Jules Verne's Use of Victorian Scientific Models

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Abstract

The extent of Jules Verne's knowledge and understanding of Victorian science is the key to Verne's futurism. Verne refused to be called a scientist; however, it was the combination of storytelling and science that attracted so many readers. Verne anchors his works in contemporary science and exploration, allowing him to project into the future. Part of Verne's perpetuity is directly related to the foundational influence of Victorian scientific theories in present-day science and engineering. This scientific foundation allows Verne's visions to be reborn even today in such areas as sea illumination, compressed air storage of energy, air batteries, liquid air engines, carbon dioxide engines, space cannons, pneumatic air trains, hydrogen-fueled vehicles, circular cities, floating cities, economic hydrogen production through electrolysis, wind power and tractor rays. This paper deals with Verne's use of the theories of Victorian scientists and polymaths such as Humphrey Davy, François Arago, Michael Faraday, James Maxwell, Heinrich Hertz, Charles Sainte-Claire Deville, Elie de Beaumont, Louis Figuier, and adventurers such as Jacques Arago, Alexander von Humboldt, Jean Chaffanjon, and Camille Flammarion to define the future. The article looks at specific examples of Victorian scientific applications in various Verne novels. Finally, we will look at Verne's visionary methodology for the future of technology.

Verne's Science Based Futurism

Many stand in awe of Jules Verne's imagination, but he does not imagine the future as much as he extrapolates into it. He is not a prophet but an exceptional scientific researcher, imagining the engineering future of evolving scientific principles. The famous science writer Isaac Asimov called Verne a "futurist." Asimov described Verne as "the first futurist in the modern sense – the first person to consider what might be done with continued technological advance, what discoveries might be made" (1986, 13). Verne used the past to build his future. He also explored the complex mix of science with social and philosophical themes in his stories, contributing to a broad understanding of the future.

Verne's studies of Victorian science had given him a sense of how technology evolves. This sense allowed Verne to morph current scientific concepts into science fiction. As celebrated author Ursula K. Le Guin (1929-2018) noted, "Science Fiction is not a

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prediction, but an observation. It takes a current society and extrapolates its characteristics into an environment shaped by different environmental factors, dictated by predicted developments" (Rattay 2019).

Verne was quick to notice the acceleration of technology in Victorian times. At the start of the nineteenth century, it took two days for the news of the American victory at New Orleans to reach Washington D.C. and two weeks to reach London, as it had taken centuries prior. Thanks to electricity, such a process would be instantaneous by the end of the nineteenth century. To go around the world in 1800 took about the same as in 1519 when Portuguese explorer Ferdinand Magellan did it by ship in 1082 days. Verne put scientific reality into *80 Days Around the World* (1873). Verne "predicted" 80 days based on the opening of the Suez Canal in 1871. In 1889, journalist Nellie Bly of the *New York World* successfully traveled around the world in 72 days, beating Verne's fictional record.

A 2005 roundtable noted Verne's continuing relevance: "His novels remain of enduring interest in the twenty-first century because of the practically unparalleled sensitivity with which he responded to technological change … what is crucial here is less the technical details than the general understanding that science and technology were remaking everyday life in radical ways" (Freedman et al. 2005, 173-174). Verne's literary combination of science, storytelling, adventure, futurism, mystery, and prediction is a unique genre**.** Verne predicts the advance of science and foresees possible problematic social and philosophical interactions in his novels, much like in Asimov's *I, Robot* series.

Many have argued whether Verne's fiction is "scientific fiction," in a sense opposed to "science fiction." Kat Jivkova offers insight into the difference: "The difference between the two lies in the way that science is used in the structure of the text – while science fiction uses science, often pseudoscience, as a tool to drive along its story, scientific fiction uses its story to disseminate factual scientific knowledge to a wide readership" (Jivkova 2022). Verne often mixes scientific fiction and science fiction in many of his stories. However, Verne describes his works as *romans scientifiques*—scientific novels (Evans 2005, 84). But the essential thing is that Verne intertwines science and literature in his novels.

Verne sometimes puts scientific details above the story, while at other times, he suspends scientific facts to drive the story forward. In *Hector Servadac (Off on A Comet)* (1877), Verne knowingly ignores scientific facts to begin and end his adventure on a comet but returns to Victorian science in the body with the famous experiments of Michael Faraday and Humphrey Davy. Similarly, Verne partially ignores favored science, using less preferred theories to frame his journey to the earth's center. Many critics classify *Hector Servadac (Off on A Comet)* as fantastic and impossible. But Verne loves to mix fantasy and science. Verne takes the reader on a scientific journey of clues in the story to discover the comet's material, nature, and origin. His choice of gold telluride as the comet's composition is based on hard science, since volcanic veins of gold telluride (gold and tellurium) triggered the gold rush of the 1860s. Verne's voyagers ultimately survive in a volcanic vein of tellurium that conducts the lava's heat for warmth.

This mix of science, literature, and fantasy makes Verne challenging to label. Whatever the label of the genre, Verne's success lies in the scientific knowledge applied to his storytelling. Verne had a love affair with science and kept current on all its advances.

His novels embody his sense of wonder for science and exploration. Science sometimes drives the story or is used to highlight it. His editor often felt Verne used too much scientific detail and suggested cuts. In an 1883 letter to his editor, Verne notes, "Obviously, I'll keep as much as to the geography and the scientific since that is the aim of the complete works" (Butcher 2006, 268). Even then, early translators cut out lengthy scientific discussions from the manuscripts, believing them to be too dull for adults and too overwhelming for the young.

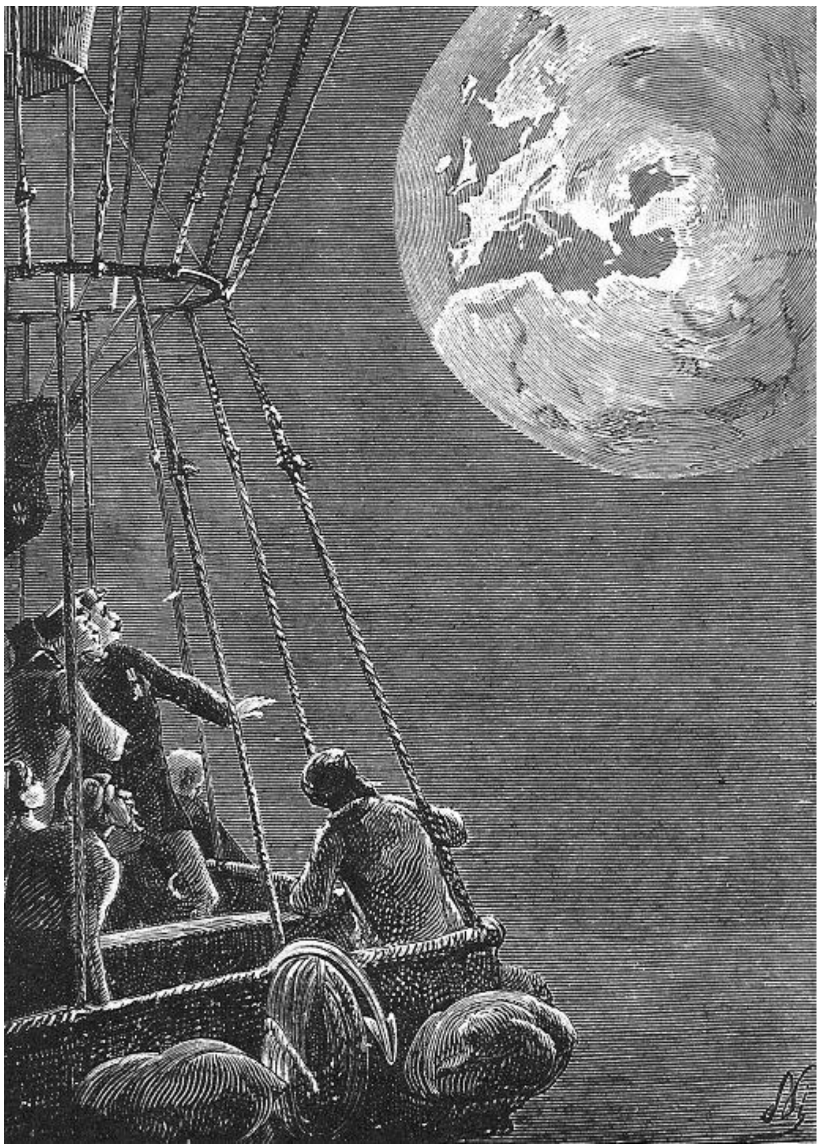
Fig. 1: Cover of *Hector Servadac / Off on a Comet (1877)*.

Illustration by Paul Philppoteaux.

Verne's novels are not always as scientifically accurate from a modern reader's perspective, but they are firmly rooted in the theories of his time. Verne often merges his imagination with the discoveries of Victorian scientists such as Michael Faraday and Humphrey Davy, adventurers like Jacques Arago, and geographers like Camille Flammarion. This firm footing in science has allowed many of Verne's engineering predictions to become a reality sooner or later. With science, Verne peers into the future.

Fig. 2: The comet castaways attempt to return safely to Earth on a makeshift balloon, in *Hector Servadac / Off on a Comet (1877)*.

Illustration by Paul Philppoteaux.



Verne's Future Visions Continue to Evolve Based on His Use of Scientific Principles

Like Leonardo da Vinci, Verne's ideas seem to resist death. It is not the engineering projects and machines that give Verne's writing longevity but the scientific roots of his writings. This immortality is related to Verne's use and study of evolving scientific principles. Victorian scientific principles such as electromagnetism, photoelectric effects, and thermodynamics are still cornerstones today.

Verne's visions are still being realized, in keeping with Robert Heilbroner's ideas that the application of scientific knowledge may lag behind its reach or the necessary practical engineering. Many barriers, such as economics and the need for new streams of knowledge, prevent applications from newly developed scientific knowledge into a "technology." Making a practical steam engine, for example, requires not only

> knowledge of the elastic properties of steam but the ability to cast iron cylinders of considerable dimensions with tolerable accuracy. It is one thing to produce a single steam machine as an expensive toy, such as the machine depicted by Hero, and another to produce a machine that will deliver power economically and effectively. The difficulties experienced by Watt and Boulton in achieving a fit of piston to cylinder illustrate the problems of creating a technology, in contrast with a single machine. (Heilbroner 1967, 335-345)

Today, the number of references to Verne's predictions in scientific and engineering journals is increasing as we see advances in engineering overcoming past roadblocks. Engineering projects that were scientifically sound but uneconomical in Victorian times are finding new opportunities through the paradigm shift of green economics, dwindling common resources, new scientific discoveries, and engineering breakthroughs.

Many Vernian technological dreams are still evolving in science and engineering, and research dollars are being received to overcome barriers to technological implementation. These emerging engineering projects include Verne's electricity from an air battery in *Master of the World* (1904), the appearance of a world financial busting gold meteor in The *Chase of the Golden Meteor* (1908), and in the same novel, the invention of a tractor ray to pull objects to earth and the possibility of mining asteroids. NASA is planning a satellite probe to explore a giant asteroid known as 16-Psyche, which possesses gold estimated in U$S 700 quintillion (Barnett 2025).

Verne's economic circular city designs in *Paris of the Twentieth Century* (1863), *The Begum's Fortune* (1879), and The *Barsac Mission* (1914) fit the 2021 European Union future city design plans known as the Circular Cities and Regions Initiative or CCRI (European Commission, 2020). Circular cities are believed to be the most efficient design for green cities. Verne used circular rail lines in *Paris in the Twentieth Century*. Verne's advanced circular steel production plant used in *Begum's Fortune* is now heralded as the most efficient layout to reduce waste, improve recycling, reduce energy, and reduce transportation costs. Some of the world's largest steel companies are starting to build circular steel mills.

Fig. 3: The industrial city of Stahlstadt, in *The Begum's Fortune* (1879)
Illustration by Léon Benett.

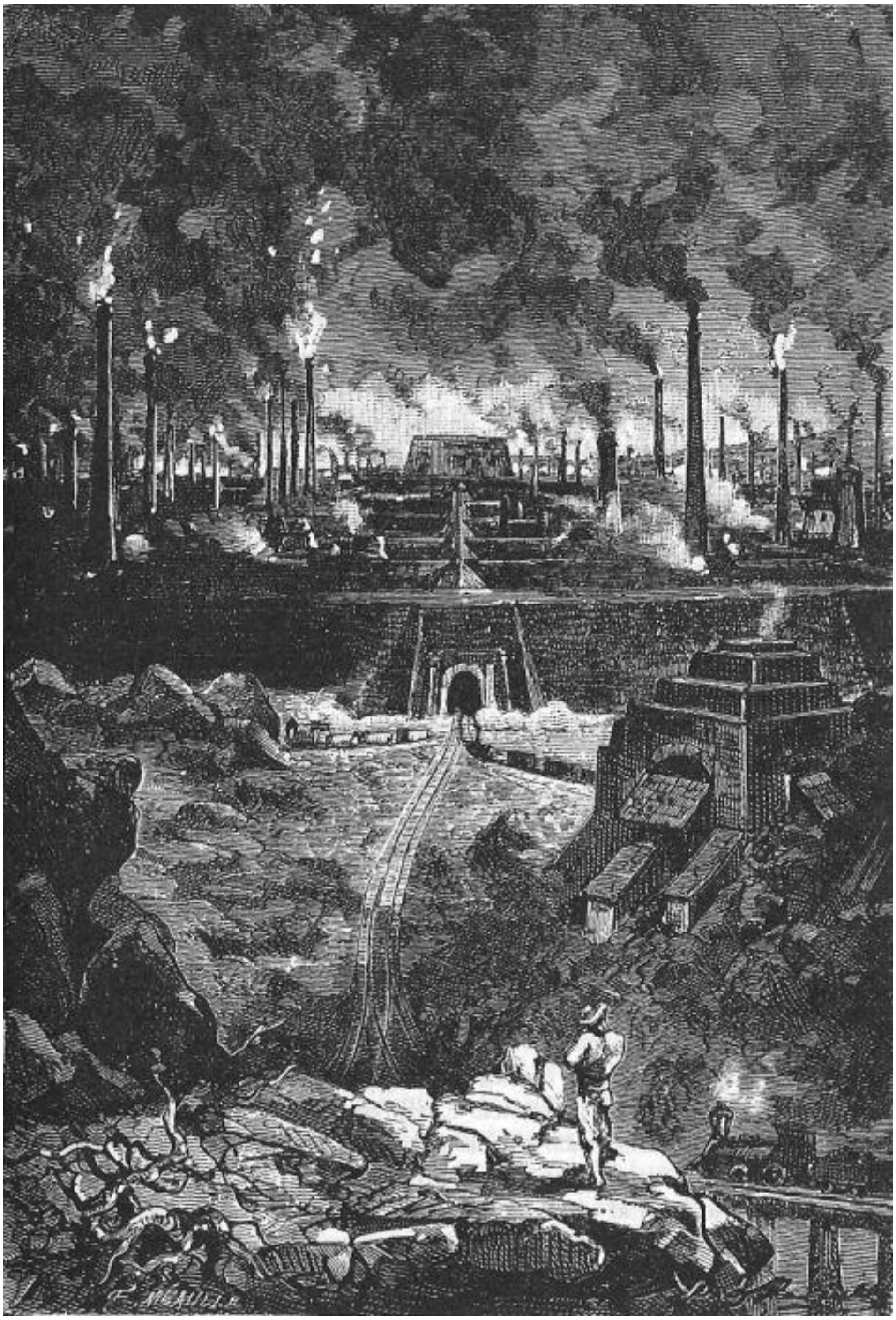
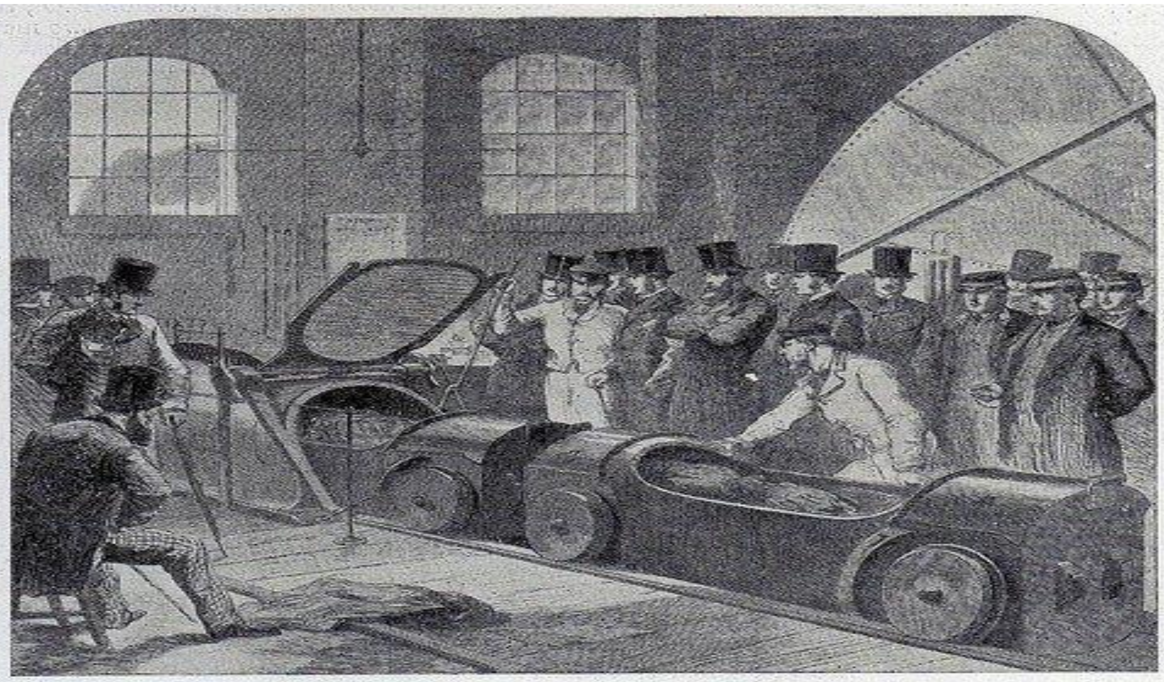


Fig. 4: The London Postal Service actually experimented with a pneumatic transport system, that eventually failed due to engineering limitations.

Illustration from *The Illustrated London News*, 28 February, 1863.



FIRST DISPATCH OF MAIL-BAGS THROUGH THE PNEUMATIC TUBE FROM THE DISTRICT OFFICE IN EVERSHOLT STREET TO EUSTON STATION.
From drawings in the "Illustrated London News," Feb. 18, 1863.

Visions are being reconsidered from *Paris of the Twentieth Century*, including compressed air storage of energy, compressed liquid air engines, carbon dioxide engines, hydrogen-fueled vehicles, and economic hydrogen from electrolysis, which are being researched today. Pneumatic tube air trains[1] and Elon Musk's Hyperloop, while struggling, continue to be tested (Kharpal 2023). Predictions such as the transatlantic tunnels in the novel *In The Year 2889*, are again being proposed by engineers. Researchers from the *Chinese Academy of Sciences* proposed a submarine rail project that would run at a theoretical speed of 1,240 mph (Garfield 2018), close to Verne's prediction!

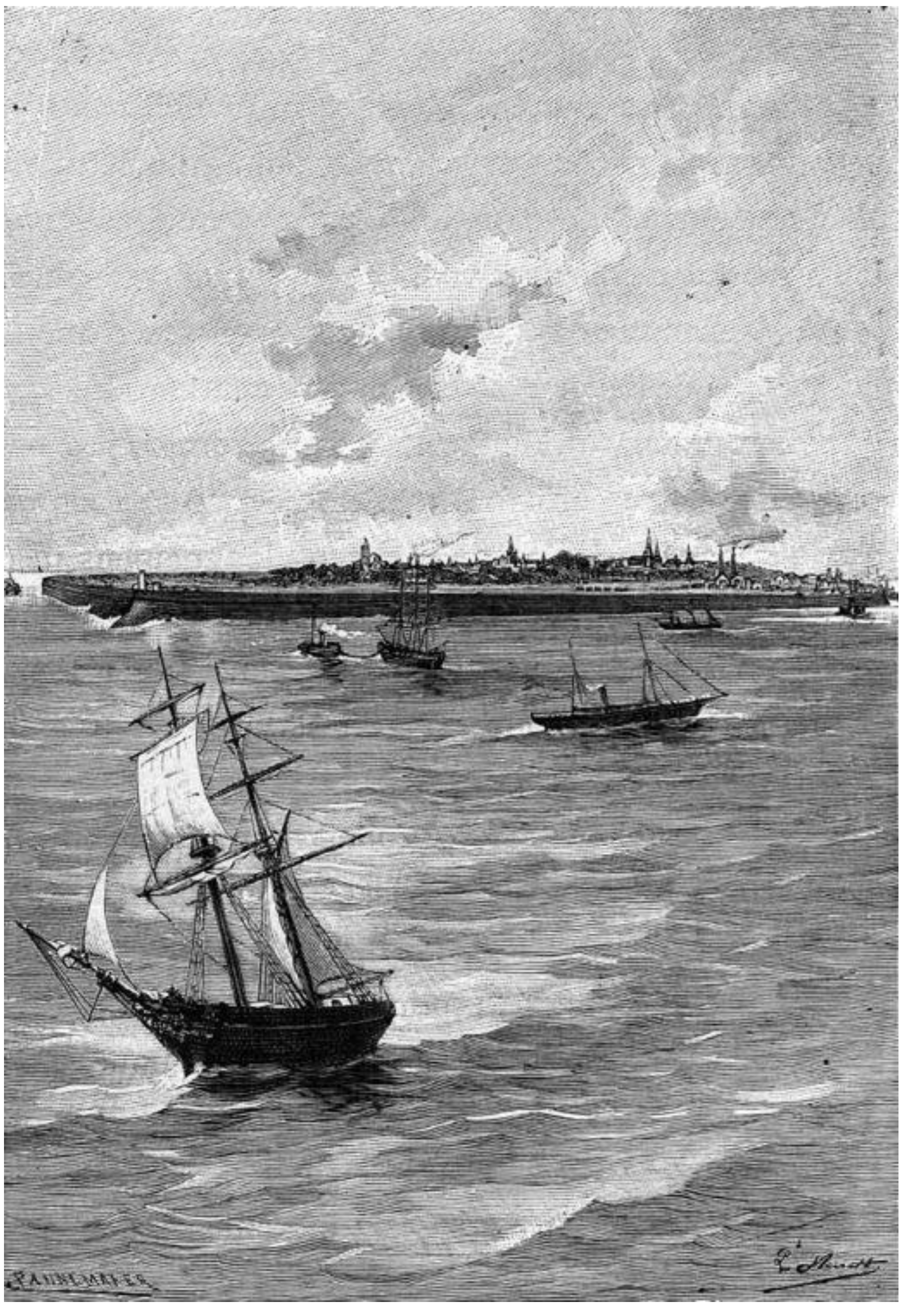
Verne's vision of a floating "city"/island is reportedly within ten years of fulfillment. Engineers hope these floating cities can address the environmental crisis and minimize energy usage (Williams 2023). Verne's earliest vision of a floating "island" is his *Leviathan IV* in *Paris in the Twentieth Century* (1863). The *Leviathan IV* was *a "*quarter of a league*"* long with parks and horse-riding paths (137). In *The Self-Propelled Island* (1895), Verne's floating "Standard Island" was an oval island four and a half miles long and three miles

[1] In July 2017, Elon Musk's startup, Hyperloop, successfully tested a full-scale system on its test track in Nevada and reached a top speed of 70 mph. Musk hopes to achieve 250 mph soon. The Hyperloop uses compressed air and magnetic force to reduce friction. Magnetic cushioning is yet another design application of Jules Verne!

wide with an 11-mile circumference and a population of 10,000. Verne's Standard Island mobility was intended to maintain favorable weather and a healthy environment, not world travel, traveling in the zone of 53 degrees north and 35 degrees south latitude. To date, most of the floating island projects are stationary, but located in Verne's weather sweet spot. Environmental concerns are causing engineers to relook at Verne's floating island concept.

Fig. 5. "Standard Island," in *The Self-Propelled Island* (1895)

Illustration by George Roux



Engineers are working today on a stationary Floating City Project (FCP) in French Polynesia, the Marquesas Islands, created because of the location's ideal weather (Gabbatiss 2017). Interestingly, the Marquesas Islands were a port of call for Verne's Standard Island (*The Self-Propelled Island*, 114). Another company, Oceanix, is also planning a mobile island like Verne's in the Marquesas Sea (Margaronis 2024). The Oceanix cities are being built with modular steel pods, just like Verne's Standard Island. Oceanix also plans a South Korean stationary floating community for 12,000 people. A consortium of major Japanese companies intends to complete the floating oval island of Dogen City, which is 2.5 miles in circumference (Williams 2023).

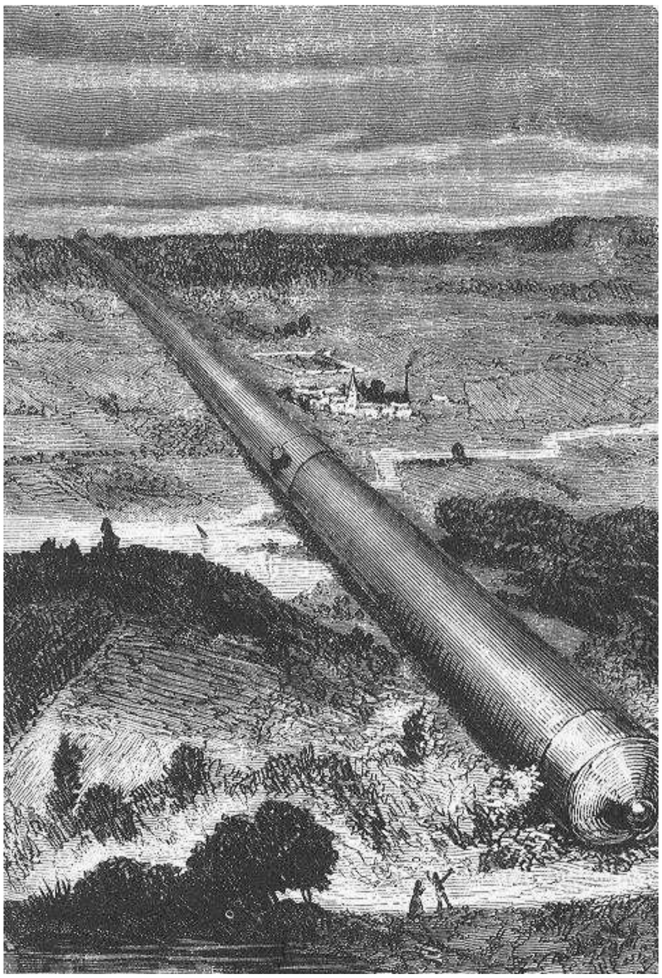
Of course, Verne did not hit a home run every time, but his batting average would have been extremely high. The legacy of Vernian science should ultimately be understood in terms of where science was at the time. Science cannot show the future, but it shows possibilities. Electromagnetic forces and "action at a distance" were evolving and debated in Victorian times. Faraday believed in ray vibrations, but Maxwell's equations suggested a wave moving through an imaginary fluid known as ether (Faraday rejected the idea of ether). Certainly, Verne's attraction to Faraday's theory was due to his experimental but non-mathematical approach as well as Faraday's narrative approach to explaining theories. Faraday's vibration theory, which Verne used for ray guns, tractor beams, and photoelectric devices, was favored until the 1890s, when Maxwell's theory became mainstream. The concept of electromagnetic waves remained unclear until Einstein's Relativity eliminated the idea of ether in the 1910s, and Bohr clearly defined the dual nature of light in the 1920s.

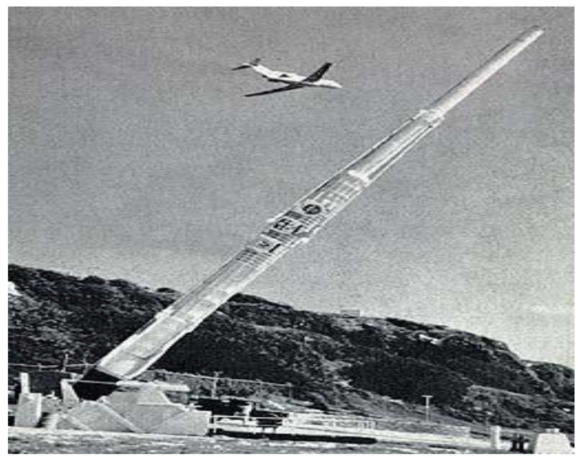
Verne even notes the necessity of theoretical errors in *Journey to the Center of Earth* (1867), with Professor Lidenbrock stating, "Science, great, mighty and in the end unerring… has fallen into many errors – errors which have been fortunate and useful rather than otherwise, for they have been the steppingstones to truth" (Ch. 28, loc. 2743). There are some errors and miscalculations (not to mention errors related to poor translations), but these instances do not reflect a shortcoming in terms of Verne's depth of scientific knowledge (Evans 2005). As noted, Verne sometimes ignores the then-current science for the story's sake.

Engineering is making many of Verne's "missed" predictions (sometimes classified as "errors") practical today. An excellent example comes from the most criticized element in *From the Earth to the Moon*: the cannon. Recently, a NASA scientist noted: "Many details in Verne's book contradict physics, and no astronaut could survive such a launch, but a cannon capable of reaching space is not impossible" (Stern 1999). And in fact, space cannons have sent projectiles into sub-orbital tracks (McFadden 2022). More recently, Quicklaunch Company built a U$S 500 million 1500-foot-long cannon to launch supplies into space. Quicklaunch is close to Verne's 900-foot cannon (McFadden 2022). Another company, Green Launch, is building a "rapid" fire hydrogen space cannon, which appears closer to Verne's Fulgurator in *For the Flag* (1896). Much of this recent cannon technology came from the controversial project engineer George Hull and Hull's 1960s Project HARP (High Altitude Research Project; Hanson 2020).

This suggests another interesting part of Verne's futurism: his belief in the need for autocratic scientific project managers like Barbicane to achieve project success. Verne used similar literary project managers, such as Nemo, to build a submarine, and Robur to build a propelled aircraft. We saw these radical managers with J. Robert Oppenheimer and the atom bomb and Werner von Braun with the NASA Moon Project. Elon Musk could be regarded as a modern reflection of Verne's Barbicane.

Figs. 6 & 7: The giant cannon in *From the Earth to the Moon* (1865), and a modern HARP cannon. Illustration by Henry de Montaut; photo by Peter Millman.





Historian Eugene Weber wrote the introduction to Verne's lost novel of 1863, *Paris in the Twentieth Century,* noting that Verne imagined some of its features because "science and technology suggested their possibility" (xiii). Verne is not a prophet but a futurist who presents possibilities based on scientific trends. For example, in *Off on a Comet* (1877), Verne dedicates an entire chapter ("Jupiter") to the possibility that his fictional comet, Gallia, may be pulled into Jupiter by its gravity. Gallia would miss, but the 1994 Comet Shoemaker-Levy 9 would crash into Jupiter, providing the first direct observation of an extraterrestrial collision of solar system objects. Today, we have the Asteroid Terrestrial-impact Last Alert System (ATLAS) to monitor comets (NASA Report, 2022).

Verne describes his approach thus: "I have always made a point in my romances of basing my so-called inventions upon a groundwork of fact, and of using in their construction methods and materials which are not entirely beyond the pale of contemporary engineering skill and knowledge" (Evans 2013; Jones 1904, 669-670). In his book *Physics of the Future* (2011), theoretical physicist Michio Kuku notes that Verne's research, study, and collaboration allowed him to be in a future that was already present (Kuku 2011, 4-6).

Verne saw many possibilities emerging from Victorian science but realized that future engineering achievements did not evolve linearly but more like Heilbroner's "streams of knowledge" and James Burkes's "connections." Likewise Leo Tolstoy, a contemporary of Jules Verne, saw the progress of history as a stream of incremental steps similar to Verne's view of scientific progress.

Verne's and Tolstoy's View of Scientific Progress

Leo Tolstoy described progress as a stream of incremental steps leading to significant historical events, not the singular acts of great men (Orlin 2019, 179-200). Verne's view similarly describes incremental advancement in various streams of science, merging into what appears to be a "breakthrough" invention.[2] Verne painstakingly documented and often traced these historical increments and advances in his novels to make future projections.

In his writings, Verne involves the reader in the stepwise history of the foundational science to predict future technology, such as in *From the Earth to the Moon* (1865). Verne's character, Barbicane, describing why a moonshot is possible, states:

> "You know the progress ballistics has made in recent years and how much more greatly firearms would have been perfected if the war had continued. You also know that, practically speaking, the strength of cannons and the expansive power of gunpowder are unlimited. Taking the fact as my starting point, I began to wonder whether, with a sufficiently large cannon constructed in such a way as to assure the necessary resistance, it might not be possible to shoot a projectile to the moon." (13)

Verne also uses history to ground his visions of the future. Verne's sometimes lengthy and painful development of the history of science in his novels gives Verne credibility. Unfortunately, many translators often dropped these detailed scientific discussions. Verne takes the reader through the exponential track of technological developments to project into the future and enhance the reader's acceptance of his predictions. Using historical timelines to illustrate the continuous advance of technology, he leads his readers to believe in his future.

While Verne supports Tolstoy's incremental step theory, he does not necessarily see these steps as sequential or linear. Verne breaks with the linear thinking of Victorian times

[2] Verne in 1889 showed he was aware of the advance of both integral and differential calculus in his novel *Purchase of the North Pole* (1889, 59).

to contemplate a more rapid view of technological growth. Linear growth underestimated the speed of technological progress. Victorians did not use the term "exponential" but had some sense of exponential growth. This intuitive Victorian understanding of exponential growth was based on the theories of Thomas Malthus (1766-1835), who described the size of the population as doubling at predictable intervals. Today, we understand that Verne had an intuitive feeling that exponential growth appears linear until it reaches a singularity or breakthrough, rocketing progress forward. Interestingly, Tolstoy saw a similar exponential theme in history (Orlin 2019). Of course, the speed and power of exponential growth were demonstrated in the 1960s, with Moore's Law predicting a doubling of chip memory every 18 months.

While Verne never uses the term "exponential," he illustrates it in *From the Earth to the Moon* (1867). In this novel, Verne encourages his fictional scientists with, "projectiles have gained range . . . if we put our minds to it, and take advantage of scientific progress, we should be able to make cannonballs ten times heavier than those of Mohammed II [a 1900 pound ball in 1453 AD]" (40). Verne needed a fictional cannon to fire a 20,000-pound capsule in 1867 when 2100 pounds was the best technology had achieved. Verne was clearly setting an exponential goal! In his novels, Verne also demonstrates that focus and leadership are needed to accelerate the evolution of knowledge into engineering success.

Thus Verne prepares the linear thinking of the Victorian for a shift towards exponential growth in order to make his futurism credible to his readers. Science fiction analyst Gary Westfahl sees the root of Verne's success as staying focused "on predicting new developments in the near future based on the state of current scientific progress, which he diligently researched" (2022, 254). James Miller notes in Verne's 1868 application of aluminum for his moon capsule: "Here Verne is using a technique that he has proved eminently successful in his novels. Verne is extrapolating from the daily news into the not-so-distant future. Thus, he predicts developments that his readers will live to see in a matter of years. And so, he more easily gains credence when he extrapolates into the more distant future" (Verne 1865, 41: footnote 10). Not surprisingly, French chemist Henri Sainte-Claire Deville (1818–1881), whom Verne had interviewed, had developed a method of preparing more significant quantities of aluminum in 1854—although still far from the amounts needed by Verne. Verne knew it took the connective progress of Humphrey Davy, Michael Faraday, and Henri Sainte-Claire Deville to develop the science that would lead to commercial quantities of aluminum.

Verne's View: Streams of Technological Progress Lead to the Future

Verne saw landing on the moon as not the result of a singular progression of technology, but as the combination of streams of factual pieces to achieve a specific goal. This progression of science is how it played out in NASA's 1960s quest for the moon landing. Verne realized the dynamics of "combinational innovation drives the rapid advance of technology and the achievement of a singularity" (Clancy 2021). According to this view of combinational innovation, "any idea or technology can also be understood as a unique configuration of pre-existing parts" (ibid.). Verne applied James Burke's view of technology as connections from various streams of ideas and inventions. Burke, like Verne, sees the advance of technology via a connective network of nodal events (Burke 2007). Of course, Burke had the luxury of looking back on technological advances to develop his thesis. Verne had to project forward a successful innovation. According to this view, while these scientific advances are progressively moving, progress is best viewed as a network of events versus a sequential progression.

Verne uses this connective thinking and network view to combine streams of component technologies into the overall project technology. In *From the Earth to the Moon* (1867), Verne dedicates a chapter to each evolving stream of technology – escape velocity, the cannon type, metal casting, "guncotton" (powder), and the cannonball – needed for his moon shot project. At the time, many translators saw these long technical descriptions as too taxing for readers. Verne's knowledge of the history of technology was essential to the renewed popularity of his *Voyages Extraordinaires*.

While Victorians loved the idea of the sole inventor with a breakthrough, Verne realized and demonstrated that breakthroughs are a collective effort, best described by Ralph Waldo Emerson: "Certain ideas are in the air. We are all impressionable, for we are made of them; all impressionable, but some more than others, and these first express them. This explains the curious contemporaneousness of inventions and discoveries" (Emerson 1860). Verne describes connective advance to a historical event as "scholars step in; they talk, write, calculate, and one fine day true success bursts into view for all to see" (Jules Verne 2018). Mark A. Lemley, in his classic development of the legal patent theory, noted: "The history of significant innovation in this country is, contrary to popular myth, a history of incremental improvements generally made by several different inventors at roughly the same time" (Lemley 2012).

Verne's study and writings illustrated the connective advance of electrical theory by Alessandro Volta (1745-1827), Hans Christian Ørsted (1777-1857), André-Marie Ampère (1775-1836), Humphrey Davy (1778-1829), Michael Faraday (1791-1867), James Clerk Maxwell (1831-1879), and Heinrich Hertz (1857-1894) over the 19th century. This historical chain of advancing theories built progressively on the individual scientist's work of the 1800s. This connective effort and achievement took decades to develop the complete relationship between electricity and magnetism. This theoretical advance over decades can be seen in Verne's body of work – compiled under the title of *Voyages Extraordinaires* – starting with Davy and Faraday's batteries and electrochemistry in novels such as *Twenty Thousand Leagues under the Sea* (1870), on to Maxwell and Hertz's electromagnetic waves in novels such as *The Year 2889* (1889) and *The Chase of the Golden Meteor* (1908).

This connective advance of Victorian science required staying current on research from various streams of technology and scientists. Verne often used or highlighted competing current theories in his stories. Science writer Isaac Asimov also argued that science fiction's predictability depended on its "closeness to science" (De Coorman and Peti 2022, 9-13). Staying close to science was foundational to Verne's futurism.

Staying Close to Science

Verne's approach to staying current with the latest scientific advances involved an aggressive mix of discussion groups and clubs of scientists and explorers of the time, library research, reading periodical journals and newspapers, cataloging discoveries, and consultation with scientists and mathematicians at the University of Paris.

Early in his career, Jules Verne attended informal discussions with French scientists at the home of Jacques Arago (1790-1854) and his brother François (1786-1853), who had worked and collaborated with Michael Faraday in the 1830s. The Arago house was a meeting place for scientists, philosophers, geographers, and adventurers (Crossland, 2001). Verne's friendship and discussion with Jacques led to inspiration throughout his career (Bollinger 2022, 233-253). Jacques Arago had taken a three-year scientific sailing expedition that circumnavigated the globe and was part of Verne's inspiration for *Around the World in Eighty Days* (1873)*, The Adventures of Three Russians and Three Englishmen* (1872*),* and *Adventures of Captain Hatteras* (1866*).* Verne also referenced Arago in *Off on a Comet* (1877) and noted Arago's works as part of Nemo's library (Bollinger, ibid.). These early scientific discussions would launch a passion for the advancements of science.

In 1861, Verne joined the Circle of the Scientific Press, a weekly discussion group (Butcher 2006, 45). Verne also engaged with the mathematicians at the Société Industrielle in Amiens to discuss his engineering projects. The Société Industrielle in Amiens was a very active organization to promote industry and industrial discoveries. Verne attended and helped arrange for speakers to attend their meetings and lectures. More importantly, Verne took the opportunity to use the Société Industrielle members as a type of "Delphi"[3] group approach to confirm the plausibility of his visions. All these discussions, lectures, and research created a need to store the information in ways that would make it easy to retrieve for writing projects.

The accumulation and cataloging of scientific advances in Victorian times was a difficult task. The explosive growth of information in Victorian times created a new problem of extracting, managing, and utilizing the rapidly developing knowledge. Historian H. Brock describes this Victorian information explosion: "From around 100 titles worldwide at the beginning of the nineteenth century, the number of science periodicals grew to an estimated 10,000 by the end, facilitating in the process an exponential growth in popular and professional forms of science" (Brock 1994, 86).

Verne had to develop his methods to catalog data in the Victorian era. Verne used a Fortean approach by researching and documenting current literature, patents, and news clips, attending lectures, joining science discussion groups, and extensive study. Verne spent countless hours in the Bibliothèque Nationale de France, taking notes from scientific journals and keeping up with the latest advances (Seidl 2021). He systematically collected these technical notes. One writer noted he had a "habit of taking notes on cards that he organized and kept for reference when writing is well known, and he avidly read scientific

[3] A method of group decision-making and forecasting that involves successively collating the judgments of experts.

bulletins, even dictionaries, and encyclopedias to understand the science concepts he was interested in dealing with" (Evans 1995, 35-46; also Yanes, 2022). Verne amassed a huge archival database of 20,000 index cards on science and nature (Verne 1863, xxiii).

In Victorian times, the past, present, and future could often be found in the patent office. Victorian patents frequently speculated about future uses of a process or invention. Verne kept his hand on the "pulse" of technical growth by reviewing many patents issued. Patents were often more helpful to futurists than engineers, in that patents frequently look to the future while lacking or hiding the details. In the 1800s, the United States Patent Office was a major tourist attraction as miniature models of patents were required to be displayed; by the mid-1800s, it was receiving 100,000 visitors annually (*The Pulse BBC Newsletter,* 2016). These visitors were not coming for building instructions but to glance into the future, like visitors to World Fairs.

Verne reviewed his analyses, calculations, and predictions with many scientists at the University of Paris (Jenson 2015, 205-214). His cousin, Henri Garcet, was a professor of mathematics, and Verne's brother Paul, a naval officer, often checked Verne's calculations. Henri Garcet was particularly helpful, having written a popular astronomy textbook in 1854, and is credited for calculations found in *From the Earth to the Moon* and *The Adventures of Three Russians and Three Englishmen in South Africa* (Crovisier 2009, 322-326). In the 1880s, Verne hired a professional engineer, Albert Badoureau, to check his science and math. Verne frequently spent hours talking to scientists at the University of Paris. Verne noted in a letter while writing *Mysterious Island*, "I am seeing a lot of chemistry professors and chemical works" (Jules-Verne 1973, 113).

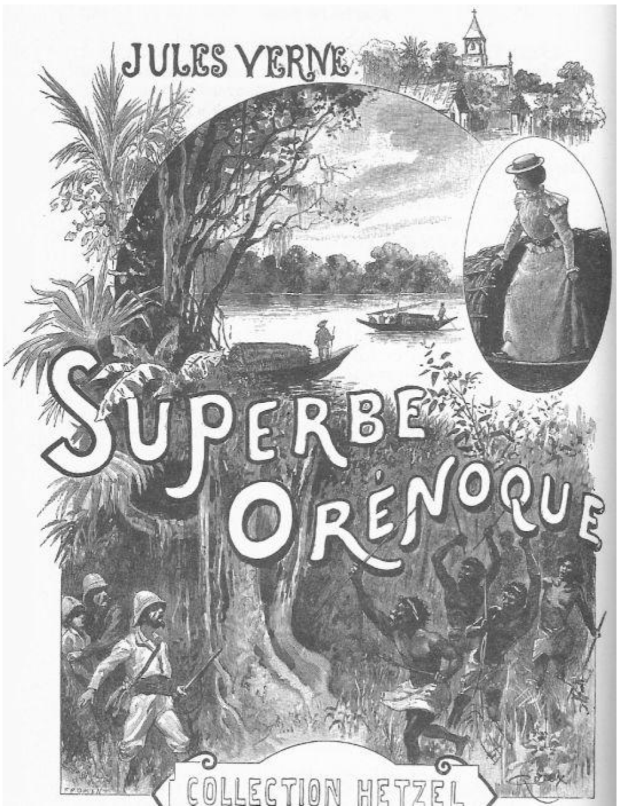
Similarly, Verne's discussions with and literary research of geographers and explorers often created a novel storyline, an adventure itinerary, or a detailed geographical background. For example, in the early 1870s, journal articles, and scientific meetings were full of ideas for a Saharan commercial sea. Verne built his storyline of *The Invasion of the Sea* (1904) based on the plan of François Élie Roudaire and Ferdinand de Lesseps (1905, xiv) of France and Scottish entrepreneur Donald Mackenzie, who seems to have filed a patent on the idea for an inland Sahara Sea for commerce. In *Off on a Comet* (1877), Verne first references Roudaire's scheme. Amazingly, while most would consider the Sahara Sea an impossible project, studies are being done today to create it! (Hale 2023)

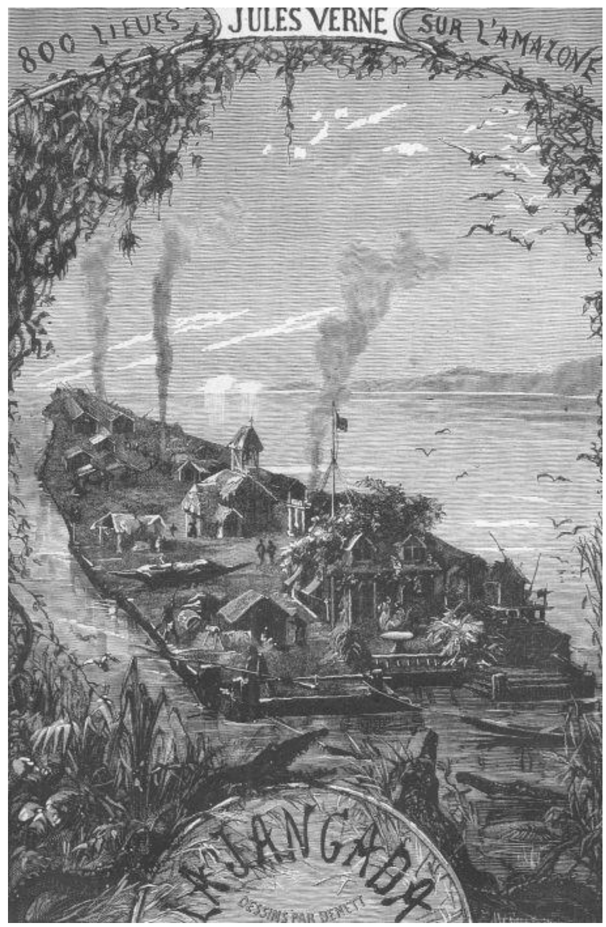
In *The Mighty Orinoco* (1898), Verne leans on French explorer Jean Chaffanjon's (1887) and Alexander von Humboldt (1769-1859) reports on the hunt for the source of the Orinoco, giving the reader a rich and detailed description of South America. Author Andrea Wulf noted, "Jules Verne mined Humboldt's descriptions of South America for his *Voyages Extraordinaires* series, often quoting verbatim for his dialogues" (Wulf 2016, 133-134). Alexander Humboldt's influence can also be seen in *In Search of the Castaways* (1868) and *800 Leagues on the Amazon* (1881). Of course, Captain Nemo had a complete set of Humboldt's works. In *Journey to the Center of the Earth* (1865), Professor Lidenbrock was visited by Von Humboldt and noted him in the text. Verne also applied Humboldt's geology to depict a cool descent to the earth's center. Von Humboldt was an important muse to Verne; and also scientist Humphrey Davy via Von Humboldt's many publications. Von Humboldt often wrote about the symbiotic relationship between science and imagination.

Von Humboldt was the father of the movement known as Romanticism and Science, which captured Verne. Scientist Michael Faraday was part of scientific romanticism, often suggesting future applications for his scientific discoveries.

Figs. 8 & 9: Covers of *Mighty Orinoco* (1898) and *La Jangada / Eight Hundred Leagues on the Amazon* (1891).

Illustrations by George Roux and Léon Benett.





Verne incorporates his personal experiences as well. In his *Backwards to Britain* (1859), a record of his early tours of England and Scotland, we see his passion for visiting factories, shipyards, tunnels, engineering monuments, and natural locations such as caves. Verne notes his visit to the construction site of the world's largest ship, the *Great Eastern,* and travels to Liverpool/ Birkenhead and Glasgow shipyards, where steel-hulled ships were pioneered at the time. In seven of Verne's novels, he notes Laird, Son, and Company of Liverpool in Birkenhead.[4] Verne uses Birkenhead to build futuristic steel ships such as the *Nautilus* from *Twenty Thousand Leagues Under the Sea* (1869), the *Dolphin* from *The Blockade Runners* (1865), the *Queen and Czar* from *The Adventures of Three Russians and Three Englishmen in South Africa* (1872), and the *Forward* from *The Adventures of Captain Hatteras* (1874).

Verne's experiences included a lifetime of nautical lore, such as milky seas, sea monsters, St. Elmo's fire, and green rays in the sky at sunset. Verne often used science to explain these myths and legends, such as the milky seas, for which he proposed possible explanations in *Twenty Thousand Leagues Under the Sea*. Milky seas are rare and striking forms of bioluminescence that glow steadily at night, covering vast areas of the ocean often for weeks or even months. Verne incorporated the 1799 journal of Alexander von Humboldt, who had observed the milky sea phenomenon on his way to the Canary Islands. Recently satellites have confirmed this form of sea luminescence (Starr, 2021).

Similarly, for years sailors had talked about the rare phenomenon known as the "green flash" and even rarer "green ray." In his 1877 novel *The Underground City*, Verne first casually notes the green ray off the coast of Scotland (168). In 1882, Jules Verne's novel *The Green Ray* attracted general attention to the phenomenon. In 2009, Jacques Crovisier of the Paris Observatory called the *Green Ray* an "exemplary case of the synergy between science and Jules Verne" (Crovisier 2009). The green ray is crepuscular or columnar, lasting up to 15 seconds (unlike the short-lived "green flashes"). Verne's story was based on his personal tour of Scotland in 1879, where he observed the green flash (Butcher 2006, 262); the novel follows his 1879 itinerary to find the conditions at sunset for the "refraction of rays (Verne 1882, 122). Verne applies Faraday's works on the color of refracted light to explain the fictional hunt. While rare green flashes are confirmed, the green ray still has no confirmed photographic evidence, but scientists believe that will come in the future.

Sea "monsters," such as the giant squid, were another part of the nautical lore that Verne loved. Danish zoologist Japetus Steenstrup, in 1856, actually gave the mythical species of squid a scientific name. Again, incorporating science and lore, Verne uses it in his stories: *The Sea Serpent: The Yarns of Jean Marie Cabidoulin* (1901) and *Twenty Thousand Leagues Under the Sea (1870)* The giant squid came into public prominence in 1861 when the French ship, the *Alecton*, encountered a live animal, and many believe this to be the source of Verne's giant 25-foot squid attacking the Nautilus in his 1870 *Twenty Thousand*

[4] Laird was across the Mersey River from Liverpool in the small town of Birkenhead

Leagues Under the Sea (Dalton 2021). In 2006, scientists from Japan's National Science Museum caught and brought a live 24-foot female giant squid to the surface (Dalton).

Unfortunately, because of poor translations and abridgments, American readers may miss a significant percentage of Verne's scientific descriptions. Arthur Evans, a Verne scholar and translator, notes: "British and American translators repeatedly watered them down and abridged them by chopping out most of the science and the longer descriptive passages (often from 20 to 40% of the original)" (Evans 2005, 80). Thankfully, much has been restored by a new generation of translators and technical advisors.

The Deep Scientific Roots of Verne

There are examples where one stands in awe at the depth of Verne's scientific knowledge. *Twenty Thousand Leagues Under the Sea* (1870*)* and *Mysterious Island* (1874) are best described as "chemical romances." Verne moves between the romance of chemistry and a textbook of Victorian chemistry. The most remarkable passage in *Mysterious Island* as a metallurgist is Verne's understanding of blast furnace chemistry: "Thus arranged, under the influence of the air from the bellows, the coal would change into carbonic acid [carbon dioxide], then into oxide of carbon [carbon monoxide], which would release the oxygen from the oxide of iron" (148-149). This is a literal description of the two-stage blast furnace reaction that, in 1873, was only in the early stages of theoretical development at the University of Paris.

Fig. 10: Cover of *The Mysterious Island* (1874)

Illustration by Jules-Descartes Férat.

However, some base principles can be traced to Michael Faraday's redux-oxidation experiments over the years. The complete theory of carbon monoxide reduction was not commonly known until Octave Leopold Boudouard of the University of Paris published his "Boudouard Reaction" in 1901. Even today, few would know of the application of the Boudouard Reaction, making it unlikely that some tech-savvy translator might have inserted it. Verne's understanding of the Boudouard Reaction demonstrates how close he was to the developing scientific research, which allowed him to predict the increasing role of coal in ironmaking.

Verne's expertise in electrochemistry was as profound as his knowledge of blast furnace chemistry. Verne's first application of an electrochemical battery was in *Five Weeks in a Balloon* (1863). This was a Bunsen cell (1843), a zinc-carbon primary cell composed of a zinc anode in dilute sulfuric acid. Verne uses his most futuristic design of a sodium battery for the Nautilus based on Faraday's theory that sodium had one of the highest electromotive forces of metals. Today, sodium is at the cutting edge of science in replacing lithium in car batteries, and is being prototyped in Tesla EVs. Faraday's electrochemical theories and battery design were the basis for Verne's unique types of batteries used in many of his novels: *Twenty Thousand Leagues under the Sea* (1870), *The Mysterious Island* (1874), *Robur the Conqueror (*1886)*, Master of the World (*1904) *and Doctor Ox (*1872).

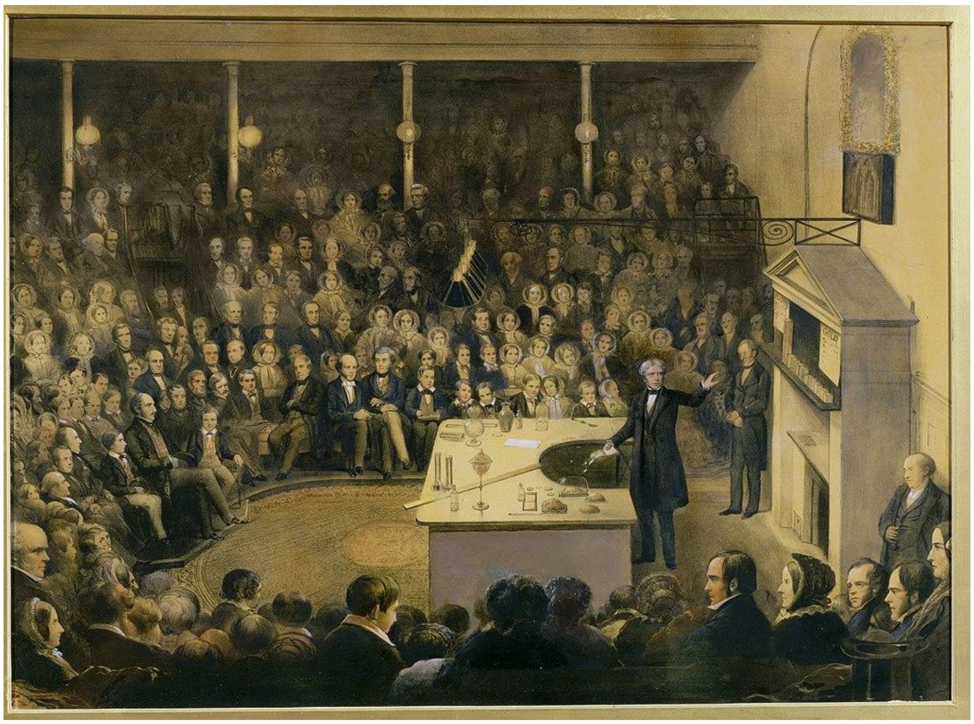
A less obvious use of electrochemistry, but a demonstration of the depth of Verne's knowledge, can be found in *The Adventures of Three Englishmen and Three Russians in Southern Africa* (1872). Verne applies Humphrey Davy's theory that a galvanic cell is formed when dissimilar metals are in physical contact, creating corrosion at the contact. In 1870, the failed David Livingston African expedition had been attributed to the corrosion of his river steamer, as published in government reports (Parr 1972). Verne's *Queen and Czar* steamer in *The Adventures of Three Englishmen and Three Russians in Southern Africa* (1872) is particularly designed to avoid metallic corrosion in this African jungle adventure. Verne demonstrated his knowledge of Davy's galvanic cells by avoiding connecting dissimilar metals between bolts and plates in constructing his fictional steamer (26). Verne also applies newly developed galvanized (zinc-coated) plates so that the zinc supplies cathodic corrosion protection (24-25), which Verne would have observed at Laird, Son, and Company of Liverpool. This design feature was critical to advancing Verne's story of a successful expedition.

Verne's prediction of generating electricity from temperatures at different ocean depths is even more astonishing: "by establishing a circuit by wires immersed at different depths, I will be able to generate electricity" states Captain Nemo, in *Twenty Thousand Leagues Under the Sea* (108). Verne probably got the idea from Faraday's thermocouple experiments generating electricity from heat. Years later, in 1881, Jacques Arsene d'Arsonval, a French physicist, proposed tapping the ocean's thermal energy. In 1970, the Tokyo Electric Power Company successfully built and deployed the first large-scale production using this principle (OTEC International, 2013).

The Use of Victorian Science in Verne's Fiction

Verne used Davy, Arago, Faraday, Maxwell, Hertz, and others' theories to project the engineering future of electricity. Verne's *Voyages Extraordinaires* follow the connective evolution of electricity and electromagnetism from Humphrey Davy's electric cells to Davy's lab assistant, Michael Faraday's and his lines of force, to Maxwell's theoretical wave equations, to Hertz's experimental proof of electromagnetic waves. Verne also studied Frances Arago's early electrical induction experiments.

Fig. 11: Michael Faraday delivering a Christmas Lecture to the general public at the Royal Institution in 1856.



Verne demonstrates his knowledge of Davy's and Faraday's works throughout his writing. Faraday was known for his adherence to the scientific method in his experiments, but he often used his imagination to design future experiments and direct his research. Michael Faraday's major discoveries came through this unique combination of experimentation and imagination, inventing the electric motor, the electric dynamo, the transformer, and the capacitor. Faraday's discoveries led to the development of electrochemistry as a science, which provided the foundation for all modern electrical sciences; he coined the words "anode," "cathode," and "electrolyte" in batteries. Davy and Faraday would lead a romantic science movement, while many see Verne's writings as scientific romances. Both Faraday and Verne used imagination to link science and romance from different professional directions. One of Faraday's famous quotes is, "Science is the dance between observation and imagination" (Pearce Williams 1989, 467). Biographers note that Faraday's imagination allowed him to advance, as he worked on the cutting edge, in the "shadow of discovery." It might also be said that Verne worked in the "shadow of discovery" (Forbes and Mahon 2014, ch. 5).

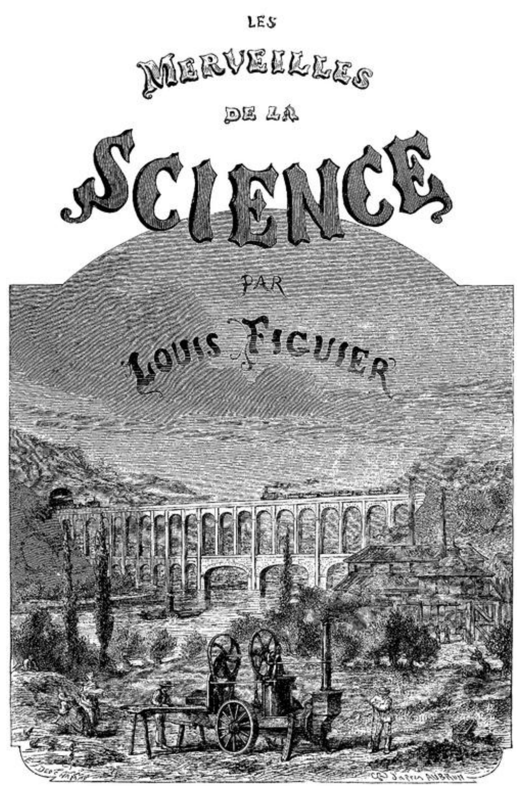
Humphry Davy and Michael Faraday developed their abilities as entertainers, fascinating crowds while increasing scientific fame. Faraday proved to be a storyteller as well. He instituted a weekly Friday public lecture series and created a Christmas lecture series for children, which continues today. Michael Faraday was the world’s first “Mr. Wizard” (Brock 2021), the “Jules Verne” of science, using stories and imaginative examples to teach science. Verne often drew on Faraday’s creative lectures.

Jules Verne often created literary examples of Faraday's experiments in his novels, such as low pressure lowering the boiling point of water. The difficulty of making hard-boiled eggs helps confirm that Verne’s voyagers are on a comet in *Off On a Comet* (1877a, 22; “Ben Zoof Watches in Vain”). In another Faraday experiment, Verne’s character uses a piece of thrown ice to freeze a supercooled ocean rapidly (97; “Frozen Ocean”).

Geology of Faraday and Davy and Louis Figuier’s Paleontology

Verne blended the early 19th century geology of Humphry Davy and Michael Faraday with the paleontology of Louis Figuier (1819-1894) in *Journey to the Center of the Earth* (1865). Verne appears to have been heavily influenced by the book *La terre avant le deluge (Before the Flood,* 1863*)* by Louis Figuier (Breyer and Butcher 2003), particularly in his paleontological description of the descent (Debus 2006) – with some suggesting he was borrowing too much, even to the point of plagiarism (Breyer and Butcher, 36-54).

Fig. 12: Cover of Louis Figuier *The Wonders of Science* (1867-1891)



Figuier was a popular scientist who used a narrative approach to geology, such as Faraday with chemistry and Flammarion with astronomy. Figuier's *La terre avant le deluge* was a science textbook blending the collective works of scientists such as Charles Lyell, George Cuvier, Evan Hopkins, Tyndall, Humphrey Davy, James Hutton, Elie de Beaumont, Sainte-Clare Deville, Heinrich, Alexander von Humboldt, and others. Figuier's book offered a scientific reference to Verne, Victorian scientists, and other writers.

In *Journey to the Center of Earth* Verne was forced to knowingly apply the doubted but popular Hollow-Earth theory and Davy/Faraday's volcanic theory to make the story work. He also pulls from Von Humboldt's geology as well. *Journey to the Center of Earth* is a geological debate at one level. Verne uses his characters, professor Lidenbrock and his nephew and fellow explorer, Axel, to embed a scientific discussion of competing theories for the reader. Davy's hollow earth versus the theory of temperature increase of the molten core theory as they descend is discussed by Axel and Lidenbrock (93). In *The Adventures of Captain Hatteras* (1866), Verne references the hollow earth theory (627). In 1877's *Hector Servadac (Off on A Comet)* Verne used the molten core theory to support the story, supplying heat for his voyagers! (69-70; 88) Again, in his 1877 novel *The Underground City*, Verne endorses the molten core theory to explain coal formation (16-18). An 1888 essay by Michel Verne notes the factual data of a temperature increase by known drilling depths. Even here, Michel Verne holds out the possibility of a hollow earth while favoring the molten core theory (Verne, M. 1888, 257-258). Of course, the hollow earth theory requires a different explanation for volcanic eruptions.

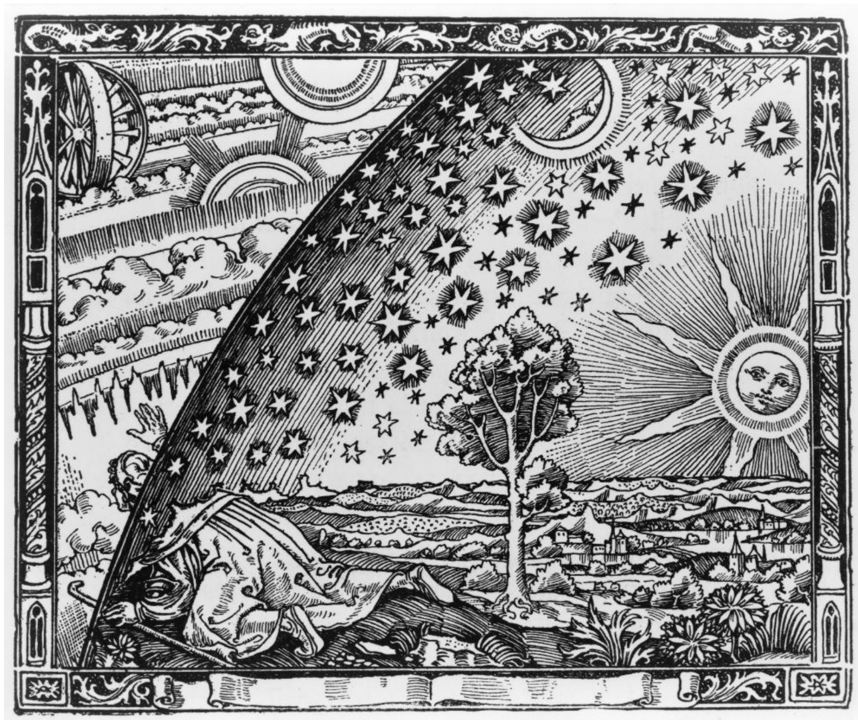
Verne's professor, Lidenbrock, supports Humphrey Davy and Michael Faraday's chemical oxidation theory of volcanic eruption, while Axel supports the emerging view of molten core earth. Lidenbrock points out in the story that the heat generated in cracks, pipes, and veins lined with alkaline, reacting with water, is the cause of volcanic eruptions (1867, 32). Davy hypothesized that volcanoes erupted due to an oxidation reaction between water permeating the cracks of the volcanic surface and the alkaline metals lining these veins. Of course, Humphrey Davy and Michael Faraday often used alkaline and water in stage volcanic demonstrations for students. In addition, Verne (as well as Davy and Faraday) leaned on Elie de Beaumont's (1798-1821) study of the origin of mountains and coal deposits, and on Charles Sainte-Claire Deville (1818–1881), who studied volcanoes such as Stromboli.

Davy also studied several phases of geology, which Verne used in stories. Verne uses Davy's studies of diamond as a form of carbon in *The Vanished Diamond* (1884). In this novel, a diamond vanished from a lightning strike, rearranging the "molecules," leaving only "dust." Both Davy and Faraday had diamonds reduced to carbon by heat in demonstrations to show that diamonds were carbon (Davy 1814, 557-570).

Faraday's Physics, Camille Flammarion's Astronomy, and Figuier's Aeronautics

In his novels, Verne uses more than the geology of polymaths Davy, Faraday, and Figuier, adventuring into physics, chemistry, and astronomy. In the early 1820s, Faraday could liquefy gases such as carbon dioxide by applying pressure alone (Encyclopedia.com). In *Begum's Millions* (1879), Verne uses Faraday's theory to release pressurized liquid carbon dioxide for a weapon of mass destruction. In *20Th Century Paris* (1863), Verne uses Faraday's work to propose that carbon dioxide's liquid/gas phase changes replace water/steam phases in engines.

Fig. 12: A traveler peers through an opening in the firmament in this illustration from Camille Flammarion's *L'atmosphère : météorologie populaire* (1888)



Camille Flammarion (1842–1925) was a well-known astronomer in France, and popularized science like Davy. Flammarion was also an illustrator and science writer. Verne references Flammarion's *Recits de l'infini* (1873) in *Off on a Comet* (1877). Flammarion also believed in Laplace's nebular theory of how the solar system was formed. Pierre-Simon Marquis de Laplace proposed the theory in 1796, stating that solar systems originate from vast clouds of gas and dust, known as solar nebulas. Verne succinctly describes the nebular theory in *From the Earth to the Moon* (1865, 25) and intertwines it in the storyline in *Off on a Comet* (1877). Amazingly, the nebular theory was debunked at the beginning of the twentieth century, only to rise again today in a modified form that proposes nova star fragments coalescing instead of gases.

Again, Figuier was also an essential reference for Verne's astronomy and aircraft. Louis Figuier was one of Verne's inspirations for aeronautic theory, which was used in *Robur The Conqueror* (1886) to design his engine-powered aircraft, the *Albatross*. Louis Figuier is recognized for his significant contribution to documenting the history of balloons in his *Wonders of Science* (1869), which led to heavier-than-air flight. Still, it was Michael Faraday who dominated Jules Verne's science.

Victorian Electrical Phenomena

Michael Faraday, probably the Victorian scientist best known for studying electrical theory, was fascinated by atmospheric static electrical phenomena like lightning, thunder, green flashes, St. Elmo's fire, luminescence, crepuscular rays, and auroras, which Verne commonly used in most of his stories. Some of Faraday's early electrical experiments included the storage and discharge of static electricity and the concept of a capacitor. Verne applied these concepts to taser-type rifles that shot static electric bullets in *Twenty Thousand Leagues Under the Sea:* "They are real Leyden bottles, into which the electricity is forced to a very high tension. With the slightest shock, they are discharged, and the animal, however strong it may be, falls dead" (1869, 101). Verne's view of electricity in a "high tension" state is a direct application of Faraday's published electrical theory in the 1830s (Faraday 1832, 125-162).

Verne uses Faraday's suggestion of the unified interchangeability of energy forms to suggest the possibility of electricity from the air. Verne speculates in *Master of the World* (1904) on the energy source for his flying machine: "I asked myself whence comes this electricity, from piles, or from accumulators? But how were these piles or accumulators charged? Unless, indeed, the electricity was drawn directly from the surrounding air or the water by processes hitherto unknown" (109). Scientists in the U.S. today have developed an experimental device that can harvest humidity in the air to create a clean electricity supply (Palmer 2023). This is possible because electricity is an electromagnetic wave.

A Unified Energy Theory: Electromagnetic Waves

Verne's study of evolving electric theories allowed him to speculate in his novels on the idea of electromagnetic waves and apply them to a possible future**.** Faraday's static electric generator experiments in the 1830s and his 1846 article *Thoughts on Ray Vibrations* led to speculation that light, solar energy, static electricity, sound, heat, and other forms of energy could be understood as a vibration of the electric and magnetic lines of force. (Beléndez 2015). Faraday discovered that a magnetic field influenced polarized light (the *Faraday effect*) and established a relationship between light and all forms of electromagnetic waves. In an 1888 joint essay*,* Verne's son, Michel Verne, explores Faraday's photoelectric effect (2018, "Zigzags Through the World of Science," 224-225).

Faraday suggested the existence of pressure from solar light, and later James Maxwell demonstrated it as theoretically possible. Verne uses Faraday's theories to suggest light could exert pressure in *From the Earth to the Moon* (1867): "Is it not evident, then, I ask you, that there will someday appear velocities far greater than these, of which light or electricity will probably be the mechanical agent?" Translator Walter James Miller notes, "Verne is right on top of new developments and racks up two more successful predictions … 'Solar wind' . . . And electricity may also figure as a mechanical agent" (Verne 1865, 105; note 7). The first successful demonstration of solar sail propulsion did not come until 2010 when Japan's Ikaros probe deployed its 46-foot-wide sail craft and became the first to cruise through space on the backs of photons.

Maxwell (1831-1879) applied mathematics to prove Faraday's observations. Maxwell's equations remain foundational even today and are commonly used. But Maxwell went further with his imagination in 1863. He proposed a unity between light, electricity, and magnetism, much of which Hertz proved experimentally. Uniting these energy sources was the breakthrough that revolutionized science, but even more, it became the seed of a revolution in scientific imagination. This unification of a world of electromagnetism, light, and waves would appear in Verne's novels. In an amazingly speculative disclosure by the Jules and Michel Verne character, Zephyrin Xirdal, in *The Chase of the Golden Meteor* (1908), we find a type of description of Faraday, Maxwell, and Hertz ideas on the relationship of matter, energy, and energy types (120-122). Also, in this novel, Verne suggests a kind of laser light or traction ray that could manipulate objects in space. This device is now commonly known in science fiction as a "tractor beam." Scientists in 2023 have built a working tractor beam at a microscopic level (Newcomb 2023). This idea of ray vibrations or lines of force that could affect bodies in space was initially suggested by Michael Faraday and, in 1857, supported by Maxwell (Forbes and Mahon 2014, 116). It was finally proven in 1905-1907 papers by Albert Einstein, and many of Michel Verne's writings suggest he was aware of Einstein's work.[5]

Science into an Engineering Future: Dynamos, Motors, Transformers, and Electrical Devices

One theme, applied electricity, dominated Verne's collection of novels (the *Voyages Extraordinaires*) and writings. In 1850, William Gladstone asked the scientist Michael Faraday why electricity was valuable. Faraday answered, "One day, sir, you may tax it" (Melcón Fernández).

Verne leaned heavily on Faraday's electrical studies, such as his early work on the magnetic induction of electricity using a dynamo. In *Paris in the Twentieth Century (*1863), Verne suggested dynamos for mass electrical production. Verne uses the more subtle implications of Faraday's early thoughts and Maxwell's on the relationship between light and electrical energy to predict modern devices such as fax machines, fiber optic cables, lasers, and tractor beams.

In the Year 2889, he describes the "photo telephone," a device that enabled "the transmission of images by means of sensitive mirrors connected by wires." At the same time, this could suggest the roots of television and video calls. Some even see it as auguring a "perfect description of fiber optic cabling to allow us high-speed internet" (Johnson 2024). Also, in Verne's novel, *In the Year 2889,* Verne predicted video conferencing, video recording, and interplanetary communications (1889).

Of course, Verne was also passionate about electrical motors. He used them to power submarines, heavier-than-air flight vehicles such as his *Albatross* in *Robur the Conqueror*, and combination air/water/land crafts such as his *Terror* in *Master of the*

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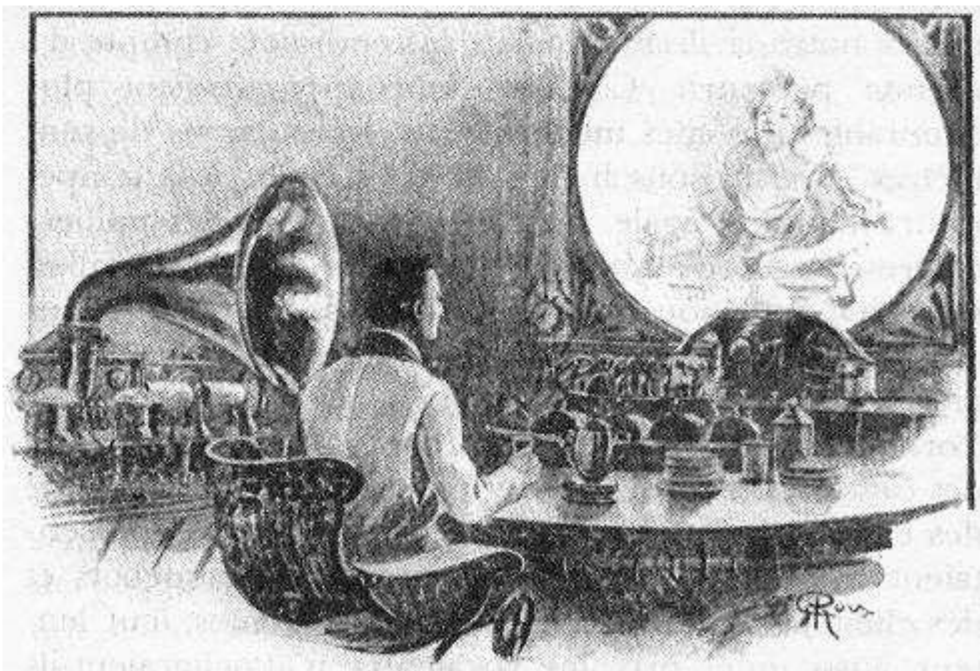
[5] See Michel Verne (2018), " Zigzags Through the World of Science"; also Crovisier 2009 and William Butcher, Lecture given at INSEE, November 1983.

World. While Verne based electrical science on scientists like Davy and Faraday, he also followed the work of great electrical engineers such as Gustave Pierre Trouvé (1839-1902), a famous Paris inventor of the times. Trouvé built and flew a tethered electric model helicopter in 1886. This was part of the inspiration for Verne's *Albatross*, a helicopter-type airship, and even today's personal drones.

Fig. 14: From *An American Journalist in 2889* (1888).

Illustration by George Roux.



Conclusion

The scientific perpetuity of Jules Verne is found in the application of foundational Victorian science and its projection into the future. Novels such as *Mysterious Island*, *From Earth to the Moon*, and *Twenty Thousand Leagues under the Sea* highlight Verne's scientific knowledge of the times. Research shows that Verne's futurism was anchored in the theories of Victorian scientists such as Humphrey Davy, Michael Faraday, James Maxwell, François Arago, Camille Flammarion, Louis Figuier, Sainte-Clare Deville, Charles Lyell, George Cuvier, Evan Hopkins, Tyndall, Heinrich Rudolf Hertz, Elie de Beaumont, and Pierre-Simon Marquis de Laplace. Verne followed these scientists with a daily reading routine. Verne spent countless hours in the Bibliothèque Nationale de France, taking notes from scientific journals, news clips, newspapers worldwide, and patents. Verne can be viewed as a literary engineer taking contemporary science into an engineering future.

Verne also used his membership in societies like the Société Industrielle, a scientific society, and the Circle of the Scientific Press, a weekly discussion group, personal communications with scientists and engineers, contracted professionals for scientific review, university meetings, and geographer clubs as a type of "Delphi" group approach to confirm the plausibility of his visions.

Verne's scientific research and database allowed Vernian visions to find application even in today's engineering. This scientific continuum of Verne into the future is aligned with Tolstoy's vision of a step-wise advance of history and technology; however, as discussed, roadblocks can delay and slow the ultimate technological destiny. Verne understood that scientific concepts develop through connective networks, collaborative research, overcoming engineering roadblocks, and technological breakthroughs. As James Burke noted in hindsight, technological nodes might branch out or take new directions, modifying the future path of technology. Verne demonstrated this view of technological progress in his four-decade literary journey of scientific novels, the *Voyages Extraordinaires*, which show, for example, the changing advances in electrical development and electrical devices in Verne's futurism – such as in Verne's use shift from battery-powered devices and arc lighting in his 1860s and 1870s novels to electromechanical powered devices and incandescent lighting, that followed theoretical advances in electrical science in later novels.

Another overall belief of Verne about technological progress was the role of scientific or engineering leadership, such as in his characters Robur, Nemo, and Lidenbrock, needed to accelerate the connective advance of technology.

Verne felt that the progress of science was an exciting narrative, often weaving the evolutionary history of Victorian science in his stories, such as in *From the Earth to the Moon* (1867). Verne used Victorian scientific theories and their evolution to move and enhance the narrative. In *Journey to the Center of the Earth* (1865), Verne employed the real Victorian scientific debate of earth geology to drive the story and narrative. Verne's historical narratives embedded in his novels also built reader credibility. Using historical timelines to illustrate the continuous advance of technology, he led his readers to believe in his future.

Verne's futurism is also linked to his intuitive feeling about technology. Verne realized that the advancement of technology may be stepwise, as Tolstoy suggested, but it is not always linear. Verne foresaw the exponential growth of technology in place of the linear view of the Victorians, and applied this model to predict the future.

Ultimately, we see Verne not as a prophet but more as a scientist. Like his icon Michael Faraday, who planned the direction of experimentation based on prior experimental successes, Verne used scientific discoveries to project a potential path for the future.

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Figure 1: *Hector Servadac / Off on a Comet*. Drawing by Paul Philippoteaux, engraving by Charles Laplante (fr), 1877. http://jv.gilead.org.il/rpaul/Hector%20Servadac/images/001.jpg

Figure 2: *Hector Servadac / Off on a Comet*. Drawing by Paul Philippoteaux, engraving by Charles Laplante (fr), 1877. http://jv.gilead.org.il/rpaul/Hector%20Servadac/images/106.jpg

Figure 3: *The Begum's fortune.* Illustration by Léon Benett. 1878. http://jv.gilead.org.il/rpaul/Les%20cinq%20cents%20millions%20de%20la%20B%C3%A9gum/images/012.jpg

Figure 4: Illustration from *The Illustrated London News*, 28 February, 1863. Downloaded from "The Beginnings of the Pneumatic Railway," by Annie Duffield. https://www.postalmuseum.org/wp-content/uploads/2020/06/1.6.-ILN-28-Feb-1863-1200x895.jpg

Figure 5: *The Self-Propelled Island*. Illustration by George Roux. 1895. http://jv.gilead.org.il/rpaul/L%E2%80%99%C3%8Ele%20%C3%A0%20h%C3%A9lice/images/011.jpg

Figure 6: Verne's cannon in *From the Earth to the Moon*. Illustration by Henri de Montaut. 1864. http://jv.gilead.org.il/rpaul/De%20la%20terre%20%C3%A0%20la%20lune/images/012.jpg

Figure 7: HARP Space Cannon. Photo by Peter Millman on front cover of *Sky and Telescope*. https://pwg.gsfc.nasa.gov/stargaze/Sfigs/Sharpgun.jpg

Figure 8: *The Mighty Orinoco*. Illustration by George Roux. 1894. http://jv.gilead.org.il/rpaul/Le%20superbe%20Or%C3%A9noque/images/001.jpg

Figure 9: *La Jangada / 800 Leagues in the Amazon*. Illustration by Léon Benett. 1880. http://jv.gilead.org.il/rpaul/La%20Jangada/images/001.jpg

Figure 10: *The Mysterious Island*. Illustration by Jules-Descartes Férat. 1874. http://jv.gilead.org.il/rpaul/L%E2%80%99%C3%8Ele%20myst%C3%A9rieuse/images/001.jpg

Figure 11: Alexander Blaikley. 1855. Michael Faraday delivering a Christmas Lecture to the general public at the Royal Institution, 27th December, 1855. https://upload.wikimedia.org/wikipedia/commons/b/b3/Professor_Faraday_lecturing_at_the_Royal_Institution%2C_27th_December%2C_1855_RIIC_0006_20110213_BAL_EP.jpg

Figure 12: Louis Figuier. *The Wonders of Science*, cover of Volume 1. Librairie Furne, Jouvet et Cie, 1867-1891. https://upload.wikimedia.org/wikipedia/commons/b/b4/T1-_d007-_Frontispice.png

Figure 13: Anonymous wood engraving. First appeared in Camille Flammarion's *L'atmosphère : météorologie populaire*, p. 163 (Paris: Hachette, 1888). Dowloaded from Wikimedia Commons. https://upload.wikimedia.org/wikipedia/commons/8/87/Flammarion.jpg

Figure 14: From *An American Journalist in 2889*. Illustration by George Roux. 1888. http://jv.gilead.org.il/rpaul/La%20journ%C3%A9e%20d%E2%80%99un%20journaliste%20am%C3%A9ricain%20en%202889/images/001.jpg