

information has led to a cleaner and more powerful theory, both of computing and communication." Shannon lived till 2001, his last years dimmed and isolated by the disease of erasure, Alzheimer's. His life had spanned the twentieth century and helped to define it. As much as any one person, he was the progenitor of the information age. Cyberspace is in part his creation; he never knew it, though he told his last interviewer, in 1987, that he was investigating the idea of mirrored rooms: "to work out all the possible mirrored rooms that make sense, in that if you looked everywhere from inside one, space would be divided into a bunch of rooms, and you would be in each room and this would go on to infinity without contradiction." He hoped to build a gallery of mirrors in his house near MIT, but he never did.

It was John Wheeler who left behind an agenda for quantum information science—a modest to-do list for the next generation of physicists and computer scientists together:

"Translate the quantum versions of string theory and of Einstein's geometrodynamics from the language of continuum to the language of bit," he exhorted his heirs.

"Survey one by one with an imaginative eye the powerful tools that mathematics—including mathematical logic—has won . . . and for each such technique work out the transcription into the world of bits."

And, "From the wheels-upon-wheels-upon-wheels evolution of computer programming dig out, systematize and display every feature that illuminates the level-upon-level-upon-level structure of physics."

And, "*Finally*. Deplete? No, celebrate the absence of a clean clear definition of the term 'bit' as elementary unit in the establishment of meaning. . . . If and when we learn how to combine bits in fantastically large numbers to obtain what we call existence, we will know better what we mean both by bit and by existence."

This is the challenge that remains, and not just for scientists: the establishment of meaning.

## 14 | AFTER THE FLOOD

*(A Great Album of Babel)*

*Suppose within every book there is another book, and within every letter on every page another volume constantly unfolding; but these volumes take no space on the desk. Suppose knowledge could be reduced to a quintessence, held within a picture, a sign, held within a place which is no place.*

—Hilary Mantel (2009)

"THE UNIVERSE (which others call the Library) . . ."

Thus Jorge Luis Borges began his 1941 story "The Library of Babel," about the mythical library that contains all books, in all languages, books of apology and prophecy, the gospel and the commentary upon that gospel and the commentary upon the commentary upon the gospel, the minutely detailed history of the future, the interpolations of all books in all other books, the faithful catalogue of the library and the innumerable false catalogues. This library (which others call the universe) enshrines all the information. Yet no knowledge can be discovered there, precisely because all knowledge *is* there, shelved side by side with all falsehood. In the mirrored galleries, on the countless shelves, can be found everything and nothing. There can be no more perfect case of information glut.

We make our own storehouses. The persistence of information, the difficulty of forgetting, so characteristic of our time, accretes confusion. As the free, amateur, collaborative online encyclopedia called Wikipedia began to overtake all the world's printed encyclopedias in volume and



comprehensiveness, the editors realized that too many names had multiple identities. They worked out a disambiguation policy, which led to the creation of disambiguation pages—a hundred thousand and more. For example, a user foraging in Wikipedia's labyrinthine galleries for "Babel" finds "Babel (disambiguation)," which leads in turn to the Hebrew name for ancient Babylon, to the Tower of Babel, to an Iraqi newspaper, a book by Parti Smith, a Soviet journalist, an Australian language teachers' journal, a film, a record label, an island in Australia, two different mountains in Canada, and "a neutrally aligned planet in the fictional Star Trek universe." And more. The paths of disambiguation fork again and again. For example, "Tower of Babel (disambiguation)" lists, besides the story in the Old Testament, songs, games, books, a Brueghel painting, an Escher woodcut, and "the rarer card." We have made many towers of Babel.

Long before Wikipedia, Borges also wrote about the encyclopedia "fallaciously called *The Anglo-American Cyclopaedia* (New York, 1917)," a warren of fiction mingling with fact, another hall of mirrors and misprints, a compendium of pure and impure information that projects its own world. That world is called Tlön. "It is conjectured that this brave new world is the work of a secret society of astronomers, biologists, engineers, metaphysicians, poets, chemists, algebraists, moralists, painters, geometers. . . ." writes Borges. "This plan is so vast that each writer's contribution is infinitesimal. At first it was believed that Tlön was a mere chaos, an irresponsible license of the imagination; now it is known that it is a cosmos." With good reason, the Argentine master has been taken up as a prophet ("our hersiarch uncle," William Gibson says) by another generation of writers in the age of information.

Long before Borges, the imagination of Charles Babbage had conjured another library of Babel. He found it in the very air: a record, scrambled yet permanent, of every human utterance.

What a strange chaos is this wide atmosphere we breathe! . . . The air itself is one vast library, on whose pages are for ever written all that man has ever said or woman whispered. There, in their mutable but unerring characters,

mixed with the earliest, as well as the latest sighs of mortality, stand for ever recorded, vows unredeemed, promises unfulfilled, perpetuating in the united movements of each particle, the testimony of man's changeful will.

Edgar Allan Poe, following Babbage's work eagerly, saw the point. "No thought can perish," he wrote in 1845, in a dialogue between two angels. "Did there not cross your mind some thought of the *physical power of words*? Is not every word an impulse on the air?" Further, every impulse vibrates outward indefinitely, "upward and onward in their influences upon all particles of all matter," until it must, "*in the end*, impress every individual thing that exists *within the universe*." Poe was also reading Newton's champion Pierre-Simon Laplace. "A being of infinite understanding," wrote Poe, "—one to whom the *perfection* of the algebraic analysis lay unfolded" could trace the undulations backward to their source.

Babbage and Poe took an information-theoretic view of the new physics. Laplace had expounded a perfect Newtonian mechanical determinism; he went further than Newton himself, arguing for a clockwork universe in which nothing is left to chance. Since the laws of physics apply equally to the heavenly bodies and the tiniest particles, and since they operate with perfect reliability, then surely (said Laplace) the state of the universe at every instant follows inexorably from the past and must lead just as relentlessly to the future. It was too soon to conceive of quantum uncertainty, chaos theory, or the limits of computability. To dramatize his perfect determinism, Laplace asked us to imagine a being—an "intelligence"—capable of perfect knowledge:

It would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes.

Nothing else Laplace wrote ever became as famous as this thought experiment. It rendered useless not only God's will but Man's. To scientists this extreme Newtonianism seemed cause for optimism. To Babbage, all



nature suddenly resembled a vast calculating engine, a grand version of his own deterministic machine: "In turning our views from these simple consequences of the juxtaposition of a few wheels, it is impossible not to perceive the parallel reasoning, as applied to the mighty and far more complex phenomena of nature." Each atom, once disturbed, must communicate its motion to others, and they in turn influence waves of air, and no impulse is ever entirely lost. The track of every canoe remains somewhere in the oceans. Babbage, whose railroad pen recorder traced on a roll of paper the history of a journey, saw information, formerly evanescent, as a series of physical impressions that were, or could be preserved. The phonograph, impressing sound into foil or wax, had yet to be invented, but Babbage could view the atmosphere as an engine of motion with meaning: "every atom impressed with good and with ill . . . which philosophers and sages have imparted to it, mixed and combined in ten thousand ways with all that is worthless and base." Every word ever said, whether heard by a hundred listeners or none, far from having vanished into the air, leaves its indelible mark, the complete record of human utterance being encrypted by the laws of motion and capable, in theory, of being recovered—given enough computing power.

This was overoptimistic. Still, the same year Babbage published his essay, the artist and chemist Louis Daguerre in Paris perfected his means of capturing visual images on silver-coated plates. His English competitor, William Fox Talbot, called this "the art of photogenic drawing, or of forming pictures and images of natural objects by means of solar light." Talbot saw something meme-like. "By means of this contrivance," he wrote, "it is not the artist who makes the picture, but the picture which makes *itself*." Now the images that fly before our eyes could be frozen, impressed upon substance, made permanent.

By painting or drawing, an artist—with skill, training, and long labor—reconstructs what the eye might see. By contrast, a daguerreotype is in some sense the thing itself—the information, stored, in an instant. It was unimaginable, but there it was. The possibilities made the mind

reel. Once storage began, where would it stop? An American essayist immediately connected photography to Babbage's atmospheric library of sounds: Babbage said that every word was registered somewhere in the air, so perhaps every image, too, left its permanent mark—somewhere.

In fact, there is a great album of Babel. But what too, if the great busi-ness of the sun be to act registrar likewise, and to give out impressions of our looks, and pictures of our actions; and so . . . for all we know to the contrary, other worlds may be peopled and conducted with the images of persons and transactions thrown off from this and from each other; the whole universal nature being nothing more than phonetic and photogenic structures.

The universe, which others called a library or an album, then came to resemble a computer. Alan Turing may have noticed this first: observing that the computer, like the universe, is best seen as a collection of states, and the state of the machine at any instant leads to the state at the next instant, and thus all the future of the machine should be predictable from its initial state and its input signals.

The universe is computing its own destiny.

Turing noticed that Laplace's dream of perfection might be possible in a machine but not in the universe, because of a phenomenon which, a generation later, would be discovered by chaos theorists and named the butterfly effect. Turing described it this way in 1950:

The system of the "universe as a whole" is such that quite small errors in initial conditions can have an overwhelming effect at a later time. The displacement of a single electron by a billionth of a centimetre at one moment might make the difference between a man being killed by an avalanche a year later, or escaping.

If the universe is a computer, we may still struggle to access its memory. If it is a library, it is a library without shelves. When all the world's sounds



disperse through the atmosphere, no word is left attached to any particular bunch of atoms. The words are anywhere and everywhere. That was why Babbage called this information store a "chaos." Once again he was ahead of his time.

When the ancients listed the Seven Wonders of the World, they included the Lighthouse of Alexandria, a 400-foot stone tower built to aid sailors, but overlooked the library nearby. The library, amassing hundreds of thousands of papyrus rolls, maintained the greatest collection of knowledge on earth, then and for centuries to come. Beginning in the third century BCE, it served the Ptolemies' ambition to buy, steal, or copy all the writings of the known world. The library enabled Alexandria to surpass Athens as an intellectual center. Its racks and cloisters held the dramas of Sophocles, Aeschylus, and Euripides; the mathematics of Euclid, Archimedes, and Eratosthenes; poetry, medical texts, star charts, mystic writings—"such a blaze of knowledge and discovery," H. G. Wells declared, "as the world was not to see again until the sixteenth century. . . . It is the true beginning of Modern History." The lighthouse loomed large, but the library was the real wonder. And then it burned.

Exactly when and how that happened, no one can ever know. Probably more than once. Vengeful conquerors burn books as if the enemy's souls reside there, too. "The Romans burnt the books of the Jews, of the Christians, and the philosophers," Isaac D'Israeli noted in the nineteenth century; "the Jews burnt the books of the Christians and the Pagans; and the Christians burnt the books of the Pagans and the Jews." The Qin dynasty burned China's books in order to erase previous history. The erasure was effective, the written word being fragile. What we have of Sophocles is not even a tenth of his plays. What we have of Aristotle is mostly second- or thirdhand. For historians peering into the past, the destruction of the Great Library is an event horizon, a boundary across which information does not pass. Not even a partial catalogue survived the flames.

"All the lost plays of the Athenians!" wails Thomasina (a young mathematician who resembles Ada Byron) to her tutor, Septimius, in Tom Stoppard's drama *Arcadia*. "Thousands of poems—Aristotle's own library. . . . How can we sleep for grief?"

"By counting our stock," Septimius replies.

You should no more grieve for the rest than for a buckle lost from your first shoe, or for your lesson book which will be lost when you are old. We shed as we pick up, like travelers who must carry everything in their arms, and what we let fall will be picked up by those behind. The procession is very long and life is very short. We die on the march. But there is nothing outside the march so nothing can be lost to it. The missing plays of Sophocles will turn up piece by piece, or be written again in another language.

Anyway, according to Borges, the missing plays can be found in the Library of Babel.

In honor of the lost library, Wikipedia drew hundreds of its editors to Alexandria in the eighth summer of its existence—people called Shipmaster, Brassrigger, Notafish, and Jimbo who ordinarily meet only online. More than 7 million such user names had been registered by then; the pilgrims came from forty-five countries, paying their own way, toting laptops, exchanging tradecraft, wearing their fervor on their T-shirts. By then, July 2008, Wikipedia comprised 2.5 million articles in English, more than all the world's paper encyclopedias combined, and a total of 11 million in 264 languages, including Wolof, Twi, and Dutch Low Saxon, but not including Choctaw, closed by community vote after achieving only fifteen articles, or Klingon, found to be a "constructed," if not precisely fictional, language. The Wikipedians consider themselves as the Great Library's heirs, their mission the gathering of all recorded knowledge. They do not, however, collect and preserve existing texts. They attempt to summarize shared knowledge, apart from and outside of the individuals who might have thought it was theirs.

Like the imaginary library of Borges, Wikipedia begins to appear



boundless. Several dozen of the non-English Wikipedias have, each, one article on Pokémon, the trading-card game, manga series, and media franchise. The English Wikipedia began with one article and then a jungle grew. There is a page for “Pokémon (disambiguation),” needed, among other reasons, in case anyone is looking for the Zbtb7 oncogene, which was called Pokémon (for POK erythroid myeloid ontogenic factor), until Nintendo’s trademark lawyers threatened to sue. There are at least five major articles about the popular-culture Pokémons, and these spawn secondary and side articles, about the Pokémon regions, items, television episodes, game tactics, and all 493 creatures, heroes, protagonists, rivals, companions, and clones, from Bulbasaur to Arcus. All are carefully researched and edited for accuracy, to ensure that they are reliable and true to the Pokémon universe, which does not actually, in some senses of the word, exist. Back in the real world, Wikipedia has, or aspires to have, detailed entries describing the routes, intersections, and histories of every numbered highway and road in the United States. (“Route 273 [New York State, decommissioned in 1980] began at an intersection with U.S. Route 4 in Whitehall. After the intersection, the route passed the Our Lady of Angels Cemetery, where it turned to the southeast. Route 273 ran along the base of Ore Red Hill, outside of Whitehall. Near Ore Red Hill, the highway intersected with a local road, which connected to US 4.”) There are pages for every known enzyme and human gene. The *Encyclopaedia Britannica* never aspired to such breadth. How could it, being made of paper?

Alone among the great enterprises of the early Internet, Wikipedia was not a business; made no money, only lost money. It was supported by a nonprofit charity established for the purpose. By the time the encyclopedia had 50 million users daily, the foundation had a payroll of eighteen people, including one in Germany, one in the Netherlands, one in Australia, and one lawyer, and everyone else was a volunteer: the millions of contributors, the thousand or more designated “administrators,” and, always a looming presence, the founder and self-described “spiritual leader,” Jimmy Wales. Wales did not plan initially the scrappy, chaotic,

dilettantish, amateurish, upstart free-for-all that Wikipedia quickly became. The would-be encyclopedia began with a roster of experts, academic credentials, verification, and peer review. But the wiki idea took over, willy-nilly. A “wiki,” from a Hawaiian word for “quick,” was a web site that could be not just viewed but edited, by anyone. A wiki was therefore self-created, or at least self-sustaining.

Wikipedia first appeared to Internet users with a simple self-description:

#### *HomePage*

*You can edit this page right now! It's a free, community project*

*Welcome to Wikipedia! We're writing a complete encyclopedia from scratch, collaboratively. We started work in January 2001. We've got over 3,000 pages already. We want to make over 100,000. So, let's get to work! Write a little (or a lot) about what you know! Read our welcome message here: Welcome, newcomers!*

The sparseness of the coverage that first year could be gauged by the list of requested articles. Under the heading of Religion: “Catholicism?—Satan?—Zoroaster?—Mythology?” Under Technology: “internal combustion engine?—dirigible?—liquid crystal display?—bandwidth?” Under Folklore: “(If you want to write about folklore, please come up with a list of folklore topics that are actually recognized as distinct, significant topics in folklore, a subject that you are not likely to know much about if all you’ve done along these lines is play Dungeons and Dragons, q.v.).” Dungeons and Dragons was already well covered. Wikipedia was not looking for flotsam and jetsam but did not scorn them. Years later, in Alexandria, Jimmy Wales said: “All those people who are obsessively writing about Britney Spears or the Simpsons or Pokémon—it’s just not true that we should try to redirect them into writing about obscure concepts in physics. Wiki is not paper, and their time is not owned by us. We can’t say, ‘Why do we have these employees doing stuff that’s so useless?’ They’re not hurting anything. Let them write it.”

“Wiki is not paper” was the unofficial motto. Self-referentially, the



phrase has its own encyclopedia page (see also "*Wiki ist kein Papier*" and "*Wikipedia n'est pas sur papier*"). It means there is no physical or economic limit on the number or the length of articles. Bits are free. "Any kind of metaphor around paper or space is dead," as Wales said.

Wikipedia found itself a mainstay of the culture with unexpected speed, in part because of its unplanned synergistic relationship with Google. It became a test case for ideas of crowd intelligence: users endlessly debated the reliability—in theory and in actuality—of articles written in an authoritative tone by people with no credentials, no verifiable identity, and unknown prejudices. Wikipedia was notoriously subject to vandalism. It exposed the difficulties—perhaps the impossibility—of reaching a neutral, consensus view of disputed, tumultuous reality. The process was plagued by so-called edit wars, when battling contributors reversed one another's alterations without surcease. At the end of 2006, people concerned with the "Cat" article could not agree on whether a human with a cat is its "owner," "caregiver," or "human companion." Over a three-week period, the argument extended to the length of a small book. There were edit wars over commas and edit wars over gods, futile wars over spelling and pronunciation and geopolitical disputes. Other edit wars exposed the malleability of words. Was the Conch Republic (Key West, Florida) a "micronation"? Was a particular photograph of a young polar bear "cute"? Experts differed, and everyone was an expert.

After the occasional turmoil, articles tend to settle toward permanence; still, if the project seems to approach a kind of equilibrium, it is nonetheless dynamic and unstable. In the Wikipedia universe, reality cannot be pinned down with finality. That idea was an illusion fostered in part by the solidity of a leather-and-paper encyclopedia. Denis Diderot aimed in the *Encyclopédie*, published in Paris beginning in 1751, "to collect all the knowledge that now lies scattered over the face of the earth, to make known its general structure to the men with whom we live, and to transmit it to those who will come after us." The *Britannica*, first produced in

Edinburgh in 1768 in one hundred weekly installments, sixpence apiece, wears the same halo of authority. It seemed finished—in every edition. It has no equivalent in any other language. Even so, the experts responsible for the third edition ("in Eighteen Volumes, Greatly Improved"), a full century after Isaac Newton's *Principia*, could not bring themselves to endorse his, or any, theory of gravity, or gravitation. "There have been great disputes," the *Britannica* stated.

Many eminent philosophers, and among the rest Sir Isaac Newton himself, have considered it as the first of all second causes; an incorporeal or spiritual substance, which never can be perceived any other way than by its effects; an universal property of matter, &c. Others have attempted to explain the phenomena of gravitation by the action of a very subtle ethereal fluid; and to this explanation Sir Isaac, in the latter part of his life, seems not to have been averse. He hath even given a conjecture concerning the matter in which this fluid might occasion these phenomena. But for a full account of . . . the state of the dispute at present, see the articles, Newtonian Philosophy, Astronomy, Atmosphere, Earth, Electricity, Fire, Light, Attraction, Repulsion, Plenum, Vacuum, &c.

As the *Britannica* was authoritative, Newton's theory of gravitation was not yet knowledge.

Wikipedia disclaims this sort of authority. Academic institutions officially distrust it. Journalists are ordered not to rely upon it. Yet the authority comes. If one wants to know how many American states contain a county named Montgomery, who will disbelieve the tally of eighteen in Wikipedia? Where else could one look for a statistic so obscure—generated by a summing of the knowledge of hundreds or thousands of people, each of whom may know of only one particular Montgomery County? Wikipedia features a popular article called "Errors in the *Encyclopaedia Britannica* that have been corrected in Wikipedia." This article is, of course, always in flux. All Wikipedia is. At any moment the reader is catching a version of truth on the wing.



When Wikipedia states, in the article "Aging,"

After a period of near perfect renewal (in humans, between 20 and 35 years of age [citation needed]), organismal senescence is characterized by the declining ability to respond to stress, increasing homeostatic imbalance and increased risk of disease. This irreversible series of changes inevitably ends in death,

a reader may trust this; yet for one minute in the early morning of December 20, 2007, the entire article comprised instead a single sentence: "Aging is what you get when you get freakin' old old old." Such obvious vandalism lasts hardly any time at all. Detecting it and reversing it are automated vandabots and legions of human vandal fighters, many of them proud members of the Counter-Vandalism Unit and Task Force. According to a popular saying that originated with a frustrated vandal, "On Wikipedia, there is a giant conspiracy attempting to have articles agree with reality." This is about right. A conspiracy is all the Wikipedians can hope for, and often it is enough.

Lewis Carroll, near the end of the nineteenth century, described in fiction the ultimate map, representing the world on a unitary scale, a mile to a mile: "It has never been spread out, yet. The farmers objected; they said it would cover the whole country, and shut out the sunlight." The point is not lost on Wikipedians. Some are familiar with a debate carried out by the German branch about the screw on the left rear brake pad of Ulrich Fuchs's bicycle. Fuchs, as a Wikipedia editor, proposed the question, Does this item in the universe of objects merit its own Wikipedia entry? The screw was agreed to be small but real and specifiable. "This is an object in space, and I've seen it," said Jimmy Wales. Indeed, an article appeared in the German Meta-Wiki (that is, the Wikipedia about Wikipedia) titled "*Die Schraube an der hinteren linken Bremsbacke am Fahrrad von Ulrich Fuchs*." As Wales noted, the very existence of this article was "a meta-irony." It was written by the very people who were arguing against its suitability. The article was not really about the screw, however. It is

about a controversy: whether Wikipedia should strive, in theory or in practice, to describe the whole world in all its detail.

Opposing factions coalesced around the labels "deletionism" and "inclusionism." Inclusionists take the broadest view of what belongs in Wikipedia. Deletionists argue for, and often perform, the removal of trivia: articles too short or poorly written or unreliable, on topics lacking notability. All these criteria are understood to be variable and subjective. Deletionists want to raise the bar of quality. In 2008 they succeeded in removing an entry on the Port Macquarie Presbyterian Church, New South Wales, Australia, on grounds of non-notability. Jimmy Wales himself leaned toward inclusionism. In the late summer of 2007, he visited Cape Town, South Africa, ate lunch at a place called Mzoli's, and created a "stub" with a single sentence: "Mzoli's Mears is a butcher shop and restaurant located in Gugulethu township near Cape Town, South Africa." It survived for twenty-two minutes before a nineteen-year-old administrator called ^demon deleted it on grounds of insignificance. An hour later, another user re-created the article and expanded it based on information from a local Cape Town blog and a radio interview transcribed online. Two minutes passed, and yet another user objected on grounds that "this article or section is written like an advertisement." And so on. The word "famous" was inserted and deleted several times. The user ^demon weighed in again, saying, "We are not the white pages and we are not a travel guide." The user EVvula retorted, "I think if we give this article a bit more than a couple of hours of existence, we might have something worthwhile." Soon the dispute attracted newspaper coverage in Australia and England. By the next year, the article had not only survived but had grown to include a photograph, an exact latitude and longitude, a list of fourteen references, and separate sections for History, Business, and Tourism. Some hard feelings evidently remained, for in March 2008 an anonymous user replaced the entire article with one sentence: "Mzoli's is an insignificant little restaurant whose article only exists here because Jimmy Wales is a bumbling egomaniac." That lasted less than a minute. Wikipedia evolves dendritically, sending off new shoots in many



directions. (In this it resembles the universe.) So deletionism and inclusionism spawn mergism and incrementalism. They lead to factionalism, and the factions fission into Associations of Deletionist Wikipedians and Inclusionist Wikipedians side by side with the Association of Wikipedians Who Dislike Making Broad Judgments About the Worthiness of a General Category of Article, and Who Are in Favor of the Deletion of Some Particularly Bad Articles, but That Doesn't Mean They Are Deletionists. Wales worried particularly about Biographies of Living Persons. In an ideal world, where Wikipedia could be freed from practical concerns of maintenance and reliability, Wales said he would be happy to see a biography of every human on the planet. It outdoes Borges.

Even then, at the impossible extreme—every person, every bicycle screw—the collection would possess nothing like All Knowledge. For encyclopedias, information tends to come in the form of topics and categories. *Britannica* framed its organization in 1790 as “a plan entirely new.” It advertised “the different sciences and arts” arranged as “distinct Treatises or Systems”—

*And full Explanations given of the*

Various Detached Parts of Knowledge, whether relating to Natural and Artificial Objects, or to Matters Ecclesiastical, Civil, Military, Commercial, &c.

In Wikipedia the detached parts of knowledge tend to keep splitting. The editors analyzed the logical dynamics as Aristotle or Boole might have:

Many topics are based on the relationship of *factor X* to *factor Y*, resulting in one or more full articles. This could refer to, for example, *situation X* in *location Y*, or *version X* of *item Y*. This is perfectly valid when the two variables put together represent some culturally significant phenomenon or some otherwise notable interest. Often, separate articles are needed for a subject within a range of different countries due to its substantial differences across international borders. Articles like Slate industry in Wales and Island Fox are fitting examples. But writing about Oak trees in North

Carolina or a Blue truck would likely constitute a POV fork, original research, or would otherwise be outright silly.

Charles Dickens had earlier considered this very problem. In *The Pickwick Papers*, a man is said to have read up in the *Britannica* on Chinese metaphysics. There was, however, no such article: “He read for metaphysics under the letter M, and for China under the letter C, and combined his information.”

In 2008 the novelist Nicholson Baker, calling himself Wageless, got sucked into Wikipedia like so many others, first seeking information and then tentatively supplying some, beginning one Friday evening with the article on bovine somatotropin and, the next day, *Sleepless in Seattle*, periodization, and hydraulic fluid. On Sunday it was pomochanchada (Brazilian sex films), a football player of the 1950s called Earl Blair, and back to hydraulic fluid. On Tuesday he discovered the Article Rescue Squadron, dedicated to finding articles in danger of deletion and saving them by making them better instead. Baker immediately signed up, typing a note: “I want to be a part of this.” His descent into obsession is documented in the archives, like everything else that happens on Wikipedia, and he wrote about it a few months later in a print publication, *The New York Review of Books*.

I began standing with my computer open on the kitchen counter, staring at my growing watchlist, checking, peeking. . . . I stopped hearing what my family was saying to me—for about two weeks I all but disappeared into my screen, trying to salvage brief, sometimes overly promotional but nevertheless worthy biographies by recasting them in neutral language, and by hastily scouring newspaper databases and Google Books for references that would bulk up their notability quotient. I had become an “inclusionist.”

He concluded with a “secret hope”: that all the flopsam and jetsam could be saved, if not in Wikipedia than in “a Wikimorgue—a bin of broken dreams.” He suggested calling it Deletopedia. “It would have much to



tell us over time." On the principle that nothing online ever perishes, Delionpedia was created shortly thereafter, and it has grown by degrees. The Port Macquarie Presbyterian Church lives on there, though it is not, strictly speaking, part of the encyclopedia. Which some call the universe.

Names became a special problem: their disambiguation; their complexity; their collisions. The nearly limitless flow of information had the effect of throwing all the world's items into a single arena, where they seemed to play a frantic game of Bumper Car. Simpler times had allowed simpler naming: "The Lord God formed every beast of the field, and every fowl of the air; and brought them unto Adam to see what he would call them," says Genesis; "and whatsoever Adam called every living creature, that was the name thereof." For each creature one name; for each name one creature. Soon, however, Adam had help.

In his novel *The Infinities*, John Banville imagines the god Hermes saying: "A hamadryad is a wood-nymph, also a poisonous snake in India, and an Abyssinian baboon. It takes a god to know a thing like that." Yet according to Wikipedia, *hamadryad* also names a butterfly, a natural history journal from India, and a Canadian progressive rock band. Are we all now as gods? The rock band and the wood nymph could coexist without friction, but more generally the breaking down of information barriers leads to conflict over names and naming rights. Impossible as it seems, the modern world is running out of names. The roster of possibilities seems infinite, but the demand is even greater.

The major telegraph companies, struggling in 1919 with the growing problem of misdirected messages, established a Central Bureau for Registered Addresses. Its central office in the financial district of New York filled an upstairs room on Broad Street with steel filing cabinets. Customers were invited to register code names for their addresses: single words of five to ten letters, required to be "pronounceable"—that is, "made up of syllables that appear in one of eight European languages."

Many customers complained about the yearly charge—\$2.50 per code name—but by 1934 the bureau was managing a list of 28,000, including ILLUMINATE (the New York Edison Company), TOOTSWEETS (the Sweet Company of America), and CHERRYTREE (George Washington Hotel). The financier Bernard M. Baruch managed to get BARUCH all to himself. It was first come, first served, and it was a modest harbinger of things to come.

Cyberspace, of course, changes everything. A South Carolina company called Fox & Hound Realty, Billy Benton owner/broker, registered the domain name BARUCH.COM. A Canadian living in High Prairie, Alberta, registered JRRTOLEKIE.N.COM and held on to it for a decade, until a panel of the World Intellectual Property Organization in Geneva took it away from him. The name had value; others who claimed an interest in it, as a brand and a trademark, either registered or unregistered, included the late writer's heirs, publisher, and filmmakers, not to mention the several thousand people worldwide who happened to share his surname. The same High Prairie man was basing a business on his possession of famous names: Céline Dion, Albert Einstein, Michael Crichton, Pierce Brosnan, and about 1,500 more. Some of these people fought back. A select few names—the pinnacles and hilltops—have developed a tremendous concentration of economic value. The word *Nike* is thought by economists to be worth \$7 billion; *Coca-Cola* is valued at ten times more.

In the study of onomastics it is axiomatic that growing social units lead to growing name systems. For life in tribes and villages, single names like Albin and Ava were enough, but tribes gave way to clans, cities to nations, and people had to do better: surnames and patronyms; names based on geography and occupation. More complex societies demand more complex names. The Internet represents not just a new opportunity for fights over names but a leap in scale causing a phase transition.

An Atlanta music writer known as Bill Wyman received a cease-and-desist letter from lawyers representing the former Rolling Stone bass player also known as Bill Wyman; demanding, that is, that he "cease and desist"



using his name. In responding, the first Bill Wyman pointed out that the second Bill Wyman had been born William George Perks. The car company known in Germany as Dr. Ing. h.c. F. Porsche AG fought a series of battles to protect the name Carrera. Another contender was the Swiss village, postal code 7122. "The village Carrera existed prior to the Porsche trademark," Christoph Reuss of Switzerland wrote to Porsche's lawyers. "Porsche's use of that name constitutes a misappropriation of the goodwill and reputation developed by the villagers of Carrera." He added for good measure, "The village emits much less noise and pollution than Porsche Carrera." He did not mention that José Carreras, the opera singer, was embroiled in a name dispute of his own. The car company, meanwhile, also claimed trademark ownership of the numerals 911.

A useful term of art emerged from computer science: *namespace*, a realm within which all names are distinct and unique. The world has long had namespaces based on geography and other namespaces based on economic niche. You could be Bloomingdale's as long as you stayed out of New York; you could be Ford if you did not make automobiles. The world's rock bands constitute a namespace, where Pretty Boy Floyd and Pink Floyd and Pink coexist, along with the 13th Floor Elevators and the 99th Floor Elevators and Hamadryad. Finding new names in this space becomes a challenge. The singer and songwriter long called simply "Prince" was given that name at birth; when he tired of it, he found himself tagged with a meta-name, "the Artist Formerly Known as Prince." The Screen Actors Guild maintains a formal namespace of its own—only one Julia Roberts allowed. Traditional namespaces are overlapping and melting together. And many grow overcrowded.

Pharmaceutical names are a special case: a subindustry has emerged to coin them, research them, and vet them. In the United States, the Food and Drug Administration reviews proposed drug names for possible collisions, and this process is complex and uncertain. Mistakes cause death. Methadone, for opiate dependence, has been administered in place of Metadate, for attention-deficit disorder, and Taxol, a cancer drug, for

Taxotere, a different cancer drug, with fatal results. Doctors fear both look-alike errors and sound-alike errors: Zantac/Xanax; Verelan/Virilon. Linguists devise scientific measures of the "distance" between names. But Lamiactal and Lamiatil and Ludiomil and Lomocil are all approved drug names.

In the corporate namespace, signs of overcrowding could be seen in the fading away of what might be called simple, meaningful names. No new company could be called anything like General Electric or First National Bank or International Business Machines. Similarly, A.1. Steak Sauce could only refer to a food product with a long history. Millions of company names exist, and vast sums of money go to professional consultants in the business of creating more. It is no coincidence that the spectacular naming triumphs of cyberspace verge on nonsense: Yahoo!, Google, Twitter.

The Internet is not just a churner of namespaces; it is also a namespace of its own. Navigation around the globe's computer networks relies on the special system of domain names, like COCA-COLA.COM. These names are actually addresses, in the modern sense of that word: "a register, location, or a device where information is stored." The text encodes numbers; the numbers point to places in cyberspace, branching down networks, subnetworks, and devices. Although they are code, these brief text fragments also carry the great weight of meaning in the most vast of namespaces. They blend together features of trademarks, vanity license plates, postal codes, radio-station call letters, and graffiti. Like the telegraph code names, anyone could register a domain name, for a small fee, beginning in 1993. It was first come, first served. The demand exceeds the supply.

Too much work for short words. Many entities own "apple" trademarks, but there is only one APPLE.COM; when the domains of music and computing collided, so did the Beatles and the computer company. There is only one McDONALDS.COM, and a journalist named Joshua Quittner registered it first. Much as the fashion empire of Giorgio Armani wanted ARMANI.COM, so did Anand Ramnath Mani of Vancouver, and



he got there first. Naturally a secondary market emerged for trade in domain names. In 2006, one entrepreneur paid another entrepreneur \$14 million for *SEX.COM*. By then nearly every word in every well-known language had been registered; so had uncountable combinations of words and variations of words—more than 100 million. It is a new business for corporate lawyers. A team working for DaimlerChrysler in Stuttgart, Germany, managed to wrest back *MERCEDESSHOP.COM*, *DRIVEAMERCEDES.COM*, *DODGEVIPER.COM*, *CRYSLER.COM*, *CHRISTLER.COM*, *CHRISTLER.COM*, and *CHRISTLER.COM*.

The legal edifices of intellectual property were rattled. The response was a species of panic—a land grab in trademarks. As recently as 1980, the United States registered about ten thousand a year. Three decades later, the number approached three hundred thousand, jumping every year. The vast majority of trademark applications used to be rejected; now the opposite is true. All the words of the language, in all possible combinations, seem eligible for protection by governments. A typical batch of early twenty-first century United States trademarks: *GREEN CIRCLE*, *DESERT ISLAND*, *MY STUDENT BODY*, *ENJOY A PARTY IN EVERY BOWL*!, *TECHNOLOIFT*, *MEETINGS IDEAS*, *TAMPER PROOF KEY RINGS*, *THE BEST FROM THE WEST*, *AWESOME ACTIVITIES*.

The collision of names, the exhaustion of names—it has happened before, if never on this scale. Ancient naturalists knew perhaps five hundred different plants and, of course, gave each a name. Through the fifteenth century, that is as many as anyone knew. Then, in Europe, as printed books began to spread with lists and drawings, an organized, collective knowledge came into being; and with it, as the historian Brian Ogilvie has shown, the discipline called natural history. The first botanists discovered a profusion of names. Caspar Ratzenberger, a student at Wittenberg in the 1550s, assembled a herbarium and tried to keep track; for one species he noted eleven names in Latin and German: *Scandix*, *Pecten veneris*, *Herba scanaria*, *Cerfolium aculeatum*, *Nadelleraut*, *Heckelam*, *NadelKoorffel*, *Venusstrahl*, *Nadel Moehren*, *Schnubel Moehren*,

*Schnubelkoerffel*. In England it would have been called *shepherd's needle* or *shepherd's comb*. Soon enough the profusion of species overtook the profusion of names. Naturalists formed a community; they corresponded, and they traveled. By the end of the century a Swiss botanist had published a catalogue of 6,000 plants. Every naturalist who discovered a new one had the privilege and the responsibility of naming it; a proliferation of adjectives and compounds was inevitable, as were duplication and redundancy. To *shepherd's needle* and *shepherd's comb* were added, in English alone, *shepherd's bag*, *shepherd's purse*, *shepherd's beard*, *shepherd's bedstraw*, *shepherd's bodkin*, *shepherd's cress*, *shepherd's hour-glass*, *shepherd's rod*, *shepherd's gourd*, *shepherd's joy*, *shepherd's knot*, *shepherd's myrtle*, *shepherd's peddler*, *shepherd's pouche*, *shepherd's stuff*, *shepherd's tussel*, *shepherd's scrip*, and *shepherd's delight*.

Carl Linnaeus had yet to invent taxonomy; when he did, in the eighteenth century, he had 7,700 species of plants to name, along with 4,400 animals. Now there are about 300,000, not counting insects, which add millions more. Scientists still try to name them all: there are beetle species named after Barack Obama, Darth Vader, and Roy Orbison. Frank Zappa has lent his name to a spider, a fish, and a jellyfish.

"The name of a man is like his shadow," said the Viennese onomastologist Ernst Pulgram in 1954. "It is not of his substance and not of his soul, but it lives with him and by him. Its presence is not vital, nor its absence fatal." Those were simpler times.

When Claude Shannon took a sheet of paper and penciled his outline of the measures of information in 1949, the scale went from tens of bits to hundreds to thousands, millions, billions, and trillions. The transistor was one year old and Moore's law yet to be conceived. The top of the pyramid was Shannon's estimate for the Library of Congress—one hundred trillion bits,  $10^{14}$ . He was about right, but the pyramid was growing.

After bits came kilobits, naturally enough. After all, engineers had



coined the word *kilobuck*—"a scientist's idea of a short way to say 'a thousand dollars,'" *The New York Times* helpfully explained in 1951. The measures of information climbed up an exponential scale, as the realization dawned in the 1960s that everything to do with information would now grow exponentially. That idea was casually expressed by Gordon Moore, who had been an undergraduate studying chemistry when Shannon jotted his note and found his way to electronic engineering and the development of integrated circuits. In 1965, three years before he founded the Intel Corporation, Moore was merely, modestly suggesting that within a decade, by 1975, as many as 65,000 transistors could be combined on a single wafer of silicon. He predicted a doubling every year or two—a doubling of the number of components that could be packed on a chip, but then also, as it turned out, the doubling of all kinds of memory capacity and processing speed, a halving of size and cost, seemingly without end.

Kilobits could be used to express speed of transmission as well as quantity of storage. As of 1972, businesses could lease high-speed lines carrying data as fast as 240 kilobits per second. Following the lead of IBM, whose hardware typically processed information in chunks of eight bits, engineers soon adopted the modern and slightly whimsical unit, the byte. Bits and bytes. A kilobyte, then, represented 8,000 bits; a megabyte (following hard upon), 8 million. In the order of things as worked out by international standards committees, *mega-* led to *giga-*, *tera-*, *peta-*, and *exa-*, drawn from Greek, though with less and less linguistic fidelity. That was enough, for everything measured, until 1991, when the need was seen for the zettabyte (1,000,000,000,000,000,000,000) and the inadvertently comic sounding yottabyte (1,000,000,000,000,000,000,000,000,000). In this climb up the exponential ladder information left other gauges behind. Money, for example, is scarce by comparison. After kilobucks, there were megabucks and gigabucks, and people can joke about inflation leading to terabucks, but all the money in the world, all the wealth amassed by all the generations of humanity, does not amount to a petabuck.

The 1970s were the decade of megabytes. In the summer of 1970, IBM introduced two new computer models with more memory than ever before: the Model 155, with 768,000 bytes of memory, and the larger Model 165, with a full megabyte, in a large cabinet. One of these room-filling mainframes could be purchased for \$4,674,160. By 1982 Prime Computer was marketing a megabyte of memory on a single circuit board, for \$36,000. When the publishers of the *Oxford English Dictionary* began digitizing its contents in 1987 (120 typists; an IBM mainframe), they estimated its size at a gigabyte. A gigabyte also encompasses the entire human genome. A thousand of those would fill a terabyte. A terabyte was the amount of disk storage Larry Page and Sergey Brin managed to patch together with the help of \$15,000 spread across their personal credit cards in 1998, when they were Stanford graduate students building a search-engine prototype, which they first called BackRub and then renamed Google. A terabyte is how much data a typical analog television station broadcasts daily, and it was the size of the United States government's database of patent and trademark records when it went online in 1998. By 2010, one could buy a terabyte disc drive for a hundred dollars and hold it in the palm of one hand. The books in the Library of Congress represent about 10 terabytes (as Shannon guessed), and the number is many times more when images and recording music are counted. The library now archives web sites; by February 2010 it had collected 160 terabytes' worth.

As the train hurtled onward, its passengers sometimes felt the pace foreshortening their sense of their own history. Moore's law had looked simple on paper, but its consequences left people struggling to find metaphors with which to understand their experience. The computer scientist Jaron Lanier describes the feeling this way: "It's as if you kneel to plant the seed of a tree and it grows so fast that it swallows your whole town before you can even rise to your feet."

A more familiar metaphor is the cloud. All that information—all that information capacity—looms over us, not quite visible, not quite tangible, but awfully real; amorphous, spectral; hovering nearby, yet not



situated in any one place. Heaven must once have felt this way to the faithful. People talk about shifting their lives to the cloud—their informational lives, at least. You may store photographs in the cloud; Google will manage your business in the cloud; Google is putting all the world's books into the cloud; e-mail passes to and from the cloud and never really leaves the cloud. All traditional ideas of privacy, based on doors and locks, physical remoteness and invisibility, are upended in the cloud.

Money lives in the cloud; the old forms are vestigial tokens of knowledge about who owns what, who owes what. To the twenty-first century these will be seen as anachronisms, quaint or even absurd: bullion carried from shore to shore in fragile ships, subject to the tariffs of pirates and the god Poseidon; metal coins tossed from moving cars into baskets at highway tollgates and thereafter trucked about (now the history of your automobile is in the cloud); paper checks torn from pads and signed in ink; tickets for trains, performances, air travel, or anything at all, printed on weighty perforated paper with watermarks, holograms, or fluorescent fibers; and, soon enough, all forms of cash. The economy of the world is transacted in the cloud.

Its physical aspect could not be less cloudlike. Server farms proliferate in unmarked brick buildings and steel complexes, with smoked windows or no windows, miles of hollow floors, diesel generators, cooling towers, seven-foot intake fans, and aluminum chimney stacks. This hidden infrastructure grows in a symbiotic relationship with the electrical infrastructure it increasingly resembles. There are information switches, control centers, and substations. They are clustered and distributed. These are the wheel-works; the cloud is their avatar.

The information produced and consumed by humankind used to vanish—that was the norm, the default. The sights, the sounds, the songs, the spoken word just melted away. Marks on stone, parchment, and paper were the special case. It did not occur to Sophocles' audiences that it would be sad for his plays to be lost; they enjoyed the show. Now expectations have inverted. Everything may be recorded and preserved,

at least potentially: every musical performance; every crime in a shop, elevator, or city street; every volcano or tsunami on the remotest shore; every card played or piece moved in an online game; every rugby scrum and cricket match. Having a camera at hand is normal, not exceptional; something like 500 billion images were captured in 2010. YouTube was streaming more than a billion videos a day. Most of this is haphazard and unorganized, but there are extreme cases. The computer pioneer Gordon Bell, at Microsoft Research in his seventies, began recording every moment of his day, every conversation, message, document, a megabyte per hour or a gigabyte per month, wearing around his neck what he called a "SenseCam" to create what he called a "Lifelog." Where does it end? Not with the Library of Congress.

It is finally natural—even inevitable—to ask how much information is in the universe. It is the consequence of Charles Babbage and Edgar Allan Poe saying, "No thought can perish." Seth Lloyd does the math. He is a moon-faced, bespectacled quantum engineer at MIT, a theorist and designer of quantum computers. The universe, by existing, registers information, he says. By evolving in time, it processes information. How much? To figure that out, Lloyd takes into account how fast this "computer" works and how long it has been working. Considering the fundamental limit on speed,  $2E/\pi\hbar$  operations per second ("where  $E$  is the system's average energy above the ground state and  $\hbar = 1.0545 \times 10^{-34}$  joule-sec is Planck's reduced constant"), and on memory space, limited by entropy to  $S/k_B \ln 2$  ("where  $S$  is the system's thermodynamic entropy and  $k_B = 1.38 \times 10^{-23}$  joules/K is Boltzmann's constant"), along with the speed of light and the age of the universe since the Big Bang, Lloyd calculates that the universe can have performed something on the order of  $10^{120}$  "ops" in its entire history. Considering "every degree of freedom of every particle in the universe," it could now hold something like  $10^{90}$  bits. And counting.