Richard Evans Schultes, a professor of biology at Harvard and director of the Harvard Botanical Museum, was among the founders of the field of ethno-botany and a specialist in the botanical knowledge of indigenous peoples of Amazonia. David Maybury-Lewis, source of the second epigraph above, also pursued ethno-botany research.

ro billion nucleotide letters, more than enough in pure information to compose an equivalent of the *Encyclopedia Britannica*.<sup>6</sup> Wilson advocated for a synthesis of scientific and humanistic inquiry, which he dubbed “Consilience,” the title of his 1998 book. His metaphor of the genetic encyclopedia gave biology the authority of an archive that outmeasures those of history and literature, much as Richard L. Pyle, in the third epigraph, invoked, “another library that contains far more information than all other conventional libraries.” Wilson’s use of the gene/word metaphor was a direct influence on Eisenberg, in the first epigraph, and on many other nonscientists writing about species conservation. The metaphor predated E. O. Wilson’s work, however, as has been examined by Dutch scholar Iina Hellsten: “The connection between cellular systems and the alphabet first became popular in the 1960s when molecular biologists started using the metaphor to understand the working of DNA as composed of the four nucleotides represented by their initial letters, adenine (A), thymine (T), cytosine (C) and guanine (G). A, T, C and G became *the alphabet of life*.”<sup>7</sup>

The Alexandrian Library of Life takes the metaphor linking letters, words, sentences, pages, and books to base pairs, genes, genomes, and species, and combines it with well-established tropes of the “Book of Nature” and “Book of Life” that date to the Renaissance. As Hellsten put it: “This metaphor of the Book of Life is derived from our cultural appreciation of books as the basis of civilization.”<sup>8</sup> The idea that nature is God’s sacred work and that the study of nature, like the study of Holy Scripture, can provide religious edification, gained currency in the Protestant Reformation and in the scientific revolution of the seventeenth century.<sup>9</sup> The Alexandrian Library of Life has given this idea a new form suited to a more secular era in which information and knowledge are growing at a dizzying pace, even as pieces of nature’s creation are being lost. The lost library at Alexandria, which, as classicist Diana Delia says, “for two millennia, the Western intellectual tradition has mourned,” becomes a figure for the value of books and scriptures among the Abrahamic religions of Judaism, Christianity, and Islam, and the pagan civilizations of Mediterranean antiquity.<sup>10</sup> In the Alexandrian Library of Life, each species and its genetic text is a book, and the species/books are collected into a massive virtual library, each Linnaean binomial title cataloged within a taxonomic tree of life. The electronic biological library assembled in the last quarter-century or so claims a hallowed place at the foundation of Western civilization by wrapping itself in the mystique of the Alexandrian library of antiquity.

6. Wilson, *Diversity of Life*, 321, 345.

7. Hellsten, “From Sequencing to Annotating,” 285.

8. *Ibid.*, 283. Hellsten’s paper and studies by Adam Hedgecoe and by Lily Kay consider the question “whether the analogy between linguistic metaphors and molecular biology could also be taken literally in the sense that methods developed for analyzing languages could also be applied to molecular biology” (289). I am less concerned here with the linguistic and grammatical analysis of cybernetics, which Kay’s *Who Wrote the Book of Life?* examines in authoritative detail.

9. See, for example, Harrison, *Bible, Protestantism, and the Rise of Natural Science*.

10. Delia, “From Romance to Rhetoric,” 1449.

In *The Diversity of Life* Wilson did not use the metaphor in its most elaborate form, but he did promote the potential for pharmacological bioprospecting by linking it to the Alexandrian library: “It is a remarkable fact that of the 119 known pure pharmaceutical compounds used somewhere in the world, 88 were discovered through leads from traditional medicine. The knowledge of all the world’s indigenous cultures, if gathered and cataloged, would constitute a library of Alexandrian proportions.”<sup>11</sup> Ecologists and microbiologists in the 1980s were expecting revolutionary developments in genetic engineering, and anticipated that genes might soon be precisely manipulated, or edited like texts. The genomes of species of organisms that had not yet been sequenced, or even classified, represented a hidden, lost, or inaccessible library, like that of ancient Alexandria. And just as the nucleotide “code” is interpretable only through computerized gene sequences and databases, the world’s libraries have, beginning in the 1990s, been merged into union catalogs such as WorldCat and electronic text repositories such as [gutenberg.org](http://gutenberg.org) and [archive.org](http://archive.org), among many others, searchable only by computer. The largest and most comprehensive libraries now exist only in electronic form, and the distinction between literary text and digital information has become blurred. The information revolution has made not only books and research articles but also huge data sets and genomes available simultaneously to researchers anywhere on Earth. This has facilitated research in the life sciences, but as Bronwyn Parry has shown, it has also changed the relations of investment and control between collectors of species specimens in the field, conservators of collections of these specimens, and biotechnologists who manipulate the specimens to turn them into bioinformation. The value of bioinformatics now threatens to marginalize (to use another textual metaphor) the living organisms from which it was initially derived. In response to these trends, some biologists have become concerned about the accessibility of their own archives of scientific specimens following the shift to electronic publishing and digital databases. For instance, the metaphor of “Libraries of Life” was used as the title of a *New York Times* op-ed in February 2015, written by two scientists who called attention to the importance of collecting new specimens and funding the natural history museums and botanical gardens where many such specimens are stored.<sup>12</sup> The material status of the Alexandrian Library of Life, however, is ambiguous—it invokes both the value of musty books and manuscripts on dimly lit shelves and the tropes of the information age and its high-tech digital repositories, including genomic databases.

As genetics promoted the metaphor of books or encyclopedias of life, of species identities conserved in textual form, ecology and ethno-botany argued that the extinction of species was a threat that amounted to the willful destruction of knowledge, of a natural and intellectual heritage precious to all human civilizations. The burning of Amazonian rain forests aroused international concern in the late 1980s, and likely

11. Wilson, *Diversity of Life*, 321.

12. Lujan and Page, “Libraries of Life”; Parry, *Trading the Genome*.

contributed to the sensational image of the Alexandrian Library of Life being burned rather than simply plundered. Paul R. Ehrlich, the population ecologist and cofounder of the journal *Conservation Biology*, in delivering the Ninth World Conservation lecture in London on Earth Day, April 22, 1991, warned that the Library of Life contained untold treasures: “innumerable potential new foods, drugs, and useful products may yet be discovered—if we do not burn down the library first . . . the very basis of our civilization—our crops, domestic animals and many of our medicines and industrial products—have been derived from the planet’s vast genetic library.”<sup>13</sup> Ehrlich obliquely mentioned the bioprospectors who might profit from patents and licenses on “new foods, drugs, and useful products” found in the field and refined in laboratories, but his image of the burning library (not specified as the Alexandrian library) avoids the legal and ethical questions of property rights over those products by appealing to the value of a common biocultural heritage with the open access of a public library.

The Alexandrian Library of Life as a metaphor motivating a plan for conserving “the planet’s vast genetic library” was first popularized, my research suggests, by astrophysicist and science fiction author Gregory Benford. Benford published two articles in 1992 and 1993, the first in the prestigious journal *Proceedings of the National Academy of Sciences*:

Our situation resembles a browser in the ancient library at Alexandria who suddenly notes that the trove he had begun inspecting has caught fire. . . . What to do? There is no time to patrol the aisles, discerningly plucking forth a treatise of Aristotle or deciding to leave behind Alexander the Great’s laundry list. Instead, a better strategy is to run through the remaining library, tossing texts into a basket at random, sampling each section to give broad coverage.<sup>14</sup>

Benford invoked the fame of Aristotle and Alexander only to belittle their texts as no more valuable than others. His proposed response to the massive extinction event of the modern age was to create a “frozen zoo,” or (using a term adopted from an earlier publication by Paul Ehrlich) a collection of “artificial fossils,” by sampling and freezing a large and randomly selected number of specimens, without taxonomic classification or study, as a means of conserving Earth’s biosphere.<sup>15</sup> Thus the Alexandrian Library of Life metaphor was first used to support the creation of a representative archive of biodiversity, not a collection of nature’s Great Books. “Our goal is a complete sample of all threatened species,” Benford wrote, not just “charismatic vertebrates.” And he insisted that scientists, “as saviors of the ‘library of life,’” ought to collect now for study and use later, awaiting future biotechnologies that would make it possible to revive extinct species from the stored samples.<sup>16</sup> The frozen samples could be stored as tissues, or the

13. Ehrlich, “Environmental Deterioration, Biodiversity, and the Preservation of Civilization,” 12.

14. Benford, “Saving the ‘Library of Life,’” 11098; and Benford, “Salvaging the Library of Life.”

15. Ehrlich, “Some Axioms of Taxonomy,” 113.

16. Benford, “Saving the ‘Library of Life,’” 11099–100.

cells and their DNA could be extracted for use in cell cultures, or, as high-throughput genomics has now made possible, their genomes could be sequenced and stored as digital files. Benford told me in an email exchange that he believed he had coined the metaphor, but given concurrent uses of it, it seems likely to have been invented independently by several writers. The totalizing, apocalyptic, and evangelical plan Benford put forth suited the image of the burning Alexandrian Library of Life, and the metaphor transfers or carries across (the Greek root of the word “metaphor”) from living organisms in vivo and in situ to specimen samples preserved in vitro and genetic data in silico. A significant environmental and ethical danger of the metaphor, however, is that the possession of archived samples, whether in vitro genetic material or in silico genomic sequences, might be assumed to preclude the need for the living species themselves. Policy makers may abandon efforts to preserve habitats if they believe, or manage to convince others, that archived genomes will prevent species in those habitats from going extinct. As Donna Haraway has warned, the “frozen zoo” or “artificial fossils” turn biology into information science, “a kind of artificial life research [in which] the paradigmatic habitat for life, the [computer] program—bore no necessary relationship to messy, thick organisms.”<sup>17</sup>

Benford’s 1992 proposal reflected its moment; the words *biodiversity* and *genomics* were coined in the mid-1980s (the first occurrences listed in the *Oxford English Dictionary* are from 1985 and 1987, respectively), and both the Human Genome Project and the growth of Internet communications and digital information storage as mass phenomena began around the same time. Genomics and the Internet each inspired a mania of plans for worldwide open-access repositories of knowledge and information, a utopian optimism that has since become jaded. In spite of its conceptual weaknesses, the notion of genes as texts that can be read, copied, stored, and edited just like books is still widely used by scientists and in journalistic reports on research.<sup>18</sup>

To more closely analyze the metaphor, I will consider six separate reasons why the Alexandrian Library of Life succeeded as a rhetorical figure, and why each may mislead readers and may undermine the goals of those who use it.

### The Living Book?

First, I believe the metaphor succeeds because it bridges the cultural and institutional divide between the natural sciences and the humanities by putting the value of humanist or literary culture alongside the study of genetic biodiversity in nonhuman nature. Microbiologists use the Alexandrian Library of Life to make a case for the value of their

17. Haraway, *Modest\_Witness@Second\_Millennium*, 245.

18. Recently the development of the CRISPR Cas9 technique of genomic manipulation by Jennifer Doudna, Feng Zhang, and others has revived the metaphor. Reports in the *New Yorker* and the *New York Times Magazine* in November 2015 exclaimed: “Imagine being able to manipulate a specific region of DNA . . . almost as easily as correcting a typo” (Specter, “Gene Hackers”), and “Some researchers have compared Crispr to a word processor, capable of effortlessly editing a gene down to the level of a single letter” (Kahn, “Life Edited”).

genomic databases and archives, conservation biologists use it to build support for protecting endangered species, and humanist environmentalists can use it to rally for either or both. At its best, this ideal aims to revive the spirit of Renaissance humanists such as Andreas Vesalius and Leonard Fuchs, who in the sixteenth century studied medicine and botany with fresh eyes and whose books and illustrations interpreted and updated the texts of the ancient doctors and herbalists Galen and Dioscorides (some manuscripts of which were likely composed or conserved at the Alexandrian Library of Life).<sup>19</sup>

This high-minded ideal of plants, animals, literature, and art as all part of the cultural heritage of mankind has a flaw, however. Animals and plants are not textual artifacts that can be stored in a library, or reproduced by a scribe, a photocopy machine, a gene-sequencing computer, or a polymerase chain reaction. Benford's fantasy of a "frozen zoo" is itself a metaphor linking the preservation of genetic material to the preservation of living organisms, whether endangered megafauna species in zoos, plants in gardens, or seeds in seed banks. To survive over the long term, organisms need habitats, and they need one another to form food webs and ecosystems. Complex organisms need the fungi and bacteria that live on or within them in symbiotic and parasitic relationships, and whose genomes are sometimes partly incorporated into their own. Likewise, no single book is interpretable without knowledge of and reference to other books. But the Library of Life metaphor confuses the existence of an archive with the actual reading, teaching, and interpreting of literature, which after all was the true role of the library, lyceum, and museum of Alexandria in its pre-Christian heyday, when it served as home to hundreds of scholars copying, studying, and debating the ideas found in the many thousands of texts held there.

And given that a species cannot be reduced to its DNA barcode<sup>20</sup> and stored on a shelf, scholarly humanists who reflect upon the metaphor of species as book will also conclude that a book cannot be reduced to an alphabetic or ASCII sequence without losing many aspects of what makes it significant; the publisher's apparatus, typeface, binding, paper, annotations, marginalia, and any of the book's illustrations, illuminations, or pictures. For these reasons, the impetus for digitizing rare book collections, which spread quickly in the 1990s, has more recently given way to a renewed appreciation for the hands-on study of books and book history.<sup>21</sup>

19. See Kusakawa, "Leonhart Fuchs on the Importance of Pictures." The excavation in 1847 of a hollowed-out granite block inscribed with the name of Dioskourides, thought to be a container for manuscripts written by one of several ancient scholars with this name, is among the few archaeological clues to the location of the Alexandrian library. See Delia, "From Romance to Rhetoric," 1454; and Reinach, "ΔΙΟΣΚΟΥΡΙΑΔΗΣ ΤΟΜΟΙ."

20. The concept of a DNA barcode refers not only to the notion that every species of organism can be identified by its distinct genetic code, but also to the possibility that gene sequencing might become so efficient and inexpensive that a handheld device similar to a bar code reader might be employed in the field to identify species. See Larson, *Metaphors for Environmental Sustainability*, 127–60.

21. Among librarians and literary scholars, the study of book history and rare books has enjoyed growing interest at programs such as the University of Virginia's Rare Book School and the University of Toronto's Collaborative Program in Book History and Print Culture.



### Translating Our Biocultural Heritage

In a second aspect of the metaphor, the Alexandrian Library of Life emphasizes a sense of species biodiversity as a collective biocultural patrimony, an ideal especially persuasive insofar as it invokes both Judeo-Christian and secular humanist values. In the religious version, a divine Creator made all creatures; our value for these creatures and creation expresses our devotion to the Creator, and to imperil the creatures with extinction is to disrespect the divine. The works in the Alexandrian library were, in its heyday in the second and first century BCE, nearly all “pagan,” but the earliest available source indicates that the Septuagint translation of the Old Testament into Greek was done at Alexandria, and thus the most sacred book of Christianity was born there.<sup>22</sup> As for pagan literary works, it was scholars in the Alexandrian library and museum who divided the *Iliad* and the *Odyssey* each into twenty-four books and established the texts students and scholars read in translations today, and the library also included copies of the plays of Sophocles and Aeschylus (only 7 by each are extant, out of 120 by the former and at least 70 by the latter). According to the earliest extant text to describe the library (the “Letter of Aristeas” from the second century BCE), it was founded by Demetrios of Phaleron, a student of Theophrastus, who was author of an herbal and the successor to Aristotle at the Athens lyceum. In its early years the Alexandrian library probably contained the full texts of works of pre-Socratic philosophers, which today are known only from quotations and excerpts in texts by later writers. The Greek poet Sappho is credited with eight or more books of poetry held at Alexandria and collected into volumes according to the poems’ metrical forms. The extant fragments of Sappho’s works, estimated to comprise less than 10 percent of her total oeuvre, are classified according to this scheme. Similarly, Lucien Polastron estimates that of roughly one thousand authors of Classical Greece, modern scholars can read only about a hundred, and adds:

If, therefore, the great Library of Alexandria is incontestably posed as the symbol of all the other libraries—*um al-maktabat*, the “mother of all libraries,” in Arabic—it is, first of all, because no physical reality exists either to contradict or to support the alarming exaltations it inspires, and also because it provides a tangible symbol of the intellectual turning point between antiquity and our own dark world.<sup>23</sup>

The Alexandrian Library of Life likewise functions as a symbol inasmuch it is an archive without any physical location. To decry the destruction of the Alexandrian Library of Life, and to imagine the possibility of its preservation or rediscovery, is a fantasy of finding lost or hidden knowledge. To use it as a figure for Earth’s lost biodiversity is to imagine not only preventing the extinctions occurring in the modern era but also having access to species long since extinct. The fantasy appeals to those who study

22. Polastron, *Books on Fire*, 14.

23. *Ibid.*, 22.

natural history from fossils that generally preserve only bones, shells, or, in the case of plants, woody stems or leaves, but very rarely soft tissues, hair, skin, flowers, or feathers. All the countless images of living dinosaurs were created from such fossilized fragments. Naturalists assume that millions of other species were not fossilized, or their fossils have not yet been found. Charles Darwin himself, in *The Origin of Species*, used a metaphor of the fossil record as a fragmentary book: "I look at the natural geological record, as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume, only here and there a short chapter has been preserved: and of each page, only here and there a few lines."<sup>24</sup> The Alexandrian Library of Life repeats this metaphor and reflects a longing for lost wholeness shared by scientists (particularly paleontologists), by classicists, and by nature lovers. We invest our fantasies of wholeness, of sublime experience, in a creature we cannot see alive, or a book we cannot read in full, for in each case what we know from fragments provokes a desire to restore what is missing, and captures vividly the fear that extinction will take away biotic riches we do not know, knew but did not appreciate, or know only from fragments.

The major flaw in this second element of the Alexandrian Library of Life, however, lies in the problems of translation and the difference between transcription and translation. To find or to copy a missing text is not the same as being able to read and interpret it. The metaphor of DNA and RNA transcription as an encoding/decoding of letters, sentences, and books implies a single language written in a simple alphabetic script. A passage from E. O. Wilson's *The Diversity of Life* quoted above continues: "Viewed from the perspective of evolutionary time, all other species are our distant kin because we share a remote ancestry. We still use a common vocabulary, the nucleic-acid code, even though it has been sorted into radically different hereditary languages."<sup>25</sup> Wilson and other scientists who use the Alexandrian library metaphor often ignore how the gene/text metaphor implies a monolingual, uniform, alphabetic process of biological communication. The ancient Library of Alexandria held works from Greek, Egyptian, Assyrian, Chaldean, Phoenician, Syrian, and other cultures, all written by hand in a variety of scripts, and even if found today some of the clay tablets or rolls of papyrus from the library would be in languages now indecipherable. The genetic text metaphor was developed alongside theories of cybernetics or information, not linguistics or literature, and there are important differences between information and literature.

A work of literature proceeds in a continuous sequence, and every word of the text has potential significance. Although many classical and medieval literary texts (and some modern ones) have been compiled and edited from multiple manuscripts, this process is complete in the printed books that represent species in the Library of Life metaphor. Genomics involves a process even messier than the reconstruction of

24. Darwin, *On the Origin of Species*, 310–11.

25. Wilson, *Diversity of Life*, 345.

fragmentary papyrus texts. When a sample from an organism is sequenced, its cellular DNA is very difficult to separate from the DNA of bacteria and other microbiota that are living in the sample or in the researchers' lab. Sometimes the DNA of the researchers themselves can contaminate a sample.<sup>26</sup> Transcription errors and contaminated samples are unavoidable and are built into the algorithms that perform the analysis of "high throughput" gene sequencing, which operates on millions of short strands of DNA that have to be statistically reassembled into genes. Even if the genome of the target species can be reassembled, the majority of its genes, and therefore of the nucleotide letters within them, have an indirect or uncertain function, or perhaps no function at all, in the development and life of the organism.<sup>27</sup> Genes are switched on or off by other genes or by events in the life and environment of an organism. Some genes block or erase the actions of other genes. The genome is quite different from a written text; its functional signification is mixed in among a great deal of informational "noise."

### Who Burned the Library?

A third aspect of the Alexandrian Library of Life metaphor is its indictment of those who burned the library, who are branded as enemies of knowledge, of literature, and of biodiversity. In one popular myth, the library was burned by the Caliph Omar or Umar (ca. 583–644), one of the most powerful leaders of the expansion of Islam after the death of Mohammed. According to the thirteenth-century Syrian-Christian author Barhebraeus, a.k.a. Abu al-Faraj, the Caliph Omar decreed: "If these writings of the Greeks agree with the book of God [the Koran] they are useless and need not be preserved; if they disagree, they are pernicious and ought to be destroyed."<sup>28</sup> The famous orientalist Bernard Lewis lists many scholars, both European and Islamic, who have exposed this story as a myth, and yet it is repeated by some who invoke the Alexandrian library as a metaphor for extinction. The earliest instance of the metaphor that I have found dates from 1905 and laments the extermination of the Tasmanian thylacine by commenting: "As Omar destroyed the priceless treasures of the Alexandrian library so have others robbed the world for ever of many beautiful and interesting animals."<sup>29</sup> Other users of the metaphor do point out that the Alexandrian library was burned long before the rise of Islam. Julius Caesar attacked and burned Alexandria in 48–47 BCE. In 391 CE the Christian emperor Theodosius I sacked the library, and by that time Christians dominated the kingdom and scholars were ordered not to copy pagan texts into the library. The destruction of libraries has a long history as a weapon of war, and a New Alexandrian library might fare no better than the first one. It is presumptuous to assume, as

26. Moreover, some portions of the human genome, about 0.5 percent, are "plagiarized" from bacteria that have found their way into the original "text" of human cells. See Ponting, "Plagiarized Bacterial Genes in the Human Book of Life."

27. For a textbook to modern genomics, see Miklos, Nash, and Hilgert, *Genome Science*.

28. Lewis, "Arab Destruction of the Library of Alexandria."

29. Renshaw, *More Natural History Essays*, 216.

Benford does, that although humans have not preserved rare species biota in situ, we will nonetheless preserve them in vitro in giant freezers of liquid nitrogen. This frozen zoo will need to be stored in buildings that consume huge amounts of electricity, offer none of the public services of libraries, and may seem pointless or wasteful in the event of future social or environmental crises. A seed bank is more worthwhile than a “frozen zoo,” even if many seed banks are unresponsive to the real needs of the farmers for whose benefit they were created.<sup>30</sup>

Even apart from the slanders of the Caliph Omar, the Alexandrian Library of Life is still deeply ethnocentric. It implies that biological diversity belongs to Western or Abrahamic civilizations, who believe only they can save it, if indeed they don't destroy it first. The written and painted codices of Mesoamerican civilizations were nearly all burned by European conquistadors during the sixteenth- and seventeenth-century heyday of the Renaissance and scientific revolution, and yet that intellectual heritage is rarely invoked in the Library of Life. Evan Eisenberg, in a passage following the first epigraph above, mentions the Mayan codices preserved at a library in Berlin, and Thomas King, the Cherokee novelist and playwright, points out: “In the valley of Mexico, the Aztecs maintained a large library of written works that may well have been the rival of the Royal Library at Alexandria,” the destruction of which was “as devastating as Julius Caesar's destruction of the library at Alexandria.”<sup>31</sup> To equate the biodiversity of plants and animals with the collections at the Alexandrian library is only to repeat the process by which colonial conquest and imperialist scholarship documented and institutionalized European knowledge of world cultures and of the biosphere, while ignoring or destroying local indigenous cultures and their knowledge of flora and fauna. An imperial library absorbs and assimilates the literature of subject peoples, and Western imperialist science classifies as new to knowledge plants and animals already familiar to people living near the habitats of those plants and animals. A similar process was used to collect ancient literature. The Ptolemaic leaders of Alexandria bought up, copied, or stole books from other places, including Greece, to amass their collection. Now in the digital age this monopolization is much easier. Since the turn of the millennium the Encyclopedia of Life project, eol.org, has taken up the goal of collecting “a webpage for every living species” and includes the New Library of Alexandria alongside much larger and wealthier universities, museums, and foundations as its partners. The popularity of the Alexandrian Library of Life simile motivated eol.org to include the new library among its partners, in spite of the relatively small contribution of resources and researchers from the new institution, formally known as the Bibliotheca Alexandrina, founded in 2002.<sup>32</sup>

30. On the virtues and failings of seed banks as genetic repositories, see van Dooren, “Banking Seed.”

31. King, *Truth about Stories*, 98.

32. At the time of the founding of the Encyclopedia of Life, an editorial in the journal of the Federation of American Societies for Experimental Biology credited E. O. Wilson as “the guiding spirit behind the work” of eol.org and invoked the spirit of Denis Diderot, editor of the eighteenth-century *Encyclopédie ou Dictionnaire Raisonné des Sciences, des Arts, et des Metiers*. See Weissman, “Encyclopedias of Life.”

### Extinction and the Archive

The Alexandrian library's ancient destruction and recent revival sustains a dream that some of its former collections might be rediscovered, and, in a fourth aspect of the metaphor, that some extinct species might be revived. Benford's proposal from 1992 anticipated the techniques that have been used since then to recover DNA and sequence genomes from remains of animals extinct for thousands of years, most famously from frozen carcasses of the woolly mammoth found buried in arctic tundra and permafrost.<sup>33</sup> De-extinction, as some call it, is still highly speculative and relies on the use of closely related species as templates against which to compare fragmentary DNA recovered from specimens (such as elephants for mammoths) and as surrogate mothers to nurture in utero the genetically engineered embryos of extinct animals. So far, all efforts to clone extinct species from DNA have failed, yet excitement about and funding for de-extinction efforts continues to gather support not only from scientists but also from wealthy technology entrepreneurs.<sup>34</sup>

A naive idea of genetics, promoted by Benford at a time when the genomic revolution was beginning, and persisting among others who have used the Alexandrian library metaphor, assumes that storing a DNA sample amounts to preserving a species and that the process is as simple as putting a book on a shelf. In the 1980s and 1990s when the Library of Life metaphor first caught on, the possibility of storing genetic material for subsequent reproduction as living organisms was an exciting idea among both molecular biologists and conservation ecologists. Since then, much-publicized efforts to revive extinct species, such as cloning a frozen mammoth or synthesizing a new passenger pigeon by "editing" the genome of the closely related rock pigeon, have attracted a great deal of media attention and research funding. But results from the scientists have not matched the hype. Even the less publicized but far more plausible attempt to clone and revive the bucardo or Pyrenean ibex, for which scientists took genes from the last surviving live animals and attempted to clone them using a closely related surrogate mother, did not succeed.

Developments in computational genomics over the past few decades have examined genomes as the repository of deep historical phylogeny and even attempted to deduce the earliest forms of life, microorganism species extinct and not preserved in fossils, based upon a reverse modeling of evolutionary trees. Ecologist George C. Williams, writing in 1992, the same year as Benford and Maybury-Lewis, gave a historical twist to the Alexandrian library metaphor: "an organism is a living record of its own history. . . . The loss of the Stellar sea cow and the Adam-and-Eve orchid were the same kind of loss to historical scholarship as the burning of the library at Alexandria. The current wholesale extinction of organisms is especially tragic and ironic because we are

33. See Shapiro, *How to Clone a Mammoth*.

34. For example Stewart Brand's Revive and Restore project, an arm of the Long Now Foundation, has sponsored several TED Talks promoting its de-extinction programs.

only now learning to read history in molecular structure.”<sup>35</sup> Environmental philosopher Ted Toadvine, quoting this passage, proposed that the metaphor of a language would better suit this interpretation of genetics than the metaphor of a library, because a language is a dynamic source of world making, not a static text, and thus human bodies (and those of other organisms) might carry within them, if not the memory of all evolution that led up to them, at least the means to express this history.<sup>36</sup> Toadvine offers a phenomenological approach, drawing upon structuralist linguistics, that understands communication as both textual and nontextual modes of expression and organisms as interacting through genetic, material, and semiotic modes all at once. Such biosemiotic methods have grown among a small group of interdisciplinary scholars but have not changed the popular metaphor of genetic information as textual.

### Shelving Species in the Library

The Library of Life metaphor implies that the classification or indexing of nature and of literature is somehow equivalent. To make sense and order of nature, scientists taxonomize the millions of species of organisms. To make the world’s textual heritage accessible through libraries, humanists edit, publish, and catalog millions of books, manuscripts, and periodicals. Benford advised that amid the fire that represents extinction, scientists should sample the sections of the library and thereby get a diverse collection of the world’s organisms. But no one knows how the Library of Alexandria was cataloged, or if it even had sections separating, as we do today, history, medicine, religion, poetry, and other subjects. Cicero, however, tells us that the papyrus rolls were stored in niches in stone walls and that by torchlight one could read the *syllabi*, or label tags attached to them, to search for a title.<sup>37</sup>

The Library of Life implies that a species/book consists of a population of identical copies, one of which is preserved in the library as a specimen that patrons can consult as a type or reference of that population’s essence. The ancient Alexandrian library was of course a collection not of printed books but of manuscripts, most on papyrus paper scrolls, as well as of art and artifacts. A related but less often used metaphor has compared biodiversity to a collection of artworks, and extinctions to the “Louvre of biodiversity burning.”<sup>38</sup> The Library of Life phrase has prevailed over The Museum of Life, even though the ancient Alexandrian institution comprised both, because museums are assumed to hold unique works of art, unlike a library’s collection of species/books as specimen copies of a collective biocultural heritage. But scribes rarely produce exact copies of manuscripts, and neither does the diploid sexual reproduction of organisms result in exact copies of plants and animals. Scribes make both errors and corrections,

35. Williams, *Natural Selection*, 72–73.

36. Toadvine, “Biodiversity and the Diacritics of Life,” 235–48.

37. Delia, “From Romance to Rhetoric,” 1459.

38. von Weiszäcker, “Biodiversity Newspeak,” 60.

as well as minor and major editorial decisions, and many of the scribes in ancient Alexandria produced not copies but translations. These processes are more like the process of biological reproduction than the gene/text and species/book metaphors suggest, for the true source of biological and intellectual diversity is not preservation and copying, but mating and sexuality, reading and thinking. The Alexandrian Library of Life metaphor holds the germ for this fruitful idea, but the way it has been used does not adequately develop it. With a critical examination of the Library of Life metaphor, book history could also contribute to the study of biodiversity. It is worth reflecting on the fact that the idea of a worldwide multiplicity of plant and animal species, most of which no one person could see or know firsthand and thus would need to learn from graphic sources, emerged at the same time as the development of printing in the Renaissance. The early printed illustrated plant books, such as Leonard Fuchs's *De historia stirpium* (1542), made it possible for a large number of readers over a wide area to identify hundreds of different plants, secure in the knowledge that they were all referring to the same species, a plant that grew over a larger or smaller range in the wild. The concept of a species was scarcely possible without printing; printing not only of texts but also of pictures.

#### **A New Noah's Ark?**

A humanistic view holds that the beauty of a living organism, or the genius of a literary text, each transcends the symbols that represent or transmit it. The Alexandrian Library of Life figure emphasizes the storage or conservation rather than the enjoyment or use of the species/books in its collection. Implicit in Benford's proposal to collect and freeze biota without studying them first is the assumption that a frozen sample adequately represents a given species and will be sufficient to study and to reproduce that organism in the future, just as one can copy a manuscript or print a text from a file. Likewise, whereas libraries of the predigital age circulated books for borrowers to read and then return, electronic and genetic database libraries copy books and genomes without recourse to human reading, and store the results in digital formats that may become obsolete or unreadable in the future. The promises of the early hype surrounding the Human Genome Project, and more recent hype about personalized genetic medical treatments, have not really come to fruition, but nonetheless a popular notion persists that genomes are, like texts, easily copied, read, and interpreted. The success of personal genetic analysis services such as 23andme.com have capitalized on this conception of genes as legible sources of knowledge about ancestry, racial, and ethnic identity, as well as tools for health and wellness. Preserving a rare or extinct species, however, is not like donating a book to the library, or locating and transcribing a famous author's lost manuscript. Scientists and conservationists are seduced by a heroic Noah's ark myth, and so celebrate efforts to gather "of every living thing of all flesh, two of every sort . . . into the ark, to keep them alive with thee" (Genesis 6:19), when in fact modern humans are causing the flood that threatens the animals. Climate change and rising sea levels make the biblical metaphor even more pertinent, but the message is less

comforting than the Alexandrian Library of Life. In the biblical myth God both implores Noah to save the beasts that He has created and Adam has named and condemns the violation of His covenant: “God looked upon the earth, and, behold, it was corrupt; for all flesh had corrupted his way upon the earth” (6:12).

### **Conclusion: Life, not Printed**

So whereas the Alexandrian Library of Life makes a compelling appeal for the value of biodiversity, there are serious problems with the metaphor. In his 1992 article Benford acknowledged how “the far larger prospect of eventually reading and using a Library of Life is difficult for us to imagine or anticipate, at the early stages of a revolution in biological technology.”<sup>39</sup> The past twenty-five years have failed to deliver on some of the early promises of genetic engineering, and many people have come to see its risks as more salient than its benefits. Opposition to genetically modified food crops, livestock, and fish remains strong in many parts of the world. The sense of biodiversity as a common biocultural heritage has been challenged by indigenous rights organizations that accuse multinational biotechnology firms of exploiting tropical fauna without benefiting local residents.<sup>40</sup> Meanwhile, the dreams of a “new Alexandrian library” that would collect and digitize the world’s species, along with the world’s literature, have run up against the linguistic, political, and practical challenges that any such utopian project was bound to face.

Printed, published texts collected in libraries, both on paper and in electronic databases, are fundamental to the work of scholars, whether in literature, history, or the natural sciences. Indeed, academic careers are measured by the production and consumption of published and archived texts, the fixity, accessibility, and permanence of which all scholars rely on. The Library of Life concept extends these archival resources to species and specimens by merging the herbaria, fossils, and other natural history specimen collections with textual archives and adding to them the newer digital genomic databases, a goal facilitated by the widely accepted metaphor of genes as texts. But because the gene/text and species/book metaphors have serious limitations, the Library of Life is flawed as well. Actual plants, animals, and microorganisms are important and meaningful because they are alive, in habitats and ecosystems, and exist in confusing variety and multiplicity. Mutations and local adaptations are the basis for new speciation and, together with extinction, are continually changing biomes. A frozen or static collection, however large, does not do justice to this dynamic biodiversity.

However, in one sense the ancient Alexandrian library, with its fragile handwritten papyrus scrolls, may be a better figure for natural history than the popular metaphor admits. Because boundaries and distinctions between populations, varieties, and species are fuzzy, species names and boundaries are frequently disputed. Even aside

39. Benford, “Saving the ‘Library of Life,’” 11100.

40. See Kate and Laird, *Commercial Use of Biodiversity*.



from the classification of living organisms, the scribal problem of consistent spelling and copying of long binomial species names can render searchable electronic archives of species/texts ineffective.<sup>41</sup> Because the vast majority of the millions of species that make up Earth's sublime biodiversity are not charismatic vertebrates but fungi and bacteria whose distinct characteristics are not visible and whose vast numbers of specimens are too numerous or too ephemeral to archive, species and their modes of reproduction or translation may in truth be more like manuscripts than like printed books. When Richard Pyle, in the third epigraph, wrote, "Every species on Earth is like a unique book," he hinted at the weakness of the metaphor of species as a printed book, the copies of which are hardly unique. But as botanist Vernon Heywood, editor of the 1995 *Global Biodiversity Assessment*, pointed out: "It has to be remembered that the vast majority of species described in the literature are 'herbarium' or 'museum' species and their existence as coherent, repeatable population-based phenomena is only suppositional."<sup>42</sup> Geoffrey Bowker quotes Heywood in his article "Biodiversity Datadiversity" and adds, "There is often only one of a given species in preserved form," and that in practice, "most species are known through a single example—their holotype. Many of these holotypes are known only through books or other publications, since the original specimen either was not collected or has been lost: these are called 'lectoholotypes.'"<sup>43</sup> For these lectoholotypes the specimen is lost and only the verbal, graphic, or genomic representations remain in the archive. As Bowker argues in his article, biodiversity as a scientific and political priority has been driven by the development of digital databases and the computer-powered research that creates and uses them, and has created "panoptical dreams" to "catalogue completely the natural empire."<sup>43</sup> The article does not mention the Alexandrian Library of Life, but the metaphor is symptomatic of Bowker's and Haraway's insight on how data has come to replace the entities and phenomena it was meant to measure and represent.

Books, unlike plants and animals, cannot survive or reproduce in the absence of humans, whose lives they express and interpret. The books in the Alexandrian library were written by humans, as indeed all books are made and maintained by human writers and readers, whereas living organisms reproduce themselves. Humans have for centuries identified diverse species and maintained representations of them in the media of verbal descriptions, drawings, paintings and photographs, catalogs, herbaria, specimen collections, zoos, gardens, and genomic databases. In that sense the Library of Life metaphor is valid. Papyrus scrolls in little stone niches, fossilized bones in boxes in drawers, leaves and flowers pressed onto paper, moths and beetles crucified by pins, each with a name on a label—these are the things that, as well as manuscripts and

41. See Johnson, "All-Genera Index."

42. Heywood and Watson, *Global Biodiversity Assessment*, quoted in Bowker, "Biodiversity Datadiversity," 649.

43. Bowker, "Biodiversity Datadiversity," 650, 671.

printed paper books on shelves, have long constituted human knowledge of biodiversity. Recently, digital libraries and genomic databases aspire to represent and to supplement (or supersede) these tangible archives by annihilating the distance, the decay, and the ambiguous particularity of the texts and specimens. This imperial gesture of a universal archive of biodiversity, such as at eol.org, threatens to obscure and distract from the true richness of life. To understand the relationship between organisms, species, and specimens on one side of the simile and books, manuscripts, texts, and images on the other side requires a humanistic and literary approach. This is because the species concept, ever since antiquity, has always been dependent on the forms of media used to represent, record, and disseminate descriptions and images of these species. As our media change, our understandings and images of species change too, and as extinction threatens more species we must appreciate the differences between organisms and archives, or we may find ourselves in an impoverished biosphere clutching only our data.

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