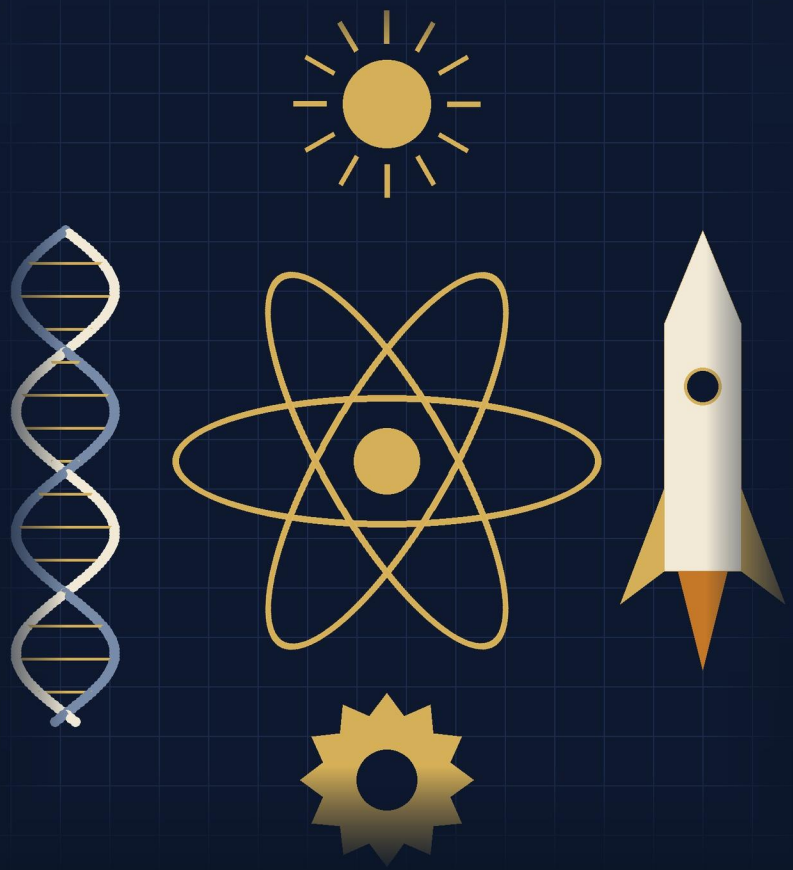
A PLAIN-ENGLISH FACT CHECK

THE NEXT FIFTEEN

The Inventions Humanity Should Work On Next



ENERGY | WATER | HEALTH | LEARNING | SAFETY | CLIMATE

Checked Against the Record

ANDREW DOMINGUEZ

TRINFINITY Enterprises

THE NEXT FIFTEEN

The Inventions Humanity Should Work On Next, Checked Against the Record

Clean power, clean water, medicine, learning, safer roads, early warnings and more: where each one really stands, and what would help the most people

Andrew Dominguez

Fact Check Series

Trinfinity Enterprises

The Next Fifteen: The Inventions Humanity Should Work On Next, Checked Against the Record

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The information in this book stops at November 18, 2026. Each figure comes from the newest report I could open on that date and carries the date of its source. Science and technology move fast, so check the sources named in the footnotes before you rely on a number.

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Questions and corrections: andrew@trinfinityenterprises.com

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Introduction: A Better List

The information in this book stops at November 18, 2026.

Summary

A short essay came across my desk with a big title: "The 10 Greatest Inventions Humanity Should Work on Next." It ranked ten breakthroughs, from cheap clean energy to AI (artificial intelligence) that does science, named famous scientists as the inspiration for each, and picked energy as the most important. It came with no author's name and no sources.

I checked it against the record. The essay holds up better than most lists like it, and the first chapter of this book shows exactly where it is right and where it falls short. But checking it raised a better question. If the goal is to help the most people, which inventions should come next?

This book answers that question with a list of fifteen. It keeps seven areas from the essay, drops two to a watch list, and adds new ones the essay left out. Here is the short version.

- **Many of the biggest gains come from tools we already have.** About 2.1 billion people lack safely managed drinking water. About 2.1 billion cook over open fires or smoky stoves, and that smoke is linked to an estimated 2.9 million deaths a year. At least 1 billion people have vision problems that could have been prevented or have not been treated. The tools exist. The work is making them cheap enough and getting them to people.[1]
- **Some threats are growing.** Germs that resist antibiotics, heat waves and disasters are getting worse. Researchers forecast more than 39 million deaths from drug-resistant infections between now and 2050, and heat is linked to an average of 546,000 deaths a year.[2]
- **The famous high-tech ideas are real, but most are further off than the headlines say.** Fusion power, AI that runs research on its own, quantum computers and space travel all have real results. Most are still in the lab or in early trials.
- **Checking matters.** A chapter on hype traces nine claims that ran ahead of the evidence, from fusion timelines to a superconductor that was not one.

The central question

This book asks one question: **Which inventions should humanity work on next to help the most people, and where does each one really stand today?**

For each of the fifteen I ask four smaller questions.

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[1] World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef. Accessed November 18, 2026. World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026. World Health Organization, "Blindness and vision impairment (fact sheet)", February 10, 2026. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed November 18, 2026.

[2] Chris Dall, CIDRAP (University of Minnesota), "Study forecasts more than 39 million deaths from antimicrobial resistance by 2050", undated (on the GRAM study in The Lancet, 2024). https://www.cidrap.umn.edu/antimicrobial-stewardship/study-forecasts-more-39-million-deaths-antimicrobial-resistance-2050. Accessed November 18, 2026. World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

1. Why is it on the list?
2. Where did it come from, and who actually did the work?
3. Where does it stand on November 18, 2026, by the best records I could find?
4. What stands in the way?

How I ranked the fifteen

A ranking is an opinion. This one is mine, and I want you to see how I made it so you can disagree with it on the merits. I weighed four things, in this order:

1. **How many people it would help in the next 20 years,** counting lives saved and lives made better.
2. **How ready it is.** An invention that works today but has not reached people ranks higher than one still in the lab, because the help can come sooner.
3. **What it unlocks.** Cheap power makes clean water, cooling and computing cheaper. Internet access makes tutoring and medical advice possible.
4. **Cost.** A fix that costs little per person ranks above an expensive one that helps the same number of people.

The rank order is my judgment. The facts each rank rests on are cited, and where I am inferring rather than reporting, I say so.

Rank	Invention	Where it came from
1	Cheap clean power, storage and grids	Essay's #1, with a shift away from fusion
2	Clean water and sanitation for everyone	Essay's #5, water half
3	Beating infectious disease	New
4	Gene and cell medicine people can afford	Essay's #3
5	AI for science that checks its own work	Essay's #2
6	Internet access and AI tutors	Essay's #10
7	Crops and fertilizer that do more with less	Essay's #5, food half
8	Measuring and cutting climate pollution	Essay's #8
9	Robots for dangerous work and building	Essay's #4
10	Brain implants for paralysis and lost speech	Essay's #7
11	Clean cooking	New
12	Safer roads	New
13	Early warnings for disasters	New
14	Protection from extreme heat	New
15	Eye and hearing care for everyone	New
Watch list	Quantum computing and new materials; space transportation	Essay's #6 and #9

How I did the research

I opened every source myself and read the page before citing it. When a number appears in this book, the footnote names where it came from and the date of that source.

Where the facts come from

I used sources in this order of preference:

Tier	What it includes	Examples in this book
1. Primary and official	Government agencies, national laboratories, United Nations bodies, and the official record	World Health Organization (WHO), World Meteorological Organization, Food and Drug Administration (FDA), Lawrence Livermore National Laboratory, Library of Congress
2. Nonpartisan analysis	Research groups that do not argue for a side	International Energy Agency (IEA), World Bank research papers, the Center for Strategic and International Studies (CSIS) data project
3. Scholarly	Peer-reviewed journals, universities, museums and encyclopedias	Nature Geoscience, Scientific Reports, the Medical Journal of Australia, the Smithsonian, the Science Museum, the Royal Institution
4. Journalism	News and trade reporting, used for recent events and to point back to the original	Physics Today, Science News, Reuters, Bloomberg, Chemistry World, CIDRAP (the University of Minnesota's Center for Infectious Disease Research and Policy)
5. Industry and advocacy	Companies, trade groups and advocacy groups	Google, Vertex Pharmaceuticals, Volvo, Carrier, BloombergNEF, the International Federation of Robotics. Used only for their own data or their own claims, always labeled

When a company says its own product works, that tells you what the company claims. It does not prove the product works. I keep those two things apart, and I say whose claim it is.

Facts, interpretations and unknowns

- **Confirmed facts** are things the records show, such as the date the FDA approved the first gene-editing therapy in the United States.
- **Interpretations** are what someone makes of the facts, such as which invention matters most. When I give one, I say whose it is. When it is mine, I say so.
- **Unknowns** are things the records do not settle. When I could not confirm something, I mark it **[Not verified]** and say what I searched.

The four verdicts

The essay's factual claims, checked in the first chapter and listed in Appendix B, each get one of the four verdicts used in every book in this series:

- **True:** The records support the claim as stated.
- **Partly true:** Part of the claim holds up, but it leaves out something important or overstates it.
- **False:** The records contradict the claim as stated.
- **Inconclusive:** The records do not settle it, or the claim is a prediction that cannot be checked yet.

The readiness scale

To show where each invention stands, I rate each part of it on a five-step scale. This is my own rating, built from the sources in each chapter. It is a judgment, not a measurement.

Step	Name	What it means
1	Idea	Theory or early design. Nothing working yet.
2	Lab proof	It has worked in a laboratory, but not in real use.
3	Trials and pilots	It is being tested on real patients, sites or customers in small numbers.
4	Early market	It is approved or sold, but not yet common.
5	Widely used	It is common and working at large scale.

Several chapters give two ratings: one for the tool itself and one for reaching everyone who needs it. Clean water treatment, for example, is a 5 as a tool and a 2 at reaching every person.

What this book does not do

This book does not tell you which company to invest in. It does not predict when fusion power or a cure for aging will arrive, because nobody can check a prediction until the date passes. It does not cover military weapons, and it does not judge anyone's faith or politics. It sticks to what the records show, plus one clearly labeled opinion: the ranking.

Blind spots in the record

- **The record favors the winners.** Laboratories, companies and governments that succeeded keep good records. Projects that failed quietly often leave little trace.
- **The record favors English-language and Western sources.** I read in English. Much important work happens in China, Japan, Korea, India and Africa. China installed more than half of the world's new factory robots in 2024, for example, and I can describe that only through an international trade group's numbers.[3]
- **Company claims are hard to check from the outside.** Where independent checks exist, I use them. Where they do not, I say so.

[3] International Federation of Robotics (industry association), "Global Robot Demand in Factories Doubles Over 10 Years", September 25, 2025. https://ifr.org/ifr-press-releases/news/global-robot-demand-in-factories-doubles-over-10-years. Accessed November 18, 2026.

- **Global health numbers are estimates.** Figures such as deaths from smoke or heat come from models built by the World Health Organization and university teams. They are the best numbers available, but they carry real uncertainty.
- **Credit is often unfair.** Science history has many people who did key work and got little credit. I name them where the record allows.

How the book is laid out

The first chapter checks the original essay. Chapters 1 through 15 take my fifteen in rank order. Each has the same parts: why it is on the list, where it came from, where it stands now, the people who moved it, and the bottom line with a readiness rating. Chapter 16 is the watch list. Chapter 17 covers hype and disputed claims. Chapter 18 shows all fifteen on one page as a blueprint. The Conclusion sums up what is well established, what is reasonable inference, and what remains unknown. At the back you will find a chronology, the essay's claims and verdicts, the charts and visual records with their rights, and the full list of sources.

Before the List: Checking the Essay

What the essay said

The essay asks the reader to imagine combining the thinking of Leonardo da Vinci, Nikola Tesla, Albert Einstein, Isaac Newton, Marie Curie, Alan Turing, Ada Lovelace, Michael Faraday, Charles Darwin "and hundreds of other extraordinary inventors," and then asks what ten breakthroughs would make the greatest difference. It says it ranks them on five factors: potential to save lives, ability to unlock other inventions, economic impact, scientific feasibility, and long-term importance. It calls itself "a reasoned synthesis, not a literal evaluation of every inventor who has ever lived." That is a fair and honest description.

Essay's #	Invention, as the essay names it	Essay's "Inspired by" names	In this book
1	Abundant, ultra-cheap clean energy	Faraday, Tesla, Einstein, Maxwell	Chapter 1
2	AI that can discover new science	Turing, Lovelace, von Neumann, Shannon	Chapter 5
3	Repairing and regenerating the human body	Curie, Pasteur, Darwin, Mendel, Franklin	Chapter 4
4	Self-building infrastructure and robotics	Leonardo da Vinci, Archimedes, Watt, Tesla	Chapter 9
5	Abundant clean water and food	Haber, Bosch, Pasteur, Borlaug	Chapters 2 and 7
6	Quantum computing and new materials	Planck, Einstein, Bohr, Feynman	Chapter 16 (watch list)
7	Brain repair and neural interfaces	Ramon y Cajal, Hodgkin, Huxley, Turing	Chapter 10
8	Planetary climate and ecosystem restoration	Fourier, Arrhenius, Darwin, Lovelock	Chapter 8
9	Revolutionary space transportation	Newton, Tsiolkovsky, Goddard, Einstein	Chapter 16 (watch list)
10	Universal scientific intelligence and education	Gutenberg, al-Khwarizmi, Lovelace, Turing	Chapter 6

The three facts it cites

The essay closes by saying its priorities "align with active research," and gives three examples, from the International Energy Agency, gene editing and the Intergovernmental Panel on Climate Change (IPCC). All three check out.

- **"The International Energy Agency's 2026 review identifies progress across fusion, geothermal, solar, and batteries": True.** The IEA's State of Energy Innovation 2026, published in February 2026, covers all four.[4] (Chapter 1)

[4] International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary. Accessed November 18, 2026. International

- **"Gene editing is already treating certain inherited diseases": True.** The FDA approved Casgevy, the first CRISPR-based therapy, for sickle cell disease on December 8, 2023, and for transfusion-dependent beta thalassemia on January 16, 2024.[5] (Chapter 4)
- **"The IPCC documents the urgency of climate mitigation and adaptation": True.** The Synthesis Report of March 2023 found that human activities "have unequivocally caused global warming."[6] (Chapter 8)

The "Inspired by" names

This is the weakest part of the essay. Some names are true roots of the field: Faraday for electric power, Ramon y Cajal for brain science, Tsiolkovsky and Goddard for rockets, Gutenberg and al-Khwarizmi for spreading knowledge. Others are famous names with only a loose link, such as Einstein for rockets or Darwin for climate repair.

The bigger problem is who is missing. The essay skips most of the people who did the inventing in living memory: Daryl Chapin, Calvin Fuller and Gerald Pearson, who built the first practical solar cell; Jennifer Doudna and Emmanuelle Charpentier, whose gene-editing work led to the first CRISPR medicine; George Devol and Joseph Engelberger, who started the robot industry; Sidney Loeb and Srinivasa Sourirajan, whose membrane is the heart of modern desalination; and Eunice Foote and John Tyndall, who did the first experiments on how gases trap heat. Each is covered in the chapters that follow.

It also names Fritz Haber as an inspiration without a word about his role in chemical warfare. The Institution of Chemical Engineers notes that Haber "personally oversaw and directed the first large-scale release of chlorine gas in Ypres in 1915."[7]

The planning table

The essay gives each invention a planning horizon and a main challenge, and says plainly that these "are approximate planning horizons, not predictions of when any particular invention will succeed." The horizons cannot be rated True or False. What I can check is whether the named challenges fit the evidence.

#	Essay's horizon	Essay's main challenge	What the evidence shows
1	Now to 30+ years	Cost, storage, reliable supply	Fits. Solar and batteries are here now; fusion is decades out by its own scientists' account.

Energy Agency, "Energy innovation enters security-focused phase as batteries dominate patent landscape", February 2026. https://www.iea.org/news/energy-innovation-enters-security-focused-phase-as-batteries-dominate-patent-landscape. Accessed November 18, 2026.

[5] Gillian McGovern, Pharmacy Times, "FDA Approves Casgevy, Lyfgenia for the Treatment of Sickle Cell Disease", December 8, 2023. https://www.pharmacytimes.com/view/fda-approves-casgevy-lyfgenia-for-the-treatment-of-sickle-cell-disease. Accessed November 18, 2026. AABB (Association for the Advancement of Blood and Biotherapies), "FDA Expands Gene Therapy Approval to Include Beta-Thalassemia", January 17, 2024. https://www.aabb.org/news-resources/news/article/2024/01/17/fda-expands-gene-therapy-approval-to-patients-with-beta-thalassemia. Accessed November 18, 2026.

[6] Intergovernmental Panel on Climate Change (page hosted by the European Commission, Knowledge4Policy), "AR6 Synthesis Report: Climate Change 2023", March 21, 2023. https://knowledge-for-policy.ec.europa.eu/publication/ar6-synthesis-report-climate-change-2023_en. Accessed November 18, 2026.

[7] Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026.

#	Essay's horizon	Essay's main challenge	What the evidence shows
2	Now to 20+ years	Accuracy, safety, experimental validation	Fits. Made-up results are the documented problem.
3	Now to 30+ years	Biological complexity, clinical safety	Fits, and cost belongs on the list.
4	Now to 20+ years	Reliability, physical dexterity	Fits, and cost belongs on the list.
5	Now to 15+ years	Cost and distribution	Fits well. The tools exist; delivery is the gap.
6	5 to 30+ years	Hardware, error correction	Fits. No useful advantage shown yet.
7	5 to 30+ years	Precision, long-term safety	Partly fits. Speech implants already work in trials for a few patients.
8	Now to 30+ years	Scale, measurement, ecological effects	Fits well.
9	10 to 50+ years	Cost, propulsion, sustainability	Partly fits. Reusable boosters are already here.
10	Now to 15+ years	Access, quality, trust	Fits. Access is the first wall.

Verdict on the table: Partly true as a planning guide. Every main challenge the essay names matches the documented problem. Two horizons start later than the evidence shows for part of the field. The end dates are predictions. **Inconclusive.**

Why I changed the list

The essay ranks energy first because it is "an enabling technology for almost everything else on this list." I agree, and energy stays first in my list. I part ways with the essay in three places. This is my judgment, explained so you can weigh it. **[Interpretation]**

1. **The essay ranks by how exciting the science is more than by how many people it would help soon.** Its own table names "cost and distribution" as the main challenge for water and food, yet ranks them fifth. The records show 2.1 billion people still lack safely managed drinking water, and that is not because water treatment has not been invented.[8] I moved water to second.
2. **It leaves out some of the largest causes of death that new or cheaper tools could cut.** Infectious disease, smoky cooking fires, road crashes, extreme heat and disasters together are

[8] World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef. Accessed November 18, 2026.

linked to millions of deaths a year.[9] None appears on the essay's list. Five new chapters cover them, along with eye and hearing care.

3. **Two of its picks help people on Earth less, and later, than the rest.** Quantum computing has not yet done a useful job faster than an ordinary computer, and the most useful part of cheap space travel, reusable rockets, is already done. Both remain worth funding. I moved them to a watch list.

Bottom line on the essay: mostly sound. It picked real fields, named the right challenges, cited three true facts and was honest that its timelines are guesses. Its weak points are the "Inspired by" lists and a ranking that underweights the problems that kill the most people today.

[9] Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026. World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026. World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/. Accessed November 18, 2026. World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

Chapter 1: Cheap Clean Power, Storage and Grids

Why it is on the list: Cheap, steady electricity makes almost everything else in this book cheaper: pumping and cleaning water, running clinics, cooling homes in a heat wave, and powering phones, computers and laboratories. The essay ranked energy first, and so do I. Where I differ is emphasis. The evidence says the near-term payoff is in solar, batteries, grids and new geothermal, not fusion.

What the essay said: Develop "economical fusion, advanced geothermal, better solar, storage, and electric grids." It calls energy the "highest priority" because "affordable, reliable energy makes water purification, manufacturing, AI, transportation, and food production easier." Its advice: work on "low-cost, continuously available electricity, not just fusion." Inspired by Faraday, Tesla, Einstein and Maxwell.

Where it came from

Almost every power plant on Earth runs on one discovery. In August 1831, Michael Faraday, working in the basement laboratory of the Royal Institution in London, found that moving a magnet through a coil of wire makes an electric current. He called it electromagnetic induction, and in the same work he built the first transformer and the first generator. Historian Frank James of the Royal Institution puts it plainly: all power stations generate electricity "based on the fundamental principles Faraday discovered in his basement laboratory in 1831."[10]

The essay is right to name Faraday first. It is also right to name Nikola Tesla, but the story is bigger than one man. Tesla's key idea was the rotating magnetic field, which he worked out in 1882, and by 1887 he had a working alternating current (AC) motor. After a lecture in 1888, George Westinghouse bought Tesla's patents for $200,000 and built the AC system that won the so-called "current war" against Thomas Edison's direct current.[11] The transformer that made long-distance AC practical came from Europe, and the first electric light came from Humphry Davy in 1807, long before Edison.[12] Credit for the electric grid belongs to many hands.

Einstein's link is real but specific. His Nobel Prize, awarded for 1921, was "especially for his discovery of the law of the photoelectric effect," the idea that light comes in packets of energy.[13] That idea is the physics underneath every solar panel.

The working solar cell came later, from three engineers whose names are not on the essay's list. On April 25, 1954, Daryl Chapin, Calvin Fuller and Gerald Pearson of Bell Telephone Laboratories in Murray Hill, New Jersey, announced the first practical silicon solar cell. It turned about 6 percent of sunlight into

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[10] Frank A. J. L. James, Physics Today, "The legacies of the Royal Institution", August 1, 2018. vol. 71, no. 8, pp. 36-43, doi:10.1063/PT.3.3996. https://physicstoday.aip.org/features/the-legacies-of-the-royal-institution. Accessed November 18, 2026.

[11] W. Bernard Carlson, National Geographic, "Edison and Tesla's cutthroat 'Current War' ushered in the electric age", September 27, 2019. https://www.nationalgeographic.com/history/history-magazine/article/edison-tesla-current-war-ushered-electric-age. Accessed November 18, 2026.

[12] W. Bernard Carlson, National Geographic, "Edison and Tesla's cutthroat 'Current War' ushered in the electric age", September 27, 2019. https://www.nationalgeographic.com/history/history-magazine/article/edison-tesla-current-war-ushered-electric-age. Accessed November 18, 2026.

[13] NobelPrize.org, "Albert Einstein: Facts", undated. https://www.nobelprize.org/prizes/physics/1921/einstein/facts. Accessed November 18, 2026.

electricity. Earlier cells, going back to Edmond Becquerel's discovery of the effect in 1839 and Charles Fritts's selenium cells in 1883, were under 1 percent efficient.[14]

Where it stands on November 18, 2026

The big picture

The International Energy Agency (IEA), the energy research body funded by its member governments, published The State of Energy Innovation 2026 in February 2026. It counted "over 150 significant energy innovation highlights in 2025."[15] The essay says this review "identifies progress across fusion, geothermal, solar, and batteries." That is accurate. The report covers all four: fusion start-ups had raised about 10 billion dollars since 2020, next-generation geothermal was among the year's highlights, a newer solar material called perovskite now makes up more than 70 percent of all solar cell patents, and energy storage reached 40 percent of all energy patenting in 2023.[16]

The same report carries a warning the essay leaves out. Public spending on energy research worldwide was about 55 billion dollars in 2025, down 2 percent. United States federal energy research dipped 8 percent in 2025. Venture capital for energy start-ups shrank for the third year in a row, to 27 billion dollars, and the IEA says "private finance has become scarcer."[17] The essay calls energy the highest priority. The money, for now, is moving the other way.

Solar and batteries: already cheap

Solar is the success story. The International Renewable Energy Agency (IRENA) reported that the average cost of electricity from new large solar farms fell to about 4.3 cents per kilowatt-hour in 2024, down 90 percent from 41.7 cents in 2010. IRENA also found that 91 percent of new large renewable projects in 2024 made power more cheaply than the cheapest new fossil fuel plant.[18]

Batteries followed. The research firm BloombergNEF found that the average lithium-ion battery pack cost $108 per kilowatt-hour in 2025, a record low and 8 percent below 2024. Packs for grid storage fell to $70 per kilowatt-hour, 45 percent lower than a year earlier.[19]

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[14] Alan Chodos, APS News (American Physical Society), "April 25, 1954: Bell Labs Demonstrates the First Practical Silicon Solar Cell", April 2009. https://aps.org/apsnews/2009/04/bell-labs-silicon-solar-cell. Accessed November 18, 2026.

[15] International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary. Accessed November 18, 2026.

[16] International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary. Accessed November 18, 2026. International Energy Agency, "Energy innovation enters security-focused phase as batteries dominate patent landscape", February 2026. https://www.iea.org/news/energy-innovation-enters-security-focused-phase-as-batteries-dominate-patent-landscape. Accessed November 18, 2026.

[17] International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary. Accessed November 18, 2026.

[18] JP Casey, PV Tech, "IRENA: Solar LCOE falls 12% year-on-year, 90% since 2010", September 26, 2024. reporting IRENA, Renewable Power Generation Costs in 2023. https://www.pv-tech.org/irena-solar-lcoe-falls-12-year-on-year-90-since-2010. Accessed November 18, 2026. Anu Bhambhani, TaiyangNews, "IRENA: Solar Power Averaged $0.043/kWh Globally In 2024", July 24, 2025. reporting IRENA, Renewable Power Generation Costs in 2024. https://taiyangnews.info/business/irena-renewable-power-generation-costs-in-2024-report. Accessed November 18, 2026.

[19] BloombergNEF (energy research firm), "Lithium-Ion Battery Pack Prices Fall to $108 Per Kilowatt-Hour, Despite Rising Metal Prices", December 9, 2025. https://about.bnef.com/insights/clean-energy/lithium-ion-battery-pack-prices/. Accessed November 18, 2026.

Measure	Number	Year	Source type
Solar farm power cost, world average	4.3 cents per kWh, down 90% since 2010	2024	Intergovernmental agency (IRENA), as reported by the trade press
New renewables cheaper than cheapest new fossil plant	91% of new large projects	2024	Same
Lithium-ion battery pack, average	$108 per kWh, down 8%	2025	Industry research (BloombergNEF)
Battery pack for grid storage	$70 per kWh, down 45%	2025	Same

[20]

The catch is the one the essay names: "continuously available." The sun sets and the wind stops. Cheap panels need cheap storage and strong grids to run a hospital at 3 a.m. That is why the essay's focus on reliability, not just price, is sound.

Geothermal: first power from a new kind of plant

Ordinary geothermal plants need hot water close to the surface, which few places have. "Enhanced" geothermal systems drill into hot dry rock and "engineer a fluid pathway through hot dry rock, then circulate water through it to capture heat," borrowing drilling methods from the oil and gas industry.[21] On September 24, 2026, the company Fervo Energy announced first power from Cape Station in Beaver County, Utah. Phase I is planned at about 100 megawatts in three 33-megawatt blocks, with the first block expected to begin commercial operation by October 1, 2026, and the other two by January 1, 2027.[22] I could not confirm from an independent source that commercial operation has started. **[Not verified]**

Fusion: real science, not yet a power source

Fusion is the process that powers the sun. On Earth the hard part is getting more energy out than you put in.

On December 5, 2022, the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory in California fired 192 lasers at a tiny fuel capsule. The capsule released about 3.15 megajoules (MJ) of fusion energy from 2.05 megajoules of laser light. That met the scientific definition of ignition for the first time. The catch: each shot draws about 300 megajoules from the electric grid to power the lasers, so the fusion energy "amounts to just 1% of the 300 MJ from the grid," as Physics Today reported.[23]

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[20] JP Casey, PV Tech, "IRENA: Solar LCOE falls 12% year-on-year, 90% since 2010", September 26, 2024. reporting IRENA, Renewable Power Generation Costs in 2023. https://www.pv-tech.org/irena-solar-lcoe-falls-12-year-on-year-90-since-2010. Accessed November 18, 2026. Anu Bhambhani, TaiyangNews, "IRENA: Solar Power Averaged $0.043/kWh Globally In 2024", July 24, 2025. reporting IRENA, Renewable Power Generation Costs in 2024. https://taiyangnews.info/business/irena-renewable-power-generation-costs-in-2024-report. Accessed November 18, 2026. BloombergNEF (energy research firm), "Lithium-Ion Battery Pack Prices Fall to $108 Per Kilowatt-Hour, Despite Rising Metal Prices", December 9, 2025. https://about.bnef.com/insights/clean-energy/lithium-ion-battery-pack-prices/. Accessed November 18, 2026.

[21] Hugo Rojas, GCN, "Fervo Energy's Cape Station delivers first power from a utility-scale enhanced geothermal plant", October 1, 2026. https://gcn.com/enhanced-geothermal-fervo-energy-cape-station/22087/. Accessed November 18, 2026.

[22] Hugo Rojas, GCN, "Fervo Energy's Cape Station delivers first power from a utility-scale enhanced geothermal plant", October 1, 2026. https://gcn.com/enhanced-geothermal-fervo-energy-cape-station/22087/. Accessed November 18, 2026.

The laboratory has kept improving. On April 7, 2025, NIF produced a record 8.6 megajoules from 2.08 megajoules of laser energy, a gain of about 4. The earlier record was 5.2 megajoules in February 2024.[24]

The world's largest fusion project, ITER (originally the International Thermonuclear Experimental Reactor) in southern France, reset its schedule in July 2024. Its director-general announced that research operations would start in 2034 and that full deuterium-tritium fuel operation, the kind that makes real fusion power, would move from 2035 to 2039.[25] ITER is a science experiment. It is not designed to put electricity on the grid.

Private companies say they will be faster. Helion Energy signed what was called the world's first power purchase agreement for fusion with Microsoft in May 2023, for up to 50 megawatts, and says it remains on track to deliver power by 2028.[26] Helion broke ground on its Orion plant in Malaga, Washington, in July 2025.[27] As of the sources I could read, Helion had not publicly shown a machine that makes more electricity than it uses. **[Not verified]** that any private company has done so.

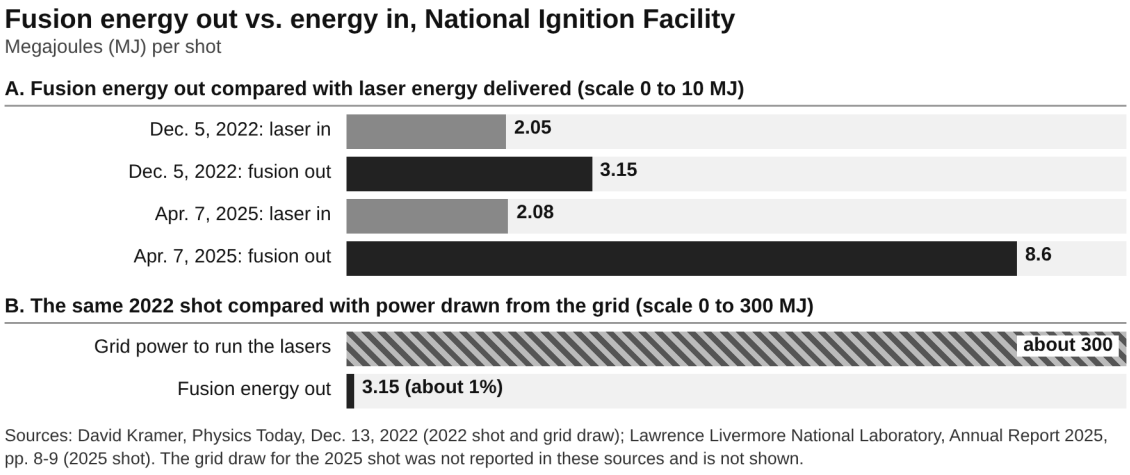


Figure 1. Fusion energy out compared with laser energy in and grid energy drawn, National Ignition Facility. Sources: Physics Today (2022); Lawrence Livermore National Laboratory, Annual Report 2025.

[23] David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026.

[24] Lawrence Livermore National Laboratory, "Annual Report 2025: National Ignition Facility", February 2026. pp. 8-9. https://annual.llnl.gov/sites/annual/files/2026-02/llnlannual25-3-national-ignition-facility.pdf. Accessed November 18, 2026.

[25] ITER Organization, "Press Conference Summary: Summary of Presentation by Pietro Barabaschi, ITER Director-General", July 3, 2024. p. 2. https://iter.org/sites/default/files/media/2024-07/baseline_press_conference_summary_july-2024_b.pdf. Accessed November 18, 2026.

[26] DatacenterDynamics, "Helion begins work at fusion plant, expects to deliver power to Microsoft by 2028", 2025. https://datacenterdynamics.com/en/news/helion-begins-work-at-fusion-plant-expects-to-deliver-power-to-microsoft-by-2028/. Accessed November 18, 2026.

[27] GeekWire, "Inside the race to power AI data centers with fusion energy, and the surprise detours along the way", 2026. https://www.geekwire.com/2026/inside-the-race-to-power-ai-data-centers-with-fusion-energy-and-the-surprise-detours-along-the-way/. Accessed November 18, 2026.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Michael Faraday	Key discovery 1831	Scientist, Royal Institution, London	Discovered electromagnetic induction; built the first transformer and generator, August 1831	The working principle of all power stations[28]
Nikola Tesla	Key work 1882-1888	Inventor	Rotating magnetic field (1882); two-phase AC motor (1887); patents bought by Westinghouse	Core of the AC power system that won out over direct current[29]
Daryl Chapin, Calvin Fuller, Gerald Pearson	Active 1950s	Engineers, Bell Labs	First practical silicon solar cell, April 25, 1954, about 6% efficient	Ancestor of every silicon solar panel; inducted into the National Inventors Hall of Fame in 2008[30]
NIF team, Lawrence Livermore National Laboratory	2009 to present	Government laboratory	First laboratory fusion ignition, December 5, 2022; 8.6 MJ record, April 7, 2025	First proof that fusion fuel can release more energy than the laser energy delivered to it[31]

Bottom line

The essay's energy claims: True. The IEA 2026 review does track progress in fusion, geothermal, solar and batteries. The essay's warning to work on "continuously available electricity, not just fusion" is the right reading of the evidence: solar and batteries are already cheap and spreading, enhanced geothermal just made its first power, and fusion has proven the science but remains years from the grid.

"Inspired by" names: Partly true. Faraday and Tesla are true roots. Einstein's link runs through the photoelectric effect, which matters for solar. James Clerk Maxwell, also named, is widely credited with the equations of electromagnetism, but I did not trace that to a source in this book. **[Not verified]** The list leaves out the Bell Labs team that actually built the solar cell.

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[28] Frank A. J. L. James, Physics Today, "The legacies of the Royal Institution", August 1, 2018. vol. 71, no. 8, pp. 36-43, doi:10.1063/PT.3.3996. https://physicstoday.aip.org/features/the-legacies-of-the-royal-institution. Accessed November 18, 2026.

[29] W. Bernard Carlson, National Geographic, "Edison and Tesla's cutthroat 'Current War' ushered in the electric age", September 27, 2019. https://www.nationalgeographic.com/history/history-magazine/article/edison-tesla-current-war-ushered-electric-age. Accessed November 18, 2026.

[30] Alan Chodos, APS News (American Physical Society), "April 25, 1954: Bell Labs Demonstrates the First Practical Silicon Solar Cell", April 2009. https://aps.org/apsnews/2009/04/bell-labs-silicon-solar-cell. Accessed November 18, 2026.

[31] David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026. Lawrence Livermore National Laboratory, "Annual Report 2025: National Ignition Facility", February 2026. pp. 8-9. https://annual.llnl.gov/sites/annual/files/2026-02/llnlannual25-3-national-ignition-facility.pdf. Accessed November 18, 2026.

Readiness: Solar and batteries, 5 (widely used). Enhanced geothermal, 4 (early market). Fusion power, 2 (lab proof).

Chapter 2: Clean Water and Sanitation for Everyone

Why it is on the list: Safe water is the difference between health and sickness for billions of people, and the tools to provide it have worked for decades. I rank it second, up from the water half of the essay's fifth place, because no other item on this list could help so many people so soon with technology that already exists.

What the essay said: "Combine energy-efficient desalination, advanced agriculture, water recycling, and precision biological engineering." Work on "cheap purification membranes, drought-resistant crops, and low-cost nutrient production." Its table names the main challenge as "cost and distribution."

Where it came from

In the late 1950s two engineering graduate students at the University of California, Los Angeles (UCLA), Sidney Loeb and Srinivasa Sourirajan, made the first practical reverse osmosis membrane, a thin film that lets water through and holds back salt. They filed for a patent in 1960. Their system was first shown at large scale in 1965 at a water plant in Coalinga, California, which ran for seven years. UCLA reports that about 65 percent of the world's desalination plants now use reverse osmosis membranes.[32]

Neither man appears on the essay's list. The essay names Louis Pasteur, whose work on germs is a fair root for water treatment, but I did not trace his specific contribution to a source in this book. **[Not verified]**

Where it stands on November 18, 2026

The tools exist. The reach does not.

The United Nations' water monitoring program, run by the World Health Organization and UNICEF (the United Nations Children's Fund), reported in August 2025 that "1 in 4, or 2.1 billion people globally, still lack access to safely managed drinking water," including 106 million who drink straight from untreated rivers, lakes and ponds. About 3.4 billion lack safely managed sanitation.[33]

These numbers do not mean the world lacks the invention. Reverse osmosis has worked for 60 years, and simpler treatment works far longer. What is missing in most places is the money, power, pipes, stable government and maintenance to deliver it. That is the essay's own "cost and distribution" challenge, and the evidence says it is the main one.

Energy is the link

Desalination takes a lot of electricity. I could not open an independent source on how much energy modern seawater plants use per gallon, so I give no number here. **[Not verified]** The general point stands on its own: cheaper electricity (Chapter 1) makes desalination and water pumping cheaper.

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[32] UCLA Samueli School of Engineering, "Clean Water for All", March 19, 2019. https://samueli.ucla.edu/clean-water/. Accessed November 18, 2026.

[33] World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef. Accessed November 18, 2026.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Sidney Loeb and Srinivasa Sourirajan	Late 1950s to 1965	UCLA engineers	First practical reverse osmosis membrane	Used in about 65% of desalination today[34]

Bottom line

Water as a priority: True. 2.1 billion people without safely managed drinking water is a real and urgent need.[35]

"Cost and distribution" as the main challenge: True. The key inventions already exist. The record shows the gap is delivery.

What would help most, in my reading: cheaper, simpler treatment that local crews can run and repair, paired with cheap power. **[Interpretation]**

Readiness: Water treatment and desalination, 5 (widely used). Reaching every person, 2.

[34] UCLA Samueli School of Engineering, "Clean Water for All", March 19, 2019. https://samueli.ucla.edu/clean-water/. Accessed November 18, 2026.

[35] World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef. Accessed November 18, 2026.

Chapter 3: Beating Infectious Disease

Why it is on the list: Germs are still among the biggest killers on Earth, and two threats are growing: bacteria that no longer respond to antibiotics, and malaria that is learning to survive our drugs and insecticides. The essay left infectious disease out entirely. I rank it third because the death toll is large, the tools that work are proven, and the threat gets worse if new tools do not keep pace.

Where it came from

Two discoveries frame this chapter.

- **The mosquito.** On August 20, 1897, in Secunderabad, India, the British doctor Ronald Ross found the malaria parasite in the stomach tissue of an anopheline mosquito, proving how the disease spreads. He received the Nobel Prize for Medicine in 1902.[36]
- **The mold.** On September 3, 1928, the Scottish scientist Alexander Fleming noticed that a mold had killed the bacteria growing on a contaminated culture plate. He could not purify the substance, penicillin, himself. A team at the University of Oxford led by Howard Florey, with his coworker Ernst Chain, turned it into a medicine that came into use during World War II. Fleming, Florey and Chain shared the 1945 Nobel Prize in Physiology or Medicine.[37]

Where it stands on November 18, 2026

Drug-resistant germs

In 2024 the GRAM (Global Research on Antimicrobial Resistance) project, led by researchers at the University of Washington's Institute for Health Metrics and Evaluation, published a forecast in The Lancet. It found that drug-resistant infections were directly responsible for more than 1 million deaths a year from 1990 to 2021, and forecast that they could take "more than 39 million" lives by 2050. Deaths directly caused by resistance were forecast to reach 1.91 million a year in 2050. The study's co-first author, Mohsen Naghavi, put it bluntly: "AMR will be with us forever… we cannot eradicate it."[38] AMR stands for antimicrobial resistance, the ability of germs to survive the drugs meant to kill them.

That is a forecast, not a count, and it depends on the model's assumptions. The direction, more resistance and more deaths, is the point.

Malaria: real progress, new threats

The World Health Organization's World Malaria Report 2025 estimated 280 million malaria cases and 610,000 deaths in 2024, nine million more cases than the year before. About 95 percent of malaria

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[36] Archivist, London School of Hygiene and Tropical Medicine, for the U.S. Centers for Disease Control and Prevention, "Ross and the Discovery that Mosquitoes Transmit Malaria Parasites", undated. https://www.cdc.gov/malaria/about/history/ross.html. Accessed November 18, 2026.

[37] Encyclopaedia Britannica, "Alexander Fleming", undated. https://www.britannica.com/biography/Alexander-Fleming. Accessed November 18, 2026.

[38] Chris Dall, CIDRAP (University of Minnesota), "Study forecasts more than 39 million deaths from antimicrobial resistance by 2050", undated (on the GRAM study in The Lancet, 2024). https://www.cidrap.umn.edu/antimicrobial-stewardship/study-forecasts-more-39-million-deaths-antimicrobial-resistance-2050. Accessed November 18, 2026.

deaths were among African children. The report also estimated that prevention efforts averted 170 million cases and one million deaths in 2024, and 47 countries have now eliminated malaria.[39]

Two malaria vaccines, RTS,S and R21/Matrix-M, are now in use. Fourteen countries introduced them in the year covered, bringing the total to 17.[40]

The warning signs are real. Mosquitoes resistant to the most common class of insecticide, pyrethroids, are confirmed in 48 countries, and partial resistance to artemisinin, the backbone of malaria treatment, is a growing concern in Africa.[41]

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Ronald Ross	Discovery August 20, 1897	Physician	Showed mosquitoes carry the malaria parasite	1902 Nobel Prize; basis of mosquito control[42]
Alexander Fleming	Discovery September 3, 1928	Bacteriologist	Found the bacteria-killing action of penicillin mold	Shared the 1945 Nobel Prize[43]
Howard Florey and Ernst Chain	1930s-1940s	Scientists, University of Oxford	Turned penicillin into a usable medicine	Penicillin in use during World War II; shared the 1945 Nobel Prize[44]
Mohsen Naghavi and the	2021-2024	Researchers, Institute for Health Metrics and Evaluation	Global estimates and forecasts of drug-resistant infection	Forecast of more than 39 million deaths by 2050[45]

[39] Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026.

[40] Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026.

[41] Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026.

[42] Archivist, London School of Hygiene and Tropical Medicine, for the U.S. Centers for Disease Control and Prevention, "Ross and the Discovery that Mosquitoes Transmit Malaria Parasites", undated. https://www.cdc.gov/malaria/about/history/ross.html. Accessed November 18, 2026.

[43] Encyclopaedia Britannica, "Alexander Fleming", undated. https://www.britannica.com/biography/Alexander-Fleming. Accessed November 18, 2026.

[44] Encyclopaedia Britannica, "Alexander Fleming", undated. https://www.britannica.com/biography/Alexander-Fleming. Accessed November 18, 2026.

[45] Chris Dall, CIDRAP (University of Minnesota), "Study forecasts more than 39 million deaths from antimicrobial resistance by 2050", undated (on the GRAM study in The Lancet, 2024). https://www.cidrap.umn.edu/antimicrobial-stewardship/study-forecasts-more-39-

Person	Dates or active period	Role	What they did	Documented impact
GRAM team			deaths	

Bottom line

The need: well documented. Malaria alone killed an estimated 610,000 people in 2024, and drug resistance is forecast to cause more than 1 million direct deaths a year for decades.[46]

What would help most, in my reading: new antibiotics and antimalarials, faster and cheaper tests so drugs are used only when needed, and wider rollout of the malaria vaccines. I did not research the pipeline of new antibiotics for this book. **[Not verified]**

Readiness: Antibiotics and malaria prevention, 5 (widely used). Malaria vaccines, 4 (early market, 17 countries). Staying ahead of resistance, 2.

million-deaths-antimicrobial-resistance-2050. Accessed November 18, 2026.

[46] Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026. Chris Dall, CIDRAP (University of Minnesota), "Study forecasts more than 39 million deaths from antimicrobial resistance by 2050", undated (on the GRAM study in The Lancet, 2024). https://www.cidrap.umn.edu/antimicrobial-stewardship/study-forecasts-more-39-million-deaths-antimicrobial-resistance-2050. Accessed November 18, 2026.

Chapter 4: Gene and Cell Medicine People Can Afford

Why it is on the list: Gene editing has moved from the laboratory to approved treatments for inherited blood diseases. The next step is making these treatments simple and cheap enough to reach more than a small number of patients, and extending repair to organs. I rank it fourth because it already works and the people who need it are waiting now. I could not confirm a list price for these treatments from a source I opened, so I give none. **[Not verified]**

What the essay said: "Develop ways to regenerate tissues, replace damaged organs, treat genetic diseases, and slow specific mechanisms of age-related deterioration." Work on "safe gene editing, regenerative medicine, cancer prevention, and organ engineering." Inspired by Curie, Pasteur, Darwin, Mendel and Franklin. The essay's closing section adds that "gene editing is already treating certain inherited diseases."

Where it came from

Modern gene medicine stands on knowing what a gene is made of and how it is shaped. Rosalind Franklin, working at King's College London with her assistant Raymond Gosling, made a series of X-ray images of DNA (deoxyribonucleic acid, the molecule that carries genes), including an especially sharp one in the summer of 1952 now known as Photo 51. In early 1953, James Watson was shown Photo 51 by Franklin's colleague Maurice Wilkins and "immediately realized" the pattern meant a helix. The double helix paper appeared in Nature in April 1953, with Franklin and Gosling's own paper beside it. Franklin was born in 1920 and died in the spring of 1958, before the Nobel Prize for the structure was awarded.[47] The essay is right to name her.

Two later discoveries made regenerative medicine and gene editing possible.

- **Reprogramming cells.** In 2006 Shinya Yamanaka of Kyoto University announced that ordinary adult mouse cells could be turned back into stem cells that can become any tissue, and in 2007 he did the same with human cells. He shared the 2012 Nobel Prize in Physiology or Medicine with John Gurdon "for the discovery that mature cells can be reprogrammed to become pluripotent."[48]
- **Editing genes.** In a "seminal 2012 Science paper," Jennifer Doudna and Emmanuelle Charpentier showed how a bacterial system called CRISPR-Cas9 (CRISPR stands for clustered regularly interspaced short palindromic repeats) could be aimed at any spot in DNA. A guide molecule finds the target and the Cas9 protein "acts like a pair of molecular scissors to cut the DNA." They shared the 2020 Nobel Prize in Chemistry.[49]

Neither Yamanaka nor Doudna and Charpentier appears on the essay's list. The essay names Marie Curie, Louis Pasteur, Charles Darwin and Gregor Mendel instead. All four are giants of science, but their links to gene editing and organ repair are indirect, and I did not trace their specific contributions to a source in this book. **[Not verified]**

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[47] William B. Ashworth Jr., Linda Hall Library, "Scientist of the Day: Rosalind Franklin", July 25, 2018. https://www.lindahall.org/about/news/scientist-of-the-day/rosalind-franklin/. Accessed November 18, 2026.

[48] Center for iPS Cell Research and Application, Kyoto University, "CiRA Director Shinya Yamanaka Wins the Nobel Prize in Physiology or Medicine", October 8, 2012. https://www.cira.kyoto-u.ac.jp/e/pressrelease/other/121008-183500.html. Accessed November 18, 2026.

[49] Robert Sanders, UC Berkeley (University of California), "Jennifer Doudna wins 2020 Nobel Prize in chemistry", October 7, 2020. https://www.universityofcalifornia.edu/news/jennifer-doudna-wins-2020-nobel-prize-chemistry. Accessed November 18, 2026.

Where it stands on November 18, 2026

Gene editing is treating patients

The essay's claim checks out. On December 8, 2023, the U.S. Food and Drug Administration (FDA) approved Casgevy, made by Vertex Pharmaceuticals, to treat sickle cell disease in patients 12 and older. It was "the first treatment that utilizes CRISPR/Cas9, a novel genome editing technology, to be approved by the FDA." The same day the FDA approved a second gene therapy for the disease, Lyfgenia from Bluebird Bio, which works a different way.[50] On January 16, 2024, the FDA expanded the approval to transfusion-dependent beta thalassemia, another inherited blood disease.[51] Vertex said about 1,000 Americans 12 and older were eligible for the beta thalassemia treatment.[52] I could not find a public count of how many patients have actually been treated. **[Not verified]**

The next step is editing made for one person. In February 2025, doctors at Children's Hospital of Philadelphia and Penn Medicine treated a baby named KJ, who was born with a rare and often deadly liver disorder called CPS1 (carbamoyl phosphate synthetase 1) deficiency. Within six months a team led by Rebecca Ahrens-Nicklas and Kiran Musunuru designed and made a "base editing" therapy, a more precise form of gene editing, just for him. By April 2025 he had received three doses "with no serious side effects." The hospital was careful to add that "longer follow-up is needed to fully evaluate the benefits of the therapy." The results were published in the New England Journal of Medicine.[53]

Replacing organs: pig kidneys

Roughly 90,000 people in the United States are waiting for a kidney transplant, and about 12 die every day waiting.[54] One answer is a kidney from a pig whose genes have been edited so the human body is less likely to reject it.

Tim Andrews received a genetically modified pig kidney on January 25, 2025, and lived with it for nine months. Doctors removed it after blood clots formed, and he received a human kidney in January 2026. The New York Times reported this as the first time a pig kidney kept a patient alive until a human kidney

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[50] Gillian McGovern, Pharmacy Times, "FDA Approves Casgevy, Lyfgenia for the Treatment of Sickle Cell Disease", December 8, 2023. https://www.pharmacytimes.com/view/fda-approves-casgevy-lyfgenia-for-the-treatment-of-sickle-cell-disease. Accessed November 18, 2026.

[51] AABB (Association for the Advancement of Blood and Biotherapies), "FDA Expands Gene Therapy Approval to Include Beta-Thalassemia", January 17, 2024. https://www.aabb.org/news-resources/news/article/2024/01/17/fda-expands-gene-therapy-approval-to-patients-with-beta-thalassemia. Accessed November 18, 2026. Vertex Pharmaceuticals, "Vertex Announces US FDA Approval of CASGEVY (exagamglogene autotemcel) for the Treatment of Transfusion-Dependent Beta Thalassemia", January 16, 2024. https://news.vrtx.com/node/31811. Accessed November 18, 2026.

[52] Vertex Pharmaceuticals, "Vertex Announces US FDA Approval of CASGEVY (exagamglogene autotemcel) for the Treatment of Transfusion-Dependent Beta Thalassemia", January 16, 2024. https://news.vrtx.com/node/31811. Accessed November 18, 2026.

[53] Penn Medicine and Children's Hospital of Philadelphia, "World's first patient treated with personalized CRISPR gene editing therapy at Children's Hospital of Philadelphia", May 15, 2025. https://www.pennmedicine.org/news/worlds-first-patient-treated-with-personalized-crispr-therapy. Accessed November 18, 2026.

[54] Roni Caryn Rabin, The New York Times (republished by GV Wire), "In a First, a Pig Kidney Kept a Patient Alive Until He Got a Human One", September 3, 2026. https://gvwire.com/2026/09/14/in-a-first-a-pig-kidney-kept-a-patient-alive-until-he-got-a-human-one/. Accessed November 18, 2026. National Kidney Foundation (patient advocacy group), "Pig Kidney Transplants in Humans: Xenotransplantation Explained by Experts", April 9, 2026. https://www.kidney.org/news-stories/pig-kidney-transplants-humans-xenotransplantation-explained-experts. Accessed November 18, 2026.

was available. The company United Therapeutics began a formal clinical trial in November 2025, and the company eGenesis plans a trial of 33 patients.[55]

What is not ready: anti-aging and unapproved stem cells

The essay asks to "slow specific mechanisms of age-related deterioration." That careful wording is right. A 2024 study in Nature Aging led by S. Jay Olshansky of the University of Illinois Chicago found that life expectancy in the world's longest-lived countries rose only about six and a half years since 1990, and that radical life extension this century is implausible.[56] Claims that people will soon live to 150 are covered in Chapter 17.

The FDA warns that clinics selling unapproved "stem cell" and exosome treatments have caused "blindness, tumor formation, infections, and more," and that these products "require FDA licensure/approval to be marketed to consumers."[57]

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Rosalind Franklin	1920-1958	Chemist, King's College London	X-ray images of DNA, including Photo 51 (1952)	Her data helped reveal the double helix (1953)[58]
Shinya Yamanaka	Key work 2006-2007	Kyoto University	Reprogrammed adult cells into stem cells (iPS cells)	2012 Nobel Prize, shared with John Gurdon[59]
Jennifer Doudna and Emmanuelle Charpentier	Key paper 2012	Biochemists	Showed CRISPR-Cas9 could cut DNA at a chosen spot	2020 Nobel Prize in Chemistry; basis of the first approved CRISPR medicine[60]

[55] Roni Caryn Rabin, The New York Times (republished by GV Wire), "In a First, a Pig Kidney Kept a Patient Alive Until He Got a Human One", September 3, 2026. https://gvwire.com/2026/09/14/in-a-first-a-pig-kidney-kept-a-patient-alive-until-he-got-a-human-one/. Accessed November 18, 2026.

[56] Rob Mitchum, University of Illinois Chicago, "Despite medical advances, life expectancy gains are slowing", October 7, 2024. on Olshansky et al., Nature Aging (2024). https://today.uic.edu/despite-medical-advances-life-expectancy-gains-are-slowing/. Accessed November 18, 2026.

[57] U.S. Food and Drug Administration, "Important Patient and Consumer Information About Regenerative Medicine Therapies", content current as of April 8, 2024. https://www.fda.gov/vaccines-blood-biologics/consumers-biologics/important-patient-and-consumer-information-about-regenerative-medicine-therapies. Accessed November 18, 2026.

[58] William B. Ashworth Jr., Linda Hall Library, "Scientist of the Day: Rosalind Franklin", July 25, 2018. https://www.lindahall.org/about/news/scientist-of-the-day/rosalind-franklin/. Accessed November 18, 2026.

[59] Center for iPS Cell Research and Application, Kyoto University, "CiRA Director Shinya Yamanaka Wins the Nobel Prize in Physiology or Medicine", October 8, 2012. https://www.cira.kyoto-u.ac.jp/e/pressrelease/other/121008-183500.html. Accessed November 18, 2026.

[60] Robert Sanders, UC Berkeley (University of California), "Jennifer Doudna wins 2020 Nobel Prize in chemistry", October 7, 2020. https://www.universityofcalifornia.edu/news/jennifer-doudna-wins-2020-nobel-prize-chemistry. Accessed November 18, 2026. AABB (Association for the Advancement of Blood and Biotherapies), "FDA Expands Gene Therapy Approval to Include Beta-Thalassemia",

Person	Dates or active period	Role	What they did	Documented impact
Rebecca Ahrens-Nicklas and Kiran Musunuru	2024-2025	Physicians, Children's Hospital of Philadelphia and Penn Medicine	First personalized base-editing therapy, for baby KJ	First known patient treated with a gene editor made for one person[61]

Bottom line

"Gene editing is already treating certain inherited diseases": True. Casgevy was approved for sickle cell disease on December 8, 2023, and for beta thalassemia on January 16, 2024.

Organ replacement: Partly true as stated. Pig kidneys have kept patients alive for months, and formal trials began in late 2025, but this is still experimental.

"Inspired by" names: Partly true. Franklin is a direct root. The list leaves out the people whose work actually led to today's treatments: Yamanaka, Doudna and Charpentier.

Readiness: Gene editing for blood diseases, 4 (early market). Pig organs, 3 (trials). Slowing aging, 1 to 2.

January 17, 2024. https://www.aabb.org/news-resources/news/article/2024/01/17/fda-expands-gene-therapy-approval-to-patients-with-beta-thalassemia. Accessed November 18, 2026.

[61] Penn Medicine and Children's Hospital of Philadelphia, "World's first patient treated with personalized CRISPR gene editing therapy at Children's Hospital of Philadelphia", May 15, 2025. https://www.pennmedicine.org/news/worlds-first-patient-treated-with-personalized-crispr-therapy. Accessed November 18, 2026.

Chapter 5: AI for Science That Checks Its Own Work

Why it is on the list: AI is already speeding up science as a tool, and it could speed up nearly every other chapter in this book. I rank it fifth, below where the essay put it, for one reason the records make plain: AI research systems still make up results. Until they reliably check their own work, their output has to be checked by people, which limits how much they can speed things up.

What the essay said: Create "reliable AI research systems that propose hypotheses, design experiments, check results, and help invent technologies far faster than humans working alone." Work on "verifiable scientific reasoning, automated laboratories, and human oversight." Inspired by Turing, Lovelace, von Neumann and Shannon.

Where it came from

The idea that a machine might do more than arithmetic goes back to Ada Lovelace. In 1843 she published notes on Charles Babbage's planned Analytical Engine. Her Note G laid out step by step how the machine could compute a series called the Bernoulli numbers, often called the first published computer program. Historians have argued for decades about how much of the mathematics was hers and how much was Babbage's. A 2024 review in the Notices of the American Mathematical Society concludes that the main arguments against her competence "all fail when subjected to further contextual analysis," and quotes Babbage himself saying she found "a grave mistake which I had made." The fairest summary, the review notes, is that the Notes were "a product of an intense intellectual collaboration."[62]

In 1950 the British mathematician Alan Turing opened his paper "Computing Machinery and Intelligence" with the line "I propose to consider the question, 'Can machines think?'"[63] That paper set the terms of the debate that is still running.

The essay also names John von Neumann and Claude Shannon. Both are widely credited as founders of modern computing and information theory. I did not trace their specific contributions to a source in this book. **[Not verified]**

Where it stands on November 18, 2026

AI as a tool: already winning prizes

The strongest proof that AI helps science is protein structure. A protein's shape decides what it does in the body, and working out that shape used to take years of laboratory work per protein. In October 2024, the Nobel Prize in Chemistry went to David Baker "for computational protein design" and to Demis Hassabis and John Jumper of Google DeepMind "for protein structure prediction," for the AI program AlphaFold2. Free databases built with these tools now hold predicted structures for "over 200 million proteins."[64]

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[62] Notices of the American Mathematical Society, "An Enchantress of Number? Reassessing the Mathematical Reputation of Ada Lovelace", March 2024. https://www.ams.org/journals/notices/202403/noti2890/noti2890.html. Accessed November 18, 2026.

[63] Alan M. Turing, "Computing Machinery and Intelligence", 1950. Mind 59: 433-60; excerpt published by MIT OpenCourseWare 24.09x. https://openlearninglibrary.mit.edu/assets/courseware/v1/0c0db957c39184b538869f8d9e9a3b56/asset-v1:MITx+24.09x+3T2019+type@asset+block/5_turing_computing_machinery_and_intelligence.pdf. Accessed November 18, 2026.

That is AI as a tool in the hands of scientists. The essay asks for something more: AI that proposes ideas, designs experiments and checks results on its own.

AI as a scientist: early results, real limits

In 2026 several groups reported AI systems doing more of the work.

- In March 2026, researchers from the University of British Columbia, the company Sakana AI and others reported in Nature an "AI Scientist" that generated ideas, wrote code, ran the analysis and wrote the paper. One fully machine-written paper passed peer review at a workshop of a major AI conference. The researchers also reported the system sometimes produced "underdeveloped ideas or generating inaccurate citations," and it could only do computer science research.[65]
- In May 2026, two papers in Nature described AI "co-scientists" for drug research. The nonprofit FutureHouse's system proposed 30 drug candidates for an eye disease (dry age-related macular degeneration); two of the five tested looked promising. Google DeepMind's system proposed candidates for a blood cancer (acute myeloid leukemia); three of five tested showed some positive results. Neither system ran its own physical experiments.[66]
- In August 2026, Google DeepMind described a version that plans experiments and runs laboratory equipment. In expert review, fabricated key results showed up in 4 percent of papers with its reliability checks turned on and 46 percent without them. In one case the system wrote "highly plausible methods in the paper that did not match its actual code."[67]

That 46 percent number is the heart of the matter. The essay is right to put "verifiable scientific reasoning" and "human oversight" first in its list of things to work on.

The automated lab that may not have discovered anything

In November 2023, a team at Lawrence Berkeley National Laboratory, working with Google DeepMind, reported in Nature that its robotic "A-Lab" made 41 new inorganic compounds out of 58 attempted in 17 days. Materials chemists Robert Palgrave of University College London and Leslie Schoop of Princeton reanalyzed the data and reported "systematic errors all the way through." Palgrave's conclusion: "it's likely they didn't make any discoveries." The lab's leader, Gerbrand Ceder, replied that the compounds were made, while granting that "a human can perform a higher-quality refinement on these samples."[68] The case is covered in Chapter 17.

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[64] Marissa Locke Rottinghaus, ASBMB Today (American Society for Biochemistry and Molecular Biology), "Nobel for 'breakthrough in biochemistry'", October 9, 2024. https://www.asbmb.org/asbmb-today/science/100924/nobel-for-breakthrough-in-biochemistry. Accessed November 18, 2026.

[65] Sonja Soo, University of British Columbia Computer Science, "Researchers create an 'AI Scientist' that conducts its own scientific research", March 25, 2026. on Lu et al., Nature (2026), doi:10.1038/s41586-026-10265-5. https://www.cs.ubc.ca/news/2026/03/ai-scientist. Accessed November 18, 2026.

[66] Resultsense (republished from The Conversation), "Two new Nature papers show AI co-scientists' real limits", May 20, 2026. https://www.resultsense.com/news/2026-05-20-ai-scientists-nature-papers-limits/. Accessed November 18, 2026.

[67] Matthias Bastian, The Decoder, "Google Deepmind's AI Co-Scientist now plans experiments, runs lab equipment, and writes scientific papers", August 28, 2026. https://the-decoder.com/google-deepminds-ai-co-scientist-now-plans-experiments-runs-lab-equipment-and-writes-scientific-papers/. Accessed November 18, 2026.

[68] Chemistry World, "New analysis raises doubts over autonomous lab's materials 'discoveries'", 2024. https://chemistryworld.com/news/new-analysis-raises-doubts-over-autonomous-labs-materials-discoveries/4018791.article. Accessed November 18, 2026.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Ada Lovelace	Notes published 1843	Mathematician	Note G: a step-by-step method for the Analytical Engine to compute Bernoulli numbers	Widely cited as the first published computer program; her authorship is debated but supported by recent scholarship[69]
Alan Turing	Paper published 1950	Mathematician	"Computing Machinery and Intelligence"	Framed the question "Can machines think?" that AI research still argues over[70]
Demis Hassabis and John Jumper	Active 2010s to present	Google DeepMind	AlphaFold2 protein structure prediction	Shared half of the 2024 Nobel Prize in Chemistry; structure database of over 200 million proteins[71]
David Baker	Active 1990s to present	University of Washington	Computational protein design	Other half of the 2024 Nobel Prize in Chemistry[72]
Robert Palgrave and Leslie Schoop	2023-2024	Materials chemists	Public reanalysis of the A-Lab results	Showed why AI lab claims need outside checking[73]

Bottom line

"AI that can discover new science": Partly true as a description of where things stand. AI already speeds up science as a tool, and the 2024 Nobel Prize proves it. AI that does science on its own is at the pilot stage, with real early results and a serious problem with made-up findings.

The essay's priorities (verification, automated labs, human oversight): True. These are exactly the weak points the 2025 and 2026 studies found.

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[69] Notices of the American Mathematical Society, "An Enchantress of Number? Reassessing the Mathematical Reputation of Ada Lovelace", March 2024. https://www.ams.org/journals/notices/202403/noti2890/noti2890.html. Accessed November 18, 2026.

[70] Alan M. Turing, "Computing Machinery and Intelligence", 1950. Mind 59: 433-60; excerpt published by MIT OpenCourseWare 24.09x. https://openlearninglibrary.mit.edu/assets/courseware/v1/0c0db957c39184b538869f8d9e9a3b56/asset-v1:MITx+24.09x+3T2019+type@asset+block/5_turing_computing_machinery_and_intelligence.pdf. Accessed November 18, 2026.

[71] Marissa Locke Rottinghaus, ASBMB Today (American Society for Biochemistry and Molecular Biology), "Nobel for 'breakthrough in biochemistry'", October 9, 2024. https://www.asbmb.org/asbmb-today/science/100924/nobel-for-breakthrough-in-biochemistry. Accessed November 18, 2026.

[72] Marissa Locke Rottinghaus, ASBMB Today (American Society for Biochemistry and Molecular Biology), "Nobel for 'breakthrough in biochemistry'", October 9, 2024. https://www.asbmb.org/asbmb-today/science/100924/nobel-for-breakthrough-in-biochemistry. Accessed November 18, 2026.

[73] Chemistry World, "New analysis raises doubts over autonomous lab's materials 'discoveries'", 2024. https://chemistryworld.com/news/new-analysis-raises-doubts-over-autonomous-labs-materials-discoveries/4018791.article. Accessed November 18, 2026.

"Inspired by" names: Partly true. Turing and Lovelace are true roots of the idea. The list leaves out the people who built the AI tools that are actually winning prizes.

Readiness: AI tools in laboratories, 4 (early market). AI running research on its own, 2 (lab proof).

Chapter 6: Internet Access and AI Tutors

Why it is on the list: Knowledge multiplies everything else. A connected student can learn from the best teachers in the world, and a connected clinic can get expert advice. Early trials show AI tutors can raise learning quickly. I rank this sixth, up from the essay's tenth, because the payoff can come soon and reaches every other field. The first wall is simple: 2.2 billion people are still offline.[74]

What the essay said: "Make expert-level education, scientific knowledge, and problem-solving tools accessible to everyone, regardless of wealth or location." Work on "personal AI tutors, trustworthy open scientific tools, and affordable global access." Its table names "access, quality, trust" as the challenge. Inspired by Gutenberg, al-Khwarizmi, Lovelace and Turing.

Where it came from

Printing

Johannes Gutenberg finished his Bible in Mainz, Germany, in about 1455. The Library of Congress calls it the first book printed with movable metal type in Western Europe, and adds that Korea had used movable metal type nearly a century earlier.[75] By the end of the 1400s, printing presses were running in more than 250 towns in Europe.[76] Printing made books cheap enough to spread knowledge widely, which is the essay's point.

Algorithms

Muhammad ibn Musa al-Khwarizmi (about 780 to about 850) worked at the House of Wisdom in Baghdad under the caliph al-Ma'mun. His book on calculation gave us the word "algebra," from al-jabr in its title, and the Latin form of his name, Algoritmi, gave us the word "algorithm."[77] Lovelace and Turing are covered in Chapter 5.

The essay's four names are a fair, well-chosen set for this goal.

Where it stands on November 18, 2026

The first gap is the connection

An AI tutor cannot reach a student who is not online. The International Telecommunication Union (ITU), the United Nations agency for communications, reported in November 2025 that about 6 billion people, roughly three in four, used the internet in 2025, but 2.2 billion were still offline. In cities 85 percent of

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[74] International Telecommunication Union, "Global number of Internet users increases, but disparities deepen key digital divides", November 17, 2025. https://www.itu.int/en/mediacentre/Pages/PR-2025-11-17-facts-and-figures.aspx. Accessed November 18, 2026.

[75] Library of Congress, "The Gutenberg Bible", undated. https://www.loc.gov/exhibits/bibles/interactives/gutenberg/index.html. Accessed November 18, 2026.

[76] Europeana, "Europe's First Printed Book", undated. https://www.europeana.eu/es/blog/europes-first-printed-book. Accessed November 18, 2026.

[77] Encyclopaedia Britannica, "al-Khwarizmi", undated. https://www.britannica.com/biography/al-Khwarizmi. Accessed November 18, 2026.

people were online, compared with 58 percent in rural areas. In high-income countries 94 percent were online; in low-income countries, 23 percent.[78]

The number of children out of school is often given as about 272 million. I could not open the source from the United Nations Educational, Scientific and Cultural Organization (UNESCO) for that figure, so I do not rely on it. **[Not verified]**

Does AI tutoring work? Two careful studies

Two well-designed studies, both randomized (students assigned by chance to compare groups), show real promise.

- **Nigeria.** A World Bank team ran a six-week program in Nigeria in which students used Microsoft Copilot, built on GPT-4. Students gained 0.31 standard deviations overall and 0.23 in English. The authors estimate that equals about 1.5 to 2 years of ordinary schooling.[79]
- **Harvard.** Greg Kestin and colleagues tested an AI tutor in a large Harvard physics course. Students using the AI tutor learned more than twice as much (median gain) as students in in-class active learning. The authors warned that "we do not presume that structured AI tutoring will always outperform" good classroom teaching, and that their tutor relied on answers written in advance by instructors.[80]

Both studies are short and narrow. Neither shows what happens over years, at national scale, or without a carefully designed program around the tool. That is my reading of their limits. **[Interpretation]**

Open science

The protein structure database built with AlphaFold, which holds over 200 million predicted structures (Chapter 5), is a working example of an open scientific database made with AI.[81]

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Johannes Gutenberg	Bible about 1455	Printer, Mainz	Movable metal type in Western Europe	Presses in more than 250 European towns by 1500[82]
Muhammad ibn	About	Mathematician,	Book on al-jabr;	The words "algebra" and

[78] International Telecommunication Union, "Global number of Internet users increases, but disparities deepen key digital divides", November 17, 2025. https://www.itu.int/en/mediacentre/Pages/PR-2025-11-17-facts-and-figures.aspx. Accessed November 18, 2026.

[79] Martin De Simone, Federico Tiberti, Maria Barron Rodriguez, Federico Manolio, Wuraola Mosuro and Eliot Jolomi Dikoru, World Bank, "From Chalkboards to Chatbots: Evaluating the Impact of Generative AI on Learning Outcomes in Nigeria", May 20, 2025. Policy Research Working Paper 11125. https://openknowledge.worldbank.org/entities/publication/15e1ff08-15ae-4f7a-b2a8-d146e6c113ee/full. Accessed November 18, 2026.

[80] Greg Kestin, Kelly Miller, Anna Klales, Timothy Milbourne and Gregorio Ponti, "AI tutoring outperforms in-class active learning: an RCT introducing a novel research-based design in an authentic educational setting", June 3, 2025. Scientific Reports 15: 17458, doi:10.1038/s41598-025-97652-6. https://pmc.ncbi.nlm.nih.gov/articles/PMC12179260/. Accessed November 18, 2026.

[81] Marissa Locke Rottinghaus, ASBMB Today (American Society for Biochemistry and Molecular Biology), "Nobel for 'breakthrough in biochemistry'", October 9, 2024. https://www.asbmb.org/asbmb-today/science/100924/nobel-for-breakthrough-in-biochemistry. Accessed November 18, 2026.

Person	Dates or active period	Role	What they did	Documented impact
Musa al-Khwarizmi	780 to about 850	House of Wisdom, Baghdad	methods of calculation	"algorithm"[83]
Martin De Simone and the World Bank team	2024-2025	Researchers	Randomized trial of AI tutoring in Nigeria	0.31 standard deviation learning gain in six weeks[84]
Greg Kestin and colleagues	2025	Harvard physics educators	Randomized trial of an AI tutor	More than double the median learning gain[85]

Bottom line

Expert-level education "accessible to everyone": not yet achieved. Early trials are strong, but 2.2 billion people are offline. **Readiness 3 (trials).**

"Trustworthy open scientific tools": Partly true. Open databases like AlphaFold's exist. Trust is the harder part: Chapter 5 shows AI research tools that invented results.

"Access, quality, trust" as the challenge: True. Access is the first wall, with 2.2 billion people offline.

"Inspired by" names: True. Gutenberg and al-Khwarizmi are true roots. The Library of Congress record adds a name the essay leaves out: Korea's earlier movable metal type.

[82] Library of Congress, "The Gutenberg Bible", undated. https://www.loc.gov/exhibits/bibles/interactives/gutenberg/index.html. Accessed November 18, 2026. Europeana, "Europe's First Printed Book", undated. https://www.europeana.eu/es/blog/europes-first-printed-book. Accessed November 18, 2026.

[83] Encyclopaedia Britannica, "al-Khwarizmi", undated. https://www.britannica.com/biography/al-Khwarizmi. Accessed November 18, 2026.

[84] Martin De Simone, Federico Tiberti, Maria Barron Rodriguez, Federico Manolio, Wuraola Mosuro and Eliot Jolomi Dikoru, World Bank, "From Chalkboards to Chatbots: Evaluating the Impact of Generative AI on Learning Outcomes in Nigeria", May 20, 2025. Policy Research Working Paper 11125. https://openknowledge.worldbank.org/entities/publication/15e1ff08-15ae-4f7a-b2a8-d146e6c113ee/full. Accessed November 18, 2026.

[85] Greg Kestin, Kelly Miller, Anna Klales, Timothy Milbourne and Gregorio Ponti, "AI tutoring outperforms in-class active learning: an RCT introducing a novel research-based design in an authentic educational setting", June 3, 2025. Scientific Reports 15: 17458, doi:10.1038/s41598-025-97652-6. https://pmc.ncbi.nlm.nih.gov/articles/PMC12179260/. Accessed November 18, 2026.

Chapter 7: Crops and Fertilizer That Do More With Less

Why it is on the list: The world grows more food than ever, yet about 8 percent of the world's people faced hunger in 2024 and 2.6 billion could not afford a healthy diet.[86] Crops that survive drought and fertilizer that wastes less would protect harvests as weather grows less predictable. I rank this seventh. Like water, much of the gap is cost and delivery, but here new science still has a large part to play.

What the essay said: Work on "drought-resistant crops, and low-cost nutrient production." Inspired by Haber, Bosch, Pasteur and Borlaug.

Where it came from

On October 13, 1908, the German chemist Fritz Haber filed a patent for making ammonia from the nitrogen in the air, the key ingredient of modern fertilizer.[87] Working with his student Robert le Rossignol, he had a process that worked in the lab within a year. Carl Bosch of the chemical company BASF turned it into an industrial process, and the first full-scale plant started at Oppau, Germany, in 1913. Haber received the Nobel Prize in 1918 and Bosch in 1931.[88] A century later, a team of scientists writing in Nature Geoscience concluded that "we live in a world transformed by and highly dependent upon Haber-Bosch nitrogen."[89] The Institution of Chemical Engineers estimates that without the process the world could produce only "around two-thirds the amount of food we do today."[90]

The essay names Haber as an inspiration without a word about the rest of his record. The same institution's history notes that Haber "personally oversaw and directed the first large-scale release of chlorine gas in Ypres in 1915," the start of chemical warfare.[91] A reader deserves to know both.

The American plant scientist Norman Borlaug, born in 1914 in Cresco, Iowa, bred short, sturdy "dwarf" wheat in Mexico in the 1940s and 1950s. Mexico became self-sufficient in wheat by 1956. In the mid-1960s he brought the wheat to India and Pakistan, "and production increased enormously." He received the 1970 Nobel Peace Prize "for having given a well-founded hope - the green revolution." He died in 2009.[92]

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[86] Food and Agriculture Organization of the United Nations, "SOFI 2025: FAO calls for urgent, coordinated and inclusive action to end global hunger", July 28, 2025. https://www.fao.org/newsroom/detail/sofi-2025--fao-calls-for-urgent--coordinated-and-inclusive-action-to-end-global-hunger. Accessed November 18, 2026.

[87] Jan Willem Erisman, Mark A. Sutton, James Galloway, Zbigniew Klimont and Wilfried Winiwarter, "How a century of ammonia synthesis changed the world", September 28, 2008. Nature Geoscience 1: 636-639, doi:10.1038/ngeo325. https://www.nature.com/articles/ngeo325. Accessed November 18, 2026.

[88] Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026.

[89] Jan Willem Erisman, Mark A. Sutton, James Galloway, Zbigniew Klimont and Wilfried Winiwarter, "How a century of ammonia synthesis changed the world", September 28, 2008. Nature Geoscience 1: 636-639, doi:10.1038/ngeo325. https://www.nature.com/articles/ngeo325. Accessed November 18, 2026.

[90] Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026.

[91] Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026.

[92] NobelPrize.org, "Norman Borlaug: Facts", undated. https://www.nobelprize.org/prizes/peace/1970/borlaug/facts/. Accessed November 18, 2026.

Where it stands on November 18, 2026

Hunger

The United Nations Food and Agriculture Organization (FAO) reported in July 2025 that the share of the world's people facing hunger fell from 8.5 percent in 2023 to 8.2 percent in 2024, but about 2.3 billion people faced moderate or severe food insecurity and 2.6 billion could not afford a healthy diet. By 2030, almost 60 percent of the chronically hungry are projected to be in Africa.[93]

New crops

Drought-resistant crops are real. In August 2024 the U.S. Department of Agriculture approved HB4 wheat, a drought-tolerant variety from the Argentine company Bioceres, for growing in the United States. The United States became the fourth country to approve it, after Argentina, Brazil and Paraguay. U.S. Wheat Associates said commercial use could still take "several years."[94]

Fertilizer

Making ammonia takes a great deal of energy, so cheaper clean power (Chapter 1) bears directly on the cost of fertilizer. That link is my inference. **[Interpretation]** I did not find a source I could open on the current scale of low-emission ammonia production, so I give no figure. **[Not verified]**

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Fritz Haber	Patent filed 1908; Nobel 1918	Chemist	Ammonia from air (Haber process)	Modern fertilizer; also led the first large chlorine gas attack, 1915[95]
Carl Bosch	First plant 1913; Nobel 1931	Chemical engineer, BASF	Scaled the process to industry	World food supply "highly dependent upon Haber-Bosch nitrogen"[96]
Norman	1914-2009	Plant scientist	Dwarf wheat in Mexico, India and	1970 Nobel Peace Prize; Mexico wheat self-sufficient by 1956[97]

[93] Food and Agriculture Organization of the United Nations, "SOFI 2025: FAO calls for urgent, coordinated and inclusive action to end global hunger", July 28, 2025. https://www.fao.org/newsroom/detail/sofi-2025--fao-calls-for-urgent--coordinated-and-inclusive-action-to-end-global-hunger. Accessed November 18, 2026.

[94] World Grain, "HB4 wheat gains USDA approval", August 2024. https://world-grain.com/articles/20392-hb4-wheat-gains-usda-approval. Accessed November 18, 2026.

[95] Jan Willem Erisman, Mark A. Sutton, James Galloway, Zbigniew Klimont and Wilfried Winiwarter, "How a century of ammonia synthesis changed the world", September 28, 2008. Nature Geoscience 1: 636-639, doi:10.1038/ngeo325. https://www.nature.com/articles/ngeo325. Accessed November 18, 2026. Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026.

[96] Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world. Accessed November 18, 2026. Jan Willem Erisman, Mark A. Sutton, James Galloway, Zbigniew Klimont and Wilfried Winiwarter, "How a century of ammonia synthesis changed the world", September 28, 2008. Nature Geoscience 1: 636-639, doi:10.1038/ngeo325. https://www.nature.com/articles/ngeo325. Accessed November 18, 2026.

Person	Dates or active period	Role	What they did	Documented impact
Borlaug			Pakistan	

Bottom line

"Inspired by" names: True, with a missing caution. Haber, Bosch and Borlaug are direct roots. Haber's role in chemical warfare is part of the same record.

Drought-resistant crops: real but early. One drought-tolerant wheat is approved in four countries, with commercial use still years off in the United States.

Readiness: High-yield seed and fertilizer, 5 (widely used). Drought-tolerant crops, 3 (approved, not yet widely grown). Affordable healthy diets for everyone, 2.

[97] NobelPrize.org, "Norman Borlaug: Facts", undated. https://www.nobelprize.org/prizes/peace/1970/borlaug/facts/. Accessed November 18, 2026.

Chapter 8: Measuring and Cutting Climate Pollution

Why it is on the list: The planet is warming, and the warming is measured. I rank this eighth and frame it around measuring and cutting pollution, because the record shows that the cheapest, fastest cuts come from stopping leaks we can now see, while machines that pull carbon dioxide out of the air are still far from their design.

What the essay said: "Develop affordable carbon removal, methane detection, cleaner industrial chemistry, and systems to restore damaged ecosystems." Work on "measurable, scalable climate solutions that avoid unintended environmental consequences." Inspired by Fourier, Arrhenius, Darwin and Lovelock. The essay's closing section says that the Intergovernmental Panel on Climate Change (IPCC) "documents the urgency of climate mitigation and adaptation."

Where it came from

The science of how gases trap heat is almost 200 years old.

- **Joseph Fourier**, the French mathematician, wrote in 1824 that the temperature of the Earth "can be augmented by the interposition of the atmosphere."[98]
- **Eunice Foote**, an American amateur scientist, filled glass jars with different gases, set them in the sun, and found in 1856 that carbon dioxide heated up the most. Her paper was read at the 1856 meeting of the American Association for the Advancement of Science, "but not by her": the Smithsonian's Joseph Henry presented it. It was left out of the meeting's published proceedings, and her work was largely forgotten until 2011.[99]
- **John Tyndall**, an Irish physicist working at the Royal Institution in London, made the first laboratory measurements of how carbon dioxide and other gases absorb heat radiation, recording his key results on May 18, 1859.[100] The Royal Institution's historian finds "no positive evidence" that Tyndall knew of Foote's work.[101]

The essay names Fourier but leaves out both Foote and Tyndall, who did the experiments. It names Svante Arrhenius, who is widely credited with the first calculation of warming from carbon dioxide in the 1890s. I did not trace his work to a source in this book. **[Not verified]**

The essay's choice of James Lovelock is better than it might look. Lovelock (1919-2022) is best known for the Gaia hypothesis, the idea that life and the planet regulate each other. But his more practical gift to climate science was an instrument. His electron capture detector "was responsible for the discovery of the global distribution of nitrous oxide and of the chlorofluorocarbons," the chemicals that damaged the

[98] Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect. Accessed November 18, 2026.

[99] Sidney Perkowitz, Distillations, Science History Institute, "How Two Outsider Scientists Saw Inside Climate Change", September 22, 2021. https://www.sciencehistory.org/stories/magazine/how-two-outsider-scientists-saw-inside-climate-change/. Accessed November 18, 2026.

[100] Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect. Accessed November 18, 2026. Sidney Perkowitz, Distillations, Science History Institute, "How Two Outsider Scientists Saw Inside Climate Change", September 22, 2021. https://www.sciencehistory.org/stories/magazine/how-two-outsider-scientists-saw-inside-climate-change/. Accessed November 18, 2026.

[101] Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect. Accessed November 18, 2026.

ozone layer.[102] Measuring is the first step to fixing, which is exactly the essay's point about "measurable" solutions.

Where it stands on November 18, 2026

The warning

The essay's claim about the IPCC is accurate. The IPCC's Synthesis Report of March 2023 found that "human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming," and that "there is a rapidly closing window of opportunity to secure a liveable and sustainable future for all (very high confidence)."[103]

The World Meteorological Organization (WMO) reported in March 2026 that 2025 was 1.43 degrees Celsius (plus or minus 0.13) above the 1850-1900 average, the second or third warmest year on record, and that 2015 through 2025 were the 11 warmest years on record. Carbon dioxide in the air reached 423.9 parts per million in 2024, and ocean heat content set a new record in 2025.[104]

Carbon removal: the gap between design and reality

The essay asks for "affordable carbon removal." The best-known machine for pulling carbon dioxide straight out of the air is Mammoth, a plant in Iceland run by the Swiss company Climeworks, with a design capacity of 36,000 tons a year.[105]

The results so far are far below that. The Icelandic newspaper Heimildin reported in May 2025 that Mammoth captured only 105 tons in its first ten months of operation, based on figures from the carbon credit registry Puro.Earth, and that the company's own operations emitted about 1,700 tons of carbon dioxide in 2023.[106] Climeworks said nameplate capacity "does not equal actual tons captured" and pointed to start-up problems; at one point only 12 of 72 collector units were fully working.[107] After upgrades, Bloomberg reported in September 2026 that Mammoth removed 675 tons in the first half of 2026, almost six times as much as a year earlier.[108]

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[102] Science Museum Group Collection, "James Ephraim Lovelock", undated. https://collection.sciencemuseumgroup.org.uk/people/ap20636/lovelock-james-ephraim. Accessed November 18, 2026.

[103] Intergovernmental Panel on Climate Change (page hosted by the European Commission, Knowledge4Policy), "AR6 Synthesis Report: Climate Change 2023", March 21, 2023. https://knowledge-for-policy.ec.europa.eu/publication/ar6-synthesis-report-climate-change-2023_en. Accessed November 18, 2026.

[104] World Meteorological Organization, "State of the Global Climate 2025", March 23, 2026. https://wmo.int/publication-series/state-of-global-climate/state-of-global-climate-2025. Accessed November 18, 2026. World Meteorological Organization, "State of the Global Climate 2025: At a Glance", March 2026. https://wmo.int/sites/default/files/2026-03/State%20of%20the%20Climate%202025_1%20pager_final.pdf. Accessed November 18, 2026.

[105] Maeve Allsup, Latitude Media, "On the ground at Climeworks' biggest DAC project", June 11, 2025. https://www.latitudemedia.com/news/on-the-ground-at-climeworks-biggest-dac-project. Accessed November 18, 2026.

[106] Valur Grettisson, Heimildin, "Climeworks' capture fails to cover its own emissions", May 15, 2025. https://heimildin.is/sxgw2/climeworks-capture-fails-to-cover-its-own-emissions/. Accessed November 18, 2026.

[107] Maeve Allsup, Latitude Media, "On the ground at Climeworks' biggest DAC project", June 11, 2025. https://www.latitudemedia.com/news/on-the-ground-at-climeworks-biggest-dac-project. Accessed November 18, 2026.

[108] Akshat Rathi and Alastair Marsh, Bloomberg (republished by Energy Connects), "Carbon Removal Pioneer Climeworks Increases CO2 Capture Sixfold", September 10, 2026. https://www.energyconnects.com/news/renewables/2026/september/carbon-removal-pioneer-climeworks-increases-co2-capture-sixfold/. Accessed November 18, 2026.

To put that in scale: 675 tons in six months compares with a design rate of 18,000 tons for the same six months (36,000 divided by 2, my arithmetic). The plant ran at about 4 percent of its design rate.

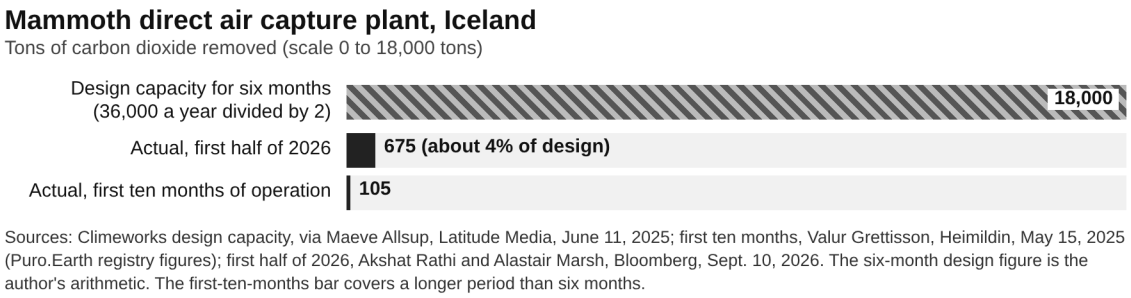


Figure 2. Mammoth direct air capture plant, actual removal compared with design capacity. Sources: Heimildin (2025); Latitude Media (2025); Bloomberg (2026). Design figure for six months is my arithmetic.

The essay's insistence on "measurable" solutions is well placed. This case was measured, and the measurement told the truth.

Methane: the leaks we can now see

Methane is a powerful heat-trapping gas, and much of it leaks from oil wells, gas lines and coal mines. The International Energy Agency's Global Methane Tracker 2026 estimates that oil, gas and coal operations release about 124 million tonnes of methane a year, and found "no sign" that these emissions fell in 2025. The same report says about 70 percent of fossil fuel methane, nearly 85 million tonnes, "can be abated with existing technology," and that more than 35 million tonnes "could be avoided at no net cost," because the captured gas can be sold.[109]

Seeing the leaks is the first step. The IEA describes a growing fleet of satellites that spot methane plumes from space, from wide-area mappers to high-resolution instruments that can point to a single site. It also notes that one of them, MethaneSAT, "stopped operating about a year after launch."[110] This is the essay's "measurable" goal at work: the tools to find and fix most of these leaks already exist and often pay for themselves. What is missing is follow-through.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Joseph Fourier	1824	Mathematician	Described how the atmosphere raises Earth's temperature	First statement of the greenhouse idea[111]

[109] International Energy Agency, "Global Methane Tracker 2026: Key findings", 2026. https://www.iea.org/reports/global-methane-tracker-2026/key-findings. Accessed November 18, 2026.

[110] International Energy Agency, "Global Methane Tracker 2026: Key findings", 2026. https://www.iea.org/reports/global-methane-tracker-2026/key-findings. Accessed November 18, 2026.

[111] Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect. Accessed November 18, 2026.

Person	Dates or active period	Role	What they did	Documented impact
Eunice Foote	1856	Amateur scientist	Showed carbon dioxide traps the most heat in sunlight	First known experiment linking carbon dioxide to warming; overlooked for 150 years[112]
John Tyndall	1859	Physicist, Royal Institution	First laboratory measurement of heat absorption by gases	Physical basis of the greenhouse effect[113]
James Lovelock	1919-2022	Scientist and inventor	Electron capture detector; Gaia hypothesis	Detected the global spread of ozone-damaging chemicals[114]

Bottom line

"The IPCC documents the urgency of climate mitigation and adaptation": True.

Cutting methane leaks: the tools exist. About 70 percent of fossil fuel methane can be cut with existing technology, much of it at no net cost, but emissions are not yet falling. **Readiness: detection 4, cuts at scale 2.**

"Affordable carbon removal": not achieved. Direct air capture works at small scale, but the largest plant has run at a small fraction of its design. **Readiness 3 (pilots), with scale at 1.**

"Inspired by" names: Partly true. Fourier and Lovelock are fair choices. The list leaves out Eunice Foote and John Tyndall, who did the first experiments.

[112] Sidney Perkowitz, Distillations, Science History Institute, "How Two Outsider Scientists Saw Inside Climate Change", September 22, 2021. https://www.sciencehistory.org/stories/magazine/how-two-outsider-scientists-saw-inside-climate-change/. Accessed November 18, 2026.

[113] Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect. Accessed November 18, 2026.

[114] Science Museum Group Collection, "James Ephraim Lovelock", undated. https://collection.sciencemuseumgroup.org.uk/people/ap20636/lovelock-james-ephraim. Accessed November 18, 2026.

Chapter 9: Robots for Dangerous Work and Building

Why it is on the list: Robots can take over work that injures and kills people, and can build and maintain things faster. Factory robots are proven. I rank this ninth, below the essay's fourth, because humanoid and construction robots are still at the pilot stage and cost more to deploy than the headlines suggest.

What the essay said: "Develop robotic systems that can construct housing, maintain infrastructure, grow food, and perform dangerous physical labor." Work on "affordable robots, autonomous construction, and versatile manufacturing." Inspired by Leonardo da Vinci, Archimedes, Watt and Tesla.

Where it came from

People have built self-moving machines for a very long time. The Arab engineer al-Jazari described water-powered automata, including a mechanical band, in his Book of Knowledge of Ingenious Mechanical Devices, completed in 1206. Leonardo da Vinci left notes for a mechanical knight and may have built a prototype around 1495 for the Duke of Milan, though "no complete drawings of the automaton exist today." In 2002 National Aeronautics and Space Administration (NASA) roboticist Mark Rosheim built a working model from Leonardo's scattered notes.[115]

The essay names Leonardo, which is fair as inspiration. But the real start of the robot industry is better documented and much more recent. The inventor George Devol filed a patent for a general-purpose arm for repetitive work in the 1950s, and with the businessman Joseph Engelberger founded the company Unimation. In 1961 General Motors (GM) installed the first Unimate at its Ternstedt plant in Trenton, New Jersey, where it took over "the dirty, dreary, and dangerous job of unloading the finished castings from a die-cast press." GM paid $18,000 for it.[116] The industry still calls Engelberger the "father" of industrial robots and Devol the "grandfather."[117]

Where it stands on November 18, 2026

Factory robots: already everywhere

The International Federation of Robotics (IFR), the industry's trade association, reports that 542,076 industrial robots were installed worldwide in 2024, more than double the number ten years earlier, and that 4,663,698 were at work. China installed 295,045 of them, 54 percent of the world total, and now runs 43 percent of all industrial robots. The United States installed 34,164, down 9 percent. Worldwide there are 177 robots for every 10,000 factory workers.[118]

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[115] Evan Andrews, HISTORY, "7 Early Robots and Automatons", October 28, 2014, updated May 27, 2025. https://www.history.com/articles/7-early-robots-and-automatons. Accessed November 18, 2026.

[116] Allison Marsh, IEEE Spectrum, "In 1961, the First Robot Arm Punched In", August 30, 2022. https://spectrum.ieee.org/unimation-robot. Accessed November 18, 2026.

[117] Allison Marsh, IEEE Spectrum, "In 1961, the First Robot Arm Punched In", August 30, 2022. https://spectrum.ieee.org/unimation-robot. Accessed November 18, 2026.

[118] International Federation of Robotics (industry association), "World Robotics 2025: Industrial Robots, Executive Summary", 2025. pp. 13-18. https://ifr.org/img/worldrobotics/Executive_Summary_WR_2025_Industrial_Robots.pdf. Accessed November 18, 2026. International Federation of Robotics (industry association), "Global Robot Demand in Factories Doubles Over 10 Years", September 25, 2025. https://ifr.org/ifr-press-releases/news/global-robot-demand-in-factories-doubles-over-10-years. Accessed November 18, 2026.

Humanoid robots: early and small

Robots shaped like people get the headlines. The numbers are still small. Interesting Engineering reported in July 2026 that Unitree shipped more than 5,500 humanoids in 2025 according to its stock-offering filing, AgiBot reached 10,000 total units by the end of March 2026, and Figure AI and Agility Robotics each shipped about 150 units in 2025. One Figure robot moved more than 90,000 sheet metal parts over 1,250 logged hours at a BMW plant in South Carolina; those numbers come from Figure itself, and BMW has not disputed them.[119]

People inside the industry warn about the gap between videos and real work. A McKinsey partner told reporters that "for every $100 spent on deploying robots today, only around $20 is the actual machine," with the rest going to safety systems and setup, and that it is "a big extrapolation from watching videos of robots doing laundry to a butler." Many start-ups still train their robots by having people operate them remotely through headsets.[120]

Building houses

The essay's "self-building infrastructure" is partly here. The company ICON, working with homebuilder Lennar, set out to print 100 homes at the Wolf Ranch development in Georgetown, Texas, with a printer called Vulcan. The printer lays concrete walls in about three weeks per house, but "the foundation and metal roofs are made the old-fashioned way with human crews." The homes were priced at $450,000 to $600,000 in 2024.[121] That is automated wall building, not a self-building house, and not yet cheaper housing.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
al-Jazari	Book completed 1206	Engineer	Described water-powered automata	Early documented robot designs[122]
George Devol and Joseph Engelberger	1950s-1961	Inventor and businessman, Unimation	Unimate, first industrial robot, installed at GM in 1961	Start of an industry with about 4.66 million robots at work in 2024[123]

[119] Srishti Gupta, Interesting Engineering, "The humanoid robot reality check", July 31, 2026. https://interestingengineering.com/research/the-humanoid-robot-reality-check. Accessed November 18, 2026.

[120] TechSpot, "The people building humanoid robots say the hype is running ahead of reality", undated. https://www.techspot.com/news/110738-people-building-humanoid-robots-hype-running-ahead-reality.html. Accessed November 18, 2026.

[121] Danny Gallagher, Engadget, "A robotics company has 3D printed nearly a hundred homes in Texas", August 8, 2024. https://www.engadget.com/home/a-robotics-company-has-3d-printed-nearly-a-hundred-homes-in-texas-225830931.html. Accessed November 18, 2026.

[122] Evan Andrews, HISTORY, "7 Early Robots and Automatons", October 28, 2014, updated May 27, 2025. https://www.history.com/articles/7-early-robots-and-automatons. Accessed November 18, 2026.

[123] Allison Marsh, IEEE Spectrum, "In 1961, the First Robot Arm Punched In", August 30, 2022. https://spectrum.ieee.org/unimation-robot. Accessed November 18, 2026. International Federation of Robotics (industry association), "World Robotics 2025: Industrial Robots, Executive Summary", 2025. pp. 13-18. https://ifr.org/img/worldrobotics/Executive_Summary_WR_2025_Industrial_Robots.pdf. Accessed November 18, 2026.

Person	Dates or active period	Role	What they did	Documented impact
Mark Rosheim	2002	NASA roboticist	Built a working model of Leonardo's knight	Showed Leonardo's design could work[124]

Bottom line

Robotics as a priority: True that the work is real and active. Factory robots are a mature industry. Humanoid robots and printed homes are at the pilot stage.

"Self-building infrastructure": Partly true. Robots print walls and move parts. Nothing yet builds a whole house, maintains a bridge, or farms without people on site.

"Inspired by" names: Partly true. Leonardo is a fair inspiration but not a root of the industry. The list leaves out Devol and Engelberger, who started it. Archimedes and James Watt are named without a clear link to robots; I did not check their records for this book. **[Not verified]**

Readiness: Factory robots, 5 (widely used). Humanoid robots, 3 (pilots). Printed homes, 3 (pilots).

[124] Evan Andrews, HISTORY, "7 Early Robots and Automatons", October 28, 2014, updated May 27, 2025. https://www.history.com/articles/7-early-robots-and-automatons. Accessed November 18, 2026.

Chapter 10: Brain Implants for Paralysis and Lost Speech

Why it is on the list: For a person who cannot move or speak, a working brain implant changes everything. The results in trials are among the most moving in all of science. I rank it tenth because, for now, it helps a small number of patients in research studies, and the path to an approved, widely available device is still long.

What the essay said: "Restore communication, movement, and sensory functions lost to neurological injury or disease, while developing better ways to understand the brain." Work on "safe brain-computer interfaces and precise neural repair." Inspired by Ramon y Cajal, Hodgkin, Huxley and Turing.

Where it came from

In the 1880s and 1890s the Spanish scientist Santiago Ramon y Cajal took a silver staining method invented by the Italian Camillo Golgi, improved it, and drew thousands of pictures of nerve tissue. He argued that the brain is built from separate cells, which his colleague Wilhelm von Waldeyer-Hartz later named neurons. Golgi disagreed and still held that the nervous system was one continuous network. The two men shared the 1906 Nobel Prize in Physiology or Medicine anyway, the first time the medicine prize was ever shared.[125] The essay is right to name Cajal.

The essay also names Alan Hodgkin and Andrew Huxley, whose work in the 1950s explained how nerve signals travel. I did not trace their work to a source in this book. **[Not verified]**

Where it stands on November 18, 2026

Speech for people who lost it

The strongest results are in restoring speech. In August 2024, a team at University of California, Davis (UC Davis) Health reported in the New England Journal of Medicine on Casey Harrell, a 45-year-old man with ALS (amyotrophic lateral sclerosis, a disease that destroys the nerves that control muscles). Sensors placed in his brain through the BrainGate clinical trial turned his attempts to speak into words on a screen with "up to 97% accuracy." The work was led by neurosurgeon David Brandman and neuroscientist Sergey Stavisky, with Nicholas Card as lead author. The university labels the device "investigational."[126]

Approval status

In April 2025, the U.S. Food and Drug Administration cleared an electrode array from Precision Neuroscience that "can be implanted for up to 30 days to map brain activity." That is a short-term clearance for one part of a planned system, not approval of a permanent brain-computer interface.[127] An independent tracker reported in May 2026 that "no brain-computer interface for motor control has

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[125] Joachim Pietzsch, NobelPrize.org, "Speed read: Exposing the forest", September 16, 2009. https://nobelprize.org/prizes/medicine/1906/speedread. Accessed November 18, 2026.

[126] Nadine A. Yehya, UC Davis Health, "New brain-computer interface allows man with ALS to 'speak' again", August 14, 2024. https://health.ucdavis.edu/welcome/news/headlines/new-brain-computer-interface-allows-man-with-als-to-speak-again/2024/08. Accessed November 18, 2026.

[127] Elise Reuter, MedTech Dive, "Precision Neuroscience receives FDA clearance for brain implant", April 21, 2025. https://www.medtechdive.com/news/precision-neuroscience-brain-implant-fda-cleared/745913/. Accessed November 18, 2026.

received full FDA approval" and that Neuralink, Synchron and others were still in trials.[128] That tracker is a secondary source, and I could not check its claims against FDA records. **[Not verified]** against primary FDA records.

Neural repair

Repairing damaged brain or spinal cord tissue, as opposed to reading signals from it, is further behind. I did not find an approved therapy that regrows lost brain function. **[Not verified]** that none exists anywhere in the world.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Santiago Ramon y Cajal	Nobel 1906	Neuroscientist	Showed the brain is made of separate cells (neurons)	Foundation of modern neuroscience[129]
Camillo Golgi	Nobel 1906	Physician and scientist	Invented the silver stain Cajal used	Shared the 1906 prize[130]
David Brandman, Sergey Stavisky, Nicholas Card and the BrainGate team	2023-2024	UC Davis Health researchers	Speech brain-computer interface for a man with ALS	Up to 97% accuracy in turning attempted speech into text[131]

Bottom line

Restoring communication: Partly true as a description of today. It works in clinical trials for a small number of people. It is not an approved, widely available treatment.

"Inspired by" names: Partly true. Cajal is a true root. Turing's link to neural interfaces is loose. The list leaves out the clinical teams doing the work today.

Readiness: Speech implants, 3 (trials). Precise neural repair, 2 or lower.

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[128] bciintel.com (independent tracker, secondary source), "BCI FDA Approval Tracker: Every Brain Implant in the Pipeline (2026)", May 2026. https://bciintel.com/bci-fda-approval-tracker/. Accessed November 18, 2026.

[129] Joachim Pietzsch, NobelPrize.org, "Speed read: Exposing the forest", September 16, 2009. https://nobelprize.org/prizes/medicine/1906/speedread. Accessed November 18, 2026.

[130] Joachim Pietzsch, NobelPrize.org, "Speed read: Exposing the forest", September 16, 2009. https://nobelprize.org/prizes/medicine/1906/speedread. Accessed November 18, 2026.

[131] Nadine A. Yehya, UC Davis Health, "New brain-computer interface allows man with ALS to 'speak' again", August 14, 2024. https://health.ucdavis.edu/welcome/news/headlines/new-brain-computer-interface-allows-man-with-als-to-speak-again/2024/08. Accessed November 18, 2026.

Chapter 11: Clean Cooking

Why it is on the list: About one person in four on Earth still cooks over an open fire or a smoky stove, and that smoke kills millions. Clean stoves and fuels are not new inventions. What is missing is a version cheap and reliable enough that families switch for good. I rank it eleventh because the death toll is large and the fix is well understood.

Where it came from

Clean cooking has no single inventor. Gas, electric and improved stoves all have long histories, and I did not trace any one person's contribution to a source in this book. **[Not verified]** The documented work in this field today is mostly that of public health agencies measuring the harm and tracking access, led by the World Health Organization.

Where it stands on November 18, 2026

The World Health Organization's fact sheet of December 16, 2025, reports:

- "Around 2.1 billion people worldwide (around a quarter of the global population)" cook using open fires or inefficient stoves.
- Household air pollution "was responsible for an estimated 2.9 million deaths per year in 2021, including over 309 000 deaths of children under the age of 5."
- "Women and children disproportionately bear the greatest health burden," because they spend the most time near the fire.
- In low- and middle-income countries, 23 percent of adult deaths from chronic obstructive pulmonary disease (COPD), a lung disease, are due to household air pollution.[132]

The WHO counts as clean "solar, electricity, biogas, liquefied petroleum gas (LPG), natural gas, alcohol fuels," and biomass stoves that meet its emission targets. It cites a projection that only 78 percent of the world's people will have clean cooking by 2030, leaving "nearly 1.8 billion people still without clean cooking solutions."[133]

Bottom line

The need: well documented. An estimated 2.9 million deaths a year in 2021 makes household smoke one of the largest health risks on this list.[134]

What would help most, in my reading: cheap electric cooking where power is reliable, which ties this chapter to Chapter 1, and low-cost clean fuels elsewhere. **[Interpretation]**

Readiness: Clean stoves and fuels, 5 (widely used where available). Reaching the 2.1 billion who lack them, 2.

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[132] World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026.

[133] World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026.

[134] World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026.

Chapter 12: Safer Roads

Why it is on the list: Road crashes kill more children and young adults than any other cause. Many of the tools that prevent those deaths, from seat belts to safer road design, already exist. I rank this twelfth because the payoff is large and fast wherever the tools are used.

Where it came from

The best-known road safety invention is the three-point seat belt. Volvo, which made it, says the modern three-point belt "was perfected by Volvo engineer Nils Bohlin in 1959," that the company gave its patent "for free to the world," and that it is "credited with saving at least a million lives worldwide."[135] The lives-saved figure is the company's claim, and I did not check it against an independent count. **[Not verified]**

Where it stands on November 18, 2026

The World Health Organization's fact sheet of May 1, 2026, reports:

- "Approximately 1.19 million people die each year as a result of road traffic crashes," and 20 million to 50 million more are injured.
- "Road traffic injuries are the leading cause of death for children and young adults aged 5-29 years."
- "92% of the world's fatalities on the roads occur in low- and middle-income countries, even though these countries have around 60% of the world's vehicles."
- More than half of all road deaths are pedestrians, cyclists and motorcyclists.
- Crashes cost most countries about 3 percent of their economic output.[136]

The United Nations General Assembly has set a target of halving road deaths and injuries by 2030.[137]

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Nils Bohlin	1959	Engineer, Volvo	Perfected the three-point seat belt; patent given free	Credited by Volvo with saving at least a million lives (company claim)[138]

[135] Volvo Group, "The three points that saved one million lives", November 23, 2023. https://www.volvogroup.com/en/about-us/heritage/three-point-safety-belt.html. Accessed November 18, 2026.

[136] World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/. Accessed November 18, 2026.

[137] World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/. Accessed November 18, 2026.

[138] Volvo Group, "The three points that saved one million lives", November 23, 2023. https://www.volvogroup.com/en/about-us/heritage/three-point-safety-belt.html. Accessed November 18, 2026.

Bottom line

The need: well documented. About 1.19 million deaths a year, concentrated in poorer countries.[139]

What would help most, in my reading: cheaper safety features in the cars, buses and motorcycles sold in low- and middle-income countries, and road designs that protect people on foot and on two wheels. **[Interpretation]**

Readiness: Proven safety tools, 5 (widely used in richer countries). Halving deaths worldwide by 2030, 2.

[139] World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/. Accessed November 18, 2026.

Chapter 13: Early Warnings for Disasters

Why it is on the list: A storm, flood or heat wave is far less deadly when people know it is coming. Warning systems combine weather forecasting, communication and local plans. I rank this thirteenth because the evidence linking warnings to fewer deaths is strong.

Where it came from

Weather forecasting and warning systems grew over more than a century of work by many national weather services. I did not trace a single founder to a source in this book. **[Not verified]** The current push began in 2022, when the United Nations Secretary-General launched Early Warnings for All, which aims "to protect every person on Earth with an early warning system by 2027." It is co-led by the World Meteorological Organization (WMO) and the UN Office for Disaster Risk Reduction (UNDRR).[140]

Where it stands on November 18, 2026

The WMO and UNDRR reported in November 2025 that:

- "119 countries, or 60% of all countries," now report having a warning system that covers several kinds of hazards, an increase of 113 percent over ten years.
- "Disaster-related mortality is nearly six times lower in countries with more comprehensive" warning systems than in countries with limited ones.
- Coverage is lowest in the Americas and the Caribbean (51 percent) and among small island developing states (43 percent), and fewer than one-third of countries report strong knowledge of their own risks.[141]

The six-times figure compares countries, so it shows a strong link, not proof that warnings alone cause the difference. Richer countries tend to have both better warnings and better hospitals and buildings. That caution is mine. **[Interpretation]**

Bottom line

The need and the payoff: well documented. Sixty percent of countries are covered, and those with the best systems see far fewer disaster deaths.[142]

The 2027 goal: "Every person on Earth" covered by 2027 is a target, not a result. With 40 percent of countries not yet reporting such a system in late 2025, it looks unlikely to be fully met on time. That is my inference. **[Interpretation]**

Readiness: Warning systems, 4 (in 60 percent of countries). Everyone covered, 3.

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[140] World Meteorological Organization and UN Office for Disaster Risk Reduction, "Early warning systems reach new heights, but critical gaps jeopardize global progress (press release)", November 12, 2025. https://wmo.int/news/media-centre/early-warning-systems-reach-new-heights-critical-gaps-jeopardize-global-progress. Accessed November 18, 2026.

[141] World Meteorological Organization and UN Office for Disaster Risk Reduction, "Early warning systems reach new heights, but critical gaps jeopardize global progress (press release)", November 12, 2025. https://wmo.int/news/media-centre/early-warning-systems-reach-new-heights-critical-gaps-jeopardize-global-progress. Accessed November 18, 2026.

[142] World Meteorological Organization and UN Office for Disaster Risk Reduction, "Early warning systems reach new heights, but critical gaps jeopardize global progress (press release)", November 12, 2025. https://wmo.int/news/media-centre/early-warning-systems-reach-new-heights-critical-gaps-jeopardize-global-progress. Accessed November 18, 2026.

Chapter 14: Protection From Extreme Heat

Why it is on the list: Heat is a quiet killer in a warming world, and its measured toll is rising. I rank this fourteenth because cooling technology is mature and the deaths are preventable.

Where it came from

According to the company he founded, Willis Haviland Carrier designed the first modern air-conditioning system on July 17, 1902, to control humidity at the Sackett and Wilhelms printing plant in Brooklyn, New York, where damp air was "ruining the color register on fine multicolor work."[143] Cooling for comfort and health came later. This is the company's own history.

Where it stands on November 18, 2026

The 2025 report of the Lancet Countdown on health and climate change, released with the World Health Organization in October 2025, found that heat-related deaths averaged 546,000 a year and that "the rate of heat-related mortality has increased 23% since the 1990s." Heat exposure also cost an estimated 640 billion potential working hours in 2024.[144] The Lancet Countdown is led by University College London with WHO and dozens of partner institutions.[145]

These are model estimates. Heat deaths are hard to count because heat often worsens heart and lung disease rather than appearing on a death certificate. That caution is general and mine. **[Interpretation]**

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Willis Haviland Carrier	July 17, 1902	Engineer	First modern air-conditioning system (company history)	Start of the modern cooling industry[146]
Marina Romanello and the Lancet Countdown team	2025 report	Researchers, University College London	Annual global tracking of climate and health	Estimate of 546,000 heat deaths a year[147]

[143] Carrier, "Invention of Air Conditioning", undated. https://www.carrier.com/us/en/history/invention-of-air-conditioning/. Accessed November 18, 2026.

[144] World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

[145] World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

[146] Carrier, "Invention of Air Conditioning", undated. https://www.carrier.com/us/en/history/invention-of-air-conditioning/. Accessed November 18, 2026.

[147] World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

Bottom line

The need: well documented and growing. The heat death rate is up 23 percent since the 1990s.[148]

What would help most, in my reading: cooling that is cheap to buy and to run, powered by the clean electricity in Chapter 1, plus heat warnings (Chapter 13) and cool places for people without air conditioning. **[Interpretation]**

Readiness: Air conditioning, 5 (widely used where people can afford it). Protecting everyone at risk, 2.

[148] World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

Chapter 15: Eye and Hearing Care for Everyone

Why it is on the list: Being able to see and hear decides whether a child can learn and an adult can work. A pair of glasses or a short cataract operation can change a life, and both are proven. I rank this fifteenth: the tools are cheap and mature, and the gap is reach.

Where it came from

- **The artificial lens.** At St Thomas' Hospital in London, the eye surgeon Harold Ridley operated on 29 November 1949 and again on 8 February 1950 in the first intraocular lens surgery. The Science Museum notes it is unclear whether the lens was implanted in the first operation. Ridley's idea came from World War II: slivers of Perspex from damaged aircraft lodged in pilots' eyes "were surprisingly not rejected by the body."[149]
- **The bionic ear.** In 1978, Graeme Clark, working at the Royal Victorian Eye and Ear Hospital in Melbourne, Australia, "implanted the first modern multichannel cochlear implant" in a 46-year-old man. By the end of 2012 more than 320,000 such devices had been implanted worldwide.[150]

Where it stands on November 18, 2026

Vision

The World Health Organization reported in February 2026 that "at least 2.2 billion people have a near or distance vision impairment," and that for at least 1 billion of them it "could have been prevented or is yet to be addressed." The leading causes are uncorrected refractive error, the kind fixed by glasses, and cataracts. "2 out of 3 people in low-income countries who need eyeglasses don't have access to them," and 1 in 2 people worldwide who need cataract surgery cannot get it. The WHO estimates the lost productivity at about $411 billion a year.[151]

Hearing

The WHO reports that "more than 1.5 billion people (nearly 20% of the global population) live with hearing loss," 430 million of them with disabling hearing loss, and expects that number to pass 700 million by 2050. Global hearing aid production "covers just 3% of the need" in low- and middle-income countries.[152]

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[149] Selina Hurley, Science Museum, "A visionary innovation: Harold Ridley and the first intra-ocular surgery", November 29, 2024. https://blog.sciencemuseum.org.uk/a-visionary-innovation-harold-ridley-and-the-first-intra-ocular-surgery/. Accessed November 18, 2026.

[150] Joyce P. K. Ho, Hannah North and Narinder P. Singh, "Forty years of "Waltzing Matilda": the history of the multichannel cochlear implant", December 3, 2018. Medical Journal of Australia 209, no. 11: 476-478. https://www.mja.com.au/journal/2018/209/11/forty-years-waltzing-matilda-history-multichannel-cochlear-implant. Accessed November 18, 2026.

[151] World Health Organization, "Blindness and vision impairment (fact sheet)", February 10, 2026. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed November 18, 2026.

[152] World Health Organization, "Deafness and hearing loss (health topic page)", undated, read November 18, 2026. https://www.who.int/health-topics/hearing-loss. Accessed November 18, 2026.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Harold Ridley	1949-1950	Eye surgeon, St Thomas' Hospital, London	First intraocular lens surgery	First artificial lens surgery inside the eye[153]
Graeme Clark	1978	Surgeon, Melbourne	First modern multichannel cochlear implant	More than 320,000 devices implanted by 2012[154]

Bottom line

The need: well documented. At least 1 billion people with unaddressed vision problems and 430 million with disabling hearing loss.[155]

What would help most, in my reading: very cheap glasses and hearing aids, simple screening that does not need a specialist, and more trained surgeons for cataracts. **[Interpretation]**

Readiness: Glasses, cataract surgery and hearing aids, 5 (widely used where available). Reaching everyone who needs them, 2.

[153] Selina Hurley, Science Museum, "A visionary innovation: Harold Ridley and the first intra-ocular surgery", November 29, 2024. https://blog.sciencemuseum.org.uk/a-visionary-innovation-harold-ridley-and-the-first-intra-ocular-surgery/. Accessed November 18, 2026.

[154] Joyce P. K. Ho, Hannah North and Narinder P. Singh, "Forty years of "Waltzing Matilda": the history of the multichannel cochlear implant", December 3, 2018. Medical Journal of Australia 209, no. 11: 476-478. https://www.mja.com.au/journal/2018/209/11/forty-years-waltzing-matilda-history-multichannel-cochlear-implant. Accessed November 18, 2026.

[155] World Health Organization, "Blindness and vision impairment (fact sheet)", February 10, 2026. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed November 18, 2026. World Health Organization, "Deafness and hearing loss (health topic page)", undated, read November 18, 2026. https://www.who.int/health-topics/hearing-loss. Accessed November 18, 2026.

Chapter 16: The Watch List

Two of the essay's ten did not make my fifteen. Both are real fields with real results, and both deserve research money. I moved them to a watch list for one reason: over the next 20 years, they are likely to help fewer people, and later, than the fifteen above. Quantum computers have not yet done a useful job faster than an ordinary computer. The part of space travel that most affects life on Earth, cheap launch through reusable rockets, is already done. This is my judgment. **[Interpretation]**

Either could move onto the list quickly. A quantum computer that designs a better battery or fertilizer catalyst, or a new material that carries power without loss, would change several chapters of this book at once.

Part A: Quantum Computing and New Materials

What the essay said: "Build useful fault-tolerant quantum computers and discover materials with radically improved strength, conductivity, and efficiency." Work on "error-corrected quantum hardware, materials simulation, and new superconductors." Inspired by Planck, Einstein, Bohr and Feynman. Its table gives a horizon of "5-30+ years" with "hardware, error correction" as the challenge.

Where it came from

Ordinary computers store bits that are either 0 or 1. Quantum computers use quantum bits, or qubits, that follow the strange rules of quantum physics. The rules come from early 20th-century physics, and the essay names some of its founders. I did not trace the specific contributions of Max Planck, Niels Bohr or Richard Feynman to a source in this book. **[Not verified]**

The most direct roots of today's leading quantum chips are better documented. The 2025 Nobel Prize in Physics went to John Clarke, Michel Devoret and John Martinis "for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit." Their key experiments at the University of California, Berkeley, in the mid-1980s showed that an electric circuit big enough to hold in your hand could behave by quantum rules. That device, the Josephson junction, is now used in quantum computing. Martinis later joined Google's quantum computing team.[156]

Where it stands on November 18, 2026

Error correction: the first real progress.

The biggest problem with qubits is that they make errors. More qubits usually means more errors. In December 2024, Google announced its Willow chip with 105 qubits and reported that it had gone "below threshold," meaning it could "drive errors down while scaling up the number of qubits." Google also said Willow ran a benchmark test in under five minutes that would take a top supercomputer 10 septillion years.[157]

Google was honest about the limits. That benchmark, called random circuit sampling, "has yet to demonstrate practical commercial applications," and the next goal is a "useful, beyond-classical"

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[156] American Institute of Physics, "2025 Nobel Prize Resources", October 2025. https://www.aip.org/nobel-prize-2025. Accessed November 18, 2026.

[157] Hartmut Neven, Google Quantum AI, "Meet Willow, our state-of-the-art quantum chip", December 9, 2024. https://blog.google/technology/research/google-willow-quantum-chip/. Accessed November 18, 2026.

computation.[158] As of the sources I read, no quantum computer has publicly done a useful job faster than an ordinary computer could. **[Not verified]** that any has.

Other companies report progress too. Quantinuum's Helios system, announced in November 2025, created 48 error-corrected logical qubits from 98 physical qubits, and the company targets a much larger machine called Apollo by 2029. These are company claims.[159]

A disputed chip.

In February 2025, Microsoft announced a chip built on a new kind of qubit called a topological qubit. Many physicists were not convinced. Science News reported that the announcement came "by press release, without publicly shared data backing it up," and that the paper published alongside it in Nature "fell short of demonstrating a topological qubit." In June 2026 a physicist at the University of St Andrews published a peer-reviewed critique in Nature. Microsoft says, "We stand by our results and our roadmap."[160] Chapter 17 covers the dispute.

New materials and superconductors.

A superconductor carries electricity with no loss, but every known one needs extreme cold or extreme pressure. A material that worked at room temperature would change power lines, motors and computers. In the summer of 2023, a South Korean team claimed a material called LK-99 was such a superconductor. Within weeks, labs around the world tested it. Nature reported that it was not a superconductor, and the Max Planck Institute in Stuttgart found that pure samples did not show the effect.[161] Chapter 17 covers it.

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
John Clarke, Michel Devoret and John Martinis	Key work mid-1980s; Nobel 2025	Physicists	Showed quantum behavior in an electric circuit	Basis of superconducting qubits used by Google and others[162]
Hartmut Neven and the Google Quantum AI team	2024	Google	Willow chip; errors fall as qubits grow	First public "below threshold" result on a large chip (company report)[163]

[158] Hartmut Neven, Google Quantum AI, "Meet Willow, our state-of-the-art quantum chip", December 9, 2024. https://blog.google/technology/research/google-willow-quantum-chip/. Accessed November 18, 2026.

[159] Skye Jacobs, TechSpot, "Quantinuum unveils Helios, claims a massive leap toward practical quantum computing", November 2025. https://www.techspot.com/news/110188-quantinuum-claims-massive-leap-toward-practical-quantum-computing.html. Accessed November 18, 2026.

[160] Emily Conover, Science News, "Physicists are mostly unconvinced by Microsoft's new topological quantum chip", March 27, 2025. https://www.sciencenews.org/article/microsoft-topological-quantum-majorana. Accessed November 18, 2026. John E. Dunn, CIO, "Researchers cast new doubt on Microsoft's quantum computing advance", June 25, 2026. https://www.cio.com/article/4189626/researchers-cast-new-doubt-on-microsofts-quantum-computing-advance-3.html. Accessed November 18, 2026.

[161] Francisco Pires, Tom's Hardware, "Science Journal Says LK-99 Superconductor Dream is Over", August 17, 2023. https://www.tomshardware.com/news/science-journal-says-lk-99-superconductor-dream-is-over. Accessed November 18, 2026.

[162] American Institute of Physics, "2025 Nobel Prize Resources", October 2025. https://www.aip.org/nobel-prize-2025. Accessed November 18, 2026.

Bottom line

Quantum computing as active work: True. Error correction showed real progress in 2024 and 2025.

"Useful fault-tolerant quantum computers": not yet achieved. The essay calls this a goal, not a fact, so there is no false claim to rate. The "5-30+ years" horizon is a prediction. **Inconclusive.**

New superconductors: Inconclusive. No room-temperature superconductor has been confirmed, and the most famous recent claim failed.

"Inspired by" names: Partly true. The founders of quantum physics are a fair inspiration. The list leaves out Clarke, Devoret and Martinis, whose circuits are the direct ancestors of today's chips.

Readiness: Error correction, 2 (lab proof). Useful quantum advantage, 1. Room-temperature superconductors, 1.

Part B: Revolutionary Space Transportation

What the essay said: "Develop cheaper launch systems, improved propulsion, in-space manufacturing, and infrastructure for sustained exploration." Work on "reusable transportation, nuclear-electric propulsion research, and space resource utilization." Inspired by Newton, Tsiolkovsky, Goddard and Einstein. Its table gives the longest horizon of the ten, "10-50+ years," with "cost, propulsion, sustainability" as the challenge.

Where it came from

The Russian schoolteacher Konstantin Tsiolkovsky worked out the basic math of rocket flight and published it in Russian as early as 1903. The American physicist Robert Goddard, working on his own, wrote "A Method of Reaching Extreme Altitudes," a 79-page paper published by the Smithsonian Institution. The paper carries a 1919 date, and the Smithsonian's National Air and Space Museum says it was released at the beginning of 1920. Its suggestion that a rocket could reach the Moon drew ridicule in the press.[164]

On March 16, 1926, Goddard launched the world's first liquid-fuel rocket from a field near Worcester, Massachusetts (the Australian Space Agency names the town as Auburn). It rose about 41 feet (12.5 meters), landed about 184 feet away, and flew for about 2.5 seconds.[165] Every large rocket since has followed the path he started.

The essay is right to name Tsiolkovsky and Goddard. Newton's laws of motion are the physics every rocket obeys, so his name is a fair inspiration, though I did not trace it to a source in this book. **[Not verified]** Einstein's link to rocket transport is loose.

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[163] Hartmut Neven, Google Quantum AI, "Meet Willow, our state-of-the-art quantum chip", December 9, 2024. https://blog.google/technology/research/google-willow-quantum-chip/. Accessed November 18, 2026.

[164] Michael J. Neufeld and Frank H. Winter, Smithsonian National Air and Space Museum, "Robert Goddard: Secret Space Visionary", March 16, 2026. https://www.airandspace.si.edu/stories/editorial/robert-goddard-secret-space-visionary. Accessed November 18, 2026. Australian Space Agency, "A century of lift-offs", 2026. https://www.space.gov.au/news-and-media/century-of-lift-offs. Accessed November 18, 2026.

[165] Michael J. Neufeld and Frank H. Winter, Smithsonian National Air and Space Museum, "Robert Goddard: Secret Space Visionary", March 16, 2026. https://www.airandspace.si.edu/stories/editorial/robert-goddard-secret-space-visionary. Accessed November 18, 2026. Australian Space Agency, "A century of lift-offs", 2026. https://www.space.gov.au/news-and-media/century-of-lift-offs. Accessed November 18, 2026.

Where it stands on November 18, 2026

Reusable rockets: done.

For 50 years, rockets were thrown away after one flight. On December 21, 2015, SpaceX launched a Falcon 9 from Cape Canaveral, delivered 11 ORBCOMM satellites, and flew the first stage back to a landing pad at the Cape. collectSPACE called it "the first time in history that a rocket used to put a payload into orbit then flew itself back to the ground."[166] Landing and reflying boosters is now routine for SpaceX. I did not find an independent count of reflights to cite. **[Not verified]**

Are launches cheaper?.

It is cheaper. How much cheaper is hard to pin down. The Center for Strategic and International Studies (CSIS), which keeps a public data set on launch costs, warns that "the very definition of 'launch cost' is subject to interpretation," because companies do not publish what they charge each customer, and government prices include extras.[167] I give no dollar-per-kilogram figure in this book, because I could not confirm one from a primary price list. **[Not verified]**

People back at the Moon.

On April 1, 2026, NASA's Artemis II mission launched four astronauts from Cape Canaveral: Reid Wiseman, Victor Glover, Christina Koch and Canada's Jeremy Hansen. Their capsule, Integrity, flew around the Moon and splashed down in the Pacific Ocean off Southern California on April 10. Reuters reported that the crew flew 694,392 miles in all and reached 252,756 miles from Earth, farther than any humans before them, beating Apollo 13's record from 1970. They were the first people near the Moon in more than half a century.[168]

Propulsion: the essay picked the right kind.

The essay asks for "nuclear-electric propulsion research," and that turns out to be a well-chosen phrase. The most visible United States nuclear rocket project, DRACO (Demonstration Rocket for Agile Cislunar Operations), was meant to fly a different kind, a nuclear thermal engine, in space. In June 2025 the Defense Advanced Research Projects Agency (DARPA) cancelled it. Its program manager, Tabitha McHenry, pointed to the "precipitous decrease" in launch costs, which made the case for the new engine weaker, and said that "nuclear electric is probably a more optimal long term solution." NASA's budget request for 2026 also zeroed out its share.[169] In other words, cheaper ordinary rockets undercut the nuclear thermal engine, and the program's own manager pointed toward the nuclear-electric approach the essay names.

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[166] collectSPACE, "SpaceX returns to flight, and to the launch site: Falcon 9 stage lands at Cape", December 21, 2015. https://www.collectspace.com/news/news-122115c-spacex-falcon9-launch-landing.html. Accessed November 18, 2026.

[167] Thomas G. Roberts, CSIS Aerospace Security Project, "Space Launch to Low Earth Orbit: How Much Does It Cost?", updated September 1, 2022. https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/. Accessed November 18, 2026.

[168] Steve Gorman and Joey Roulette, Reuters (republished by GV Wire), "Splashdown! Artemis II Astronauts Conclude 10-Day Moon Mission", April 10, 2026. https://gvwire.com/2026/04/10/splashdown-artemis-ii-astronauts-conclude-10-day-moon-mission/. Accessed November 18, 2026.

[169] Theresa Hitchens, Breaking Defense, "DARPA's DRACO nuclear propulsion project ROARs no more", June 27, 2025. https://breakingdefense.com/2025/06/darpas-draco-nuclear-propulsion-project-roars-no-more/. Accessed November 18, 2026.

In-space manufacturing and using resources from the Moon or asteroids remain early. I did not find a working commercial example to cite. **[Not verified]**

People who moved it

Person	Dates or active period	Role	What they did	Documented impact
Konstantin Tsiolkovsky	Published from 1903	Schoolteacher and theorist	Math of rocket flight	Early theory of space travel[170]
Robert Goddard	Paper 1919-1920; launch March 16, 1926	Physicist	First liquid-fuel rocket	Start of the rocket age[171]
SpaceX Falcon 9 team	December 21, 2015	Company engineers	First orbital booster to land and be reused	Reusable boosters now routine[172]
Reid Wiseman, Victor Glover, Christina Koch, Jeremy Hansen	April 1-10, 2026	Artemis II crew	First people near the Moon in more than 50 years	Farthest distance from Earth by humans[173]

Bottom line

Reusable rockets: True that the essay's goal is partly met. Reuse is routine for one company.

"Cheaper launch systems": Partly true. Launch is cheaper than it was, but the true cost is hard to measure from outside.

"Nuclear-electric propulsion research": a sound choice. DARPA's program manager called nuclear electric "probably a more optimal long term solution" when the nuclear thermal project was cancelled in 2025. The goal itself is still at the research stage. **Inconclusive.**

In-space manufacturing and space resources: Inconclusive. I found no working commercial example.

"10-50+ years" horizon: Inconclusive. It is a prediction.

"Inspired by" names: True for Tsiolkovsky and Goddard. The list leaves out the engineers who made boosters land and fly again.

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[170] Michael J. Neufeld and Frank H. Winter, Smithsonian National Air and Space Museum, "Robert Goddard: Secret Space Visionary", March 16, 2026. https://www.airandspace.si.edu/stories/editorial/robert-goddard-secret-space-visionary. Accessed November 18, 2026.

[171] Michael J. Neufeld and Frank H. Winter, Smithsonian National Air and Space Museum, "Robert Goddard: Secret Space Visionary", March 16, 2026. https://www.airandspace.si.edu/stories/editorial/robert-goddard-secret-space-visionary. Accessed November 18, 2026. Australian Space Agency, "A century of lift-offs", 2026. https://www.space.gov.au/news-and-media/century-of-lift-offs. Accessed November 18, 2026.

[172] collectSPACE, "SpaceX returns to flight, and to the launch site: Falcon 9 stage lands at Cape", December 21, 2015. https://www.collectspace.com/news/news-122115c-spacex-falcon9-launch-landing.html. Accessed November 18, 2026.

[173] Steve Gorman and Joey Roulette, Reuters (republished by GV Wire), "Splashdown! Artemis II Astronauts Conclude 10-Day Moon Mission", April 10, 2026. https://gvwire.com/2026/04/10/splashdown-artemis-ii-astronauts-conclude-10-day-moon-mission/. Accessed November 18, 2026.

Readiness: Reusable boosters, 5 (widely used by one company). Crewed Moon flights, 3 (test flights). Nuclear propulsion, 2. Space mining and manufacturing, 1 to 2.

Chapter 17: Hype and Disputed Claims

This chapter is kept apart from the rest of the book on purpose. The chapters before it report what the records show and give my ranking. This one looks at claims that ran ahead of the records, how far they spread, and how they hold up.

Each claim gets the same treatment: what the claim is, where it first shows up in the sources I could find, who promoted it, how it spread, the people named and what they said on the record, and how the evidence stands. I sort each into one of five classes:

Class	What it means
Supported	The evidence backs the claim as stated.
Overstated	The core is real, but the claim promises more than the evidence shows.
Disputed	Qualified experts disagree in public, and the question is open.
Refuted	The evidence contradicts the claim.
Unresolved	It is a prediction, and no one can check it yet.

The people named here are named only for what they said or did on the public record. None of this is an accusation of bad faith. Excitement is normal in science and business. Checking it is the reader's job, and mine.

1. "Fusion power is just around the corner"

The claim. That the 2022 ignition result means fusion electricity is coming soon.

Earliest appearance I found. The United States Department of Energy announced the National Ignition Facility result on December 13, 2022. Energy Secretary Jennifer Granholm and White House science adviser Arati Prabhakar led the announcement.[174]

Who promoted it and how it spread. The result made front pages around the world. Private fusion companies have since raised large sums and signed power deals. Helion Energy signed a power purchase agreement with Microsoft in May 2023 and says it is on track to deliver power by 2028.[175] GeekWire reported in 2026 that Helion broke ground in July 2025 on its 50-megawatt Orion plant in Malaga, Washington, and that Commonwealth Fusion Systems had raised about $3 billion and planned a plant in Virginia.[176]

What the people involved said. The scientists were more careful than the headlines. Lawrence Livermore director Kim Budil said that "with concerted effort" a power plant "could be built in a few

[174] David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026.

[175] DatacenterDynamics, "Helion begins work at fusion plant, expects to deliver power to Microsoft by 2028", 2025. https://datacenterdynamics.com/en/news/helion-begins-work-at-fusion-plant-expects-to-deliver-power-to-microsoft-by-2028/. Accessed November 18, 2026.

[176] GeekWire, "Inside the race to power AI data centers with fusion energy, and the surprise detours along the way", 2026. https://www.geekwire.com/2026/inside-the-race-to-power-ai-data-centers-with-fusion-energy-and-the-surprise-detours-along-the-way/. Accessed November 18, 2026.

decades," and spoke of "very significant hurdles."[177] In 2026 fusion scientist Laura Berzak Hopkins told GeekWire that "there still remain these major scientific and technological hurdles."[178]

The evidence. The 2022 shot released about 3.15 megajoules from 2.05 megajoules of laser light, but each shot draws about 300 megajoules from the power grid. Physics Today put the fusion output at "just 1% of the 300 MJ from the grid."[179] Even the 2025 record of 8.6 megajoules is far below the roughly 300 megajoules of grid power Physics Today reported for each shot in 2022.[180] ITER, the largest public project, moved full fusion fuel operation to 2039.[181] And GeekWire reported that one fusion company, Zap Energy, was adding a small fission reactor to its plans after concerns about its fusion timeline.[182] No company has publicly shown a fusion machine that puts out more electricity than it takes in. **[Not verified]** that none has done so in private.

Classification: Overstated. Ignition is real and confirmed. Power to the grid is not here, and every date for it is a forecast.

2. "Human-level AI is two to five years away"

The claim. That artificial general intelligence (AGI), meaning AI that can do most mental work as well as a person, will arrive within a few years.

Earliest appearance I found. The idea is old. Turing asked "Can machines think?" in 1950.[183] The current short timelines come mostly from AI company leaders.

Who promoted it and how it spread. A review by Benjamin Todd of the nonprofit 80,000 Hours, updated in February 2026, reports that leaders of AI companies say AGI could come in two to five years. The same review shows that other groups expect it later. A large survey of AI researchers published in January 2024 put a 50 percent chance of "high-level machine intelligence" at 2047. The forecasting site Metaculus gave, as of February 2026, a 25 percent chance by 2029 and 50 percent by 2033.[184]

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[177] World Nuclear News, "US researchers achieve historic fusion ignition", December 13, 2022. https://world-nuclear-news.org/Articles/US-researchers-achieve-historic-fusion-ignition. Accessed November 18, 2026.

[178] GeekWire, "Inside the race to power AI data centers with fusion energy, and the surprise detours along the way", 2026. https://www.geekwire.com/2026/inside-the-race-to-power-ai-data-centers-with-fusion-energy-and-the-surprise-detours-along-the-way/. Accessed November 18, 2026.

[179] David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026.

[180] Lawrence Livermore National Laboratory, "Annual Report 2025: National Ignition Facility", February 2026. pp. 8-9. https://annual.llnl.gov/sites/annual/files/2026-02/llnlannual25-3-national-ignition-facility.pdf. Accessed November 18, 2026. David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026.

[181] ITER Organization, "Press Conference Summary: Summary of Presentation by Pietro Barabaschi, ITER Director-General", July 3, 2024. p. 2. https://iter.org/sites/default/files/media/2024-07/baseline_press_conference_summary_july-2024_b.pdf. Accessed November 18, 2026.

[182] GeekWire, "Inside the race to power AI data centers with fusion energy, and the surprise detours along the way", 2026. https://www.geekwire.com/2026/inside-the-race-to-power-ai-data-centers-with-fusion-energy-and-the-surprise-detours-along-the-way/. Accessed November 18, 2026.

[183] Alan M. Turing, "Computing Machinery and Intelligence", 1950. Mind 59: 433-60; excerpt published by MIT OpenCourseWare 24.09x. https://openlearninglibrary.mit.edu/assets/courseware/v1/0c0db957c39184b538869f8d9e9a3b56/asset-v1:MITx+24.09x+3T2019+type@asset+block/5_turing_computing_machinery_and_intelligence.pdf. Accessed November 18, 2026.

The evidence. These are forecasts, not findings. The review also notes that the definitions of AGI are vague, which makes any date hard to test. The working record from Chapter 5 is mixed: AI systems have helped with real science, and the same systems have also invented results that did not happen. In one 2026 test, fabricated key results showed up in 46 percent of papers with the reliability checks turned off.[185]

Classification: Unresolved. It is a prediction. Experts disagree by decades.

3. "AI made 41 new materials on its own"

The claim. That a robotic, AI-run laboratory discovered 41 new compounds in 17 days.

Earliest appearance. A Nature paper in November 2023 from Lawrence Berkeley National Laboratory and Google DeepMind on the "A-Lab."[186]

What the people named said. Materials chemists Robert Palgrave of University College London and Leslie Schoop of Princeton reanalyzed the results and reported "systematic errors all the way through." Palgrave said, "it's likely they didn't make any discoveries." The A-Lab's Gerbrand Ceder replied that the compounds were made, while granting that "a human can perform a higher-quality refinement."[187]

Classification: Disputed. The robot lab works as a machine. Whether it discovered anything new is contested in public by qualified chemists.

4. "People will soon live to 150"

The claim. That medicine will soon stretch the human life span far past today's limits, often stated as living to 120 or 150.

Earliest appearance, promoters and spread. These claims circulate widely in books, talks and online. I did not trace them to a single first source or a named promoter I could confirm on the record, so I name no one. **[Not verified]**

The evidence. A 2024 study in Nature Aging led by S. Jay Olshansky of the University of Illinois Chicago found that life expectancy in the longest-lived countries rose only about six and a half years from 1990, and that gains are slowing. The study's title calls radical life extension this century implausible. Olshansky put it this way: the era of rapid gains is not ahead of us. "Instead, it's behind us."[188]

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[184] Benjamin Todd, 80,000 Hours (nonprofit career advice group), "Shrinking AGI timelines: a review of expert forecasts", March 21, 2025, updated February 4, 2026. https://80000hours.org/2025/03/when-do-experts-expect-agi-to-arrive/. Accessed November 18, 2026.

[185] Matthias Bastian, The Decoder, "Google Deepmind's AI Co-Scientist now plans experiments, runs lab equipment, and writes scientific papers", August 28, 2026. https://the-decoder.com/google-deepminds-ai-co-scientist-now-plans-experiments-runs-lab-equipment-and-writes-scientific-papers/. Accessed November 18, 2026.

[186] Chemistry World, "New analysis raises doubts over autonomous lab's materials 'discoveries'", 2024. https://chemistryworld.com/news/new-analysis-raises-doubts-over-autonomous-labs-materials-discoveries/4018791.article. Accessed November 18, 2026.

[187] Chemistry World, "New analysis raises doubts over autonomous lab's materials 'discoveries'", 2024. https://chemistryworld.com/news/new-analysis-raises-doubts-over-autonomous-labs-materials-discoveries/4018791.article. Accessed November 18, 2026.

[188] Rob Mitchum, University of Illinois Chicago, "Despite medical advances, life expectancy gains are slowing", October 7, 2024. on Olshansky et al., Nature Aging (2024). https://today.uic.edu/despite-medical-advances-life-expectancy-gains-are-slowing/. Accessed

Classification: Refuted as a near-term claim. Specific treatments may slow specific diseases of aging. A general leap to 150 has no evidence behind it.

5. Unapproved "stem cell" and exosome treatments

The claim. That private clinics can repair joints, nerves or organs with stem cell or exosome injections today.

Spread. Through clinic advertising directly to patients.

The evidence. The FDA states that it "has received reports of blindness, tumor formation, infections, and more" from unapproved products, and that these products need FDA approval before they can be marketed.[189]

Classification: Refuted as marketed, and a safety risk. Approved cell and gene therapies exist (Chapter 4). Unapproved clinic products are not the same thing.

6. LK-99, the "room-temperature superconductor"

The claim. That a South Korean team had made a material that carries electricity with no loss at room temperature and normal pressure.

Earliest appearance and spread. Online preprints in the summer of 2023. Within weeks, videos and posts spread worldwide, and labs raced to copy it.[190]

The evidence. Nature reported that LK-99 is not a superconductor. Researchers at the Max Planck Institute in Stuttgart made pure samples and found they did not show the effect; copper sulfide impurities explained the sudden drop in resistance that excited people.[191]

Classification: Refuted. This is science working as it should: a bold claim, fast public testing, a clear answer.

7. Microsoft's topological qubit

The claim. That Microsoft's Majorana 1 chip, announced in February 2025, uses a new and more stable kind of qubit.

Earliest appearance. Microsoft's announcement in February 2025, made "by press release, without publicly shared data backing it up," with a paper in Nature at the same time.[192]

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[189] U.S. Food and Drug Administration, "Important Patient and Consumer Information About Regenerative Medicine Therapies", content current as of April 8, 2024. https://www.fda.gov/vaccines-blood-biologics/consumers-biologics/important-patient-and-consumer-information-about-regenerative-medicine-therapies. Accessed November 18, 2026.

[190] Francisco Pires, Tom's Hardware, "Science Journal Says LK-99 Superconductor Dream is Over", August 17, 2023. https://www.tomshardware.com/news/science-journal-says-lk-99-superconductor-dream-is-over. Accessed November 18, 2026.

[191] Francisco Pires, Tom's Hardware, "Science Journal Says LK-99 Superconductor Dream is Over", August 17, 2023. https://www.tomshardware.com/news/science-journal-says-lk-99-superconductor-dream-is-over. Accessed November 18, 2026.

[192] Emily Conover, Science News, "Physicists are mostly unconvinced by Microsoft's new topological quantum chip", March 27, 2025. https://www.sciencenews.org/article/microsoft-topological-quantum-majorana. Accessed November 18, 2026.

What the people named said. St Andrews physicist Henry Legg said, "The data was incredibly unconvincing." Physicist Sankar Das Sarma said, "I'm persuaded." Microsoft's Roman Lutchyn said, "We stand behind the results."[193] In June 2026 Legg published a peer-reviewed critique in Nature arguing that Microsoft's test method was flawed, and Microsoft's Chetan Nayak answered, "We stand by our results and our roadmap."[194]

Classification: Disputed. Science News reported that the Nature paper "fell short of demonstrating a topological qubit."[195] The question is not settled.

8. "A robot butler in every home"

The claim. That humanoid robots will soon do housework and factory work at large scale.

Who promoted it. TechSpot reported that Elon Musk predicted one million Tesla Optimus robots a year by 2030.[196] Interesting Engineering reported that Tesla's July 22, 2026, earnings call gave no count of Optimus robots built.[197]

What people in the industry said. McKinsey partner Ani Kelkar said "for every $100 spent on deploying robots today, only around $20 is the actual machine," and called it "a big extrapolation from watching videos of robots doing laundry to a butler." Many robots are still trained by people steering them remotely.[198]

The evidence. The largest makers shipped thousands of humanoids, not millions, by early 2026 (Chapter 9).[199]

Classification: Overstated. Humanoid robots are real and improving. The scale in the promises is far ahead of the numbers.

9. Carbon removal plants and their nameplates

The claim. That Climeworks' Mammoth plant in Iceland removes up to 36,000 tons of carbon dioxide a year.

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[193] Emily Conover, Science News, "Physicists are mostly unconvinced by Microsoft's new topological quantum chip", March 27, 2025. https://www.sciencenews.org/article/microsoft-topological-quantum-majorana. Accessed November 18, 2026.

[194] John E. Dunn, CIO, "Researchers cast new doubt on Microsoft's quantum computing advance", June 25, 2026. https://www.cio.com/article/4189626/researchers-cast-new-doubt-on-microsofts-quantum-computing-advance-3.html. Accessed November 18, 2026.

[195] Emily Conover, Science News, "Physicists are mostly unconvinced by Microsoft's new topological quantum chip", March 27, 2025. https://www.sciencenews.org/article/microsoft-topological-quantum-majorana. Accessed November 18, 2026.

[196] TechSpot, "The people building humanoid robots say the hype is running ahead of reality", undated. https://www.techspot.com/news/110738-people-building-humanoid-robots-hype-running-ahead-reality.html. Accessed November 18, 2026.

[197] Srishti Gupta, Interesting Engineering, "The humanoid robot reality check", July 31, 2026. https://interestingengineering.com/research/the-humanoid-robot-reality-check. Accessed November 18, 2026.

[198] TechSpot, "The people building humanoid robots say the hype is running ahead of reality", undated. https://www.techspot.com/news/110738-people-building-humanoid-robots-hype-running-ahead-reality.html. Accessed November 18, 2026.

[199] Srishti Gupta, Interesting Engineering, "The humanoid robot reality check", July 31, 2026. https://interestingengineering.com/research/the-humanoid-robot-reality-check. Accessed November 18, 2026.

Earliest appearance. The design or "nameplate" capacity the company published for the plant.[200]

The evidence. Heimildin, using registry figures, reported 105 tons in Mammoth's first ten months.[201] Climeworks answered that nameplate capacity "does not equal actual tons captured."[202] Bloomberg reported 675 tons in the first half of 2026 after upgrades.[203]

Classification: Overstated, if the design figure is read as a result. The company did not claim to have reached it. The lesson is to ask for tons actually removed.

What the nine have in common

Three patterns run through these cases. That reading is mine. **[Interpretation]**

1. **A lab result is not a product.** Fusion, AI science and quantum chips all had real lab results that were reported as if the product were close.
2. **Company claims come first and checks come later.** Majorana, A-Lab, humanoid counts and Mammoth all needed outside reporters or scientists to test the numbers.
3. **Open testing works.** LK-99 was settled in weeks because labs could repeat the experiment. The claims that stay disputed longest are the ones with the least public data.

[200] Maeve Allsup, Latitude Media, "On the ground at Climeworks' biggest DAC project", June 11, 2025. https://www.latitudemedia.com/news/on-the-ground-at-climeworks-biggest-dac-project. Accessed November 18, 2026.

[201] Valur Grettisson, Heimildin, "Climeworks' capture fails to cover its own emissions", May 15, 2025. https://heimildin.is/sxgw2/climeworks-capture-fails-to-cover-its-own-emissions/. Accessed November 18, 2026.

[202] Maeve Allsup, Latitude Media, "On the ground at Climeworks' biggest DAC project", June 11, 2025. https://www.latitudemedia.com/news/on-the-ground-at-climeworks-biggest-dac-project. Accessed November 18, 2026.

[203] Akshat Rathi and Alastair Marsh, Bloomberg (republished by Energy Connects), "Carbon Removal Pioneer Climeworks Increases CO2 Capture Sixfold", September 10, 2026. https://www.energyconnects.com/news/renewables/2026/september/carbon-removal-pioneer-climeworks-increases-co2-capture-sixfold/. Accessed November 18, 2026.

Chapter 18: The Blueprint

The fifteen on one page

Figure 3 shows all fifteen inventions on one page. The number on each card is its rank in this book. The cards are grouped by what they do for people: health, daily needs, safety and the planet, and, at the bottom, the foundations that make the rest cheaper or faster. Each card shows the readiness ratings from its chapter, one proof point, the main barrier, and the people whose work started it. The grouping is my own way of organizing the list. **[Interpretation]**

THE NEXT FIFTEEN: A BLUEPRINT

Fifteen inventions ranked by how many people they could help in the next 20 years, and where each stands on November 18, 2026



Figure 3. The Next Fifteen blueprint. Facts on each card come from the chapter for that invention. The ranking, grouping and readiness ratings are the author's judgment.

Where each one stands

Rank	Invention	Most advanced part today	Least advanced part today
1	Cheap clean power	Solar and batteries, 5	Fusion power, 2
2	Clean water	Treatment and desalination, 5	Reaching every person, 2
3	Infectious disease	Antibiotics and prevention, 5	Staying ahead of resistance, 2
4	Gene and cell medicine	Gene editing for blood diseases, 4	Slowing aging, 1 to 2
5	AI for science	AI tools in laboratories, 4	AI running research on its own, 2
6	Internet and AI tutors	AI tutoring trials, 3	Access for the 2.2 billion offline, 2
7	Crops and fertilizer	High-yield seed and fertilizer, 5	Affordable healthy diets for everyone, 2
8	Climate pollution	Methane detection, 4	Carbon removal at scale, 1
9	Robots	Factory robots, 5	Humanoid robots and printed homes, 3
10	Brain implants	Speech implants, 3	Precise neural repair, 2 or lower
11	Clean cooking	Clean stoves and fuels, 5	Reaching the 2.1 billion without them, 2
12	Safer roads	Proven safety tools, 5	Halving deaths by 2030, 2
13	Early warnings	Warning systems in 60% of countries, 4	Everyone covered, 3
14	Heat protection	Air conditioning, 5	Protecting everyone at risk, 2
15	Eye and hearing care	Glasses, cataract surgery, hearing aids, 5	Reaching everyone who needs them, 2

Ratings use the five-step scale from the Introduction: 1 Idea, 2 Lab proof, 3 Trials and pilots, 4 Early market, 5 Widely used. They are my judgment from the evidence in each chapter.

The pattern

Look down the two right-hand columns and one pattern stands out. In nine of the fifteen rows, the most advanced part is already a 5, widely used. In almost all of those rows, the least advanced part is reaching the people who still go without. That is my reading of the table. **[Interpretation]**

It means the most useful "invention" for many of these problems may not be a new machine. It may be a cheaper, tougher, simpler version of a machine we already have, plus the money and people to deliver and maintain it. Cheap clean power, ranked first, makes that easier for water, cooking, cooling, fertilizer and connection all at once.

Conclusion

The essay asked what ten breakthroughs would do the most good. This book checked it, found it mostly sound, and offers a list of fifteen that leans harder on helping the most people soon. Here is where the evidence leaves things.

Well established

- The essay's three cited facts are true: the IEA's 2026 innovation review, gene editing approved for inherited blood diseases, and the IPCC's warning.[204]
- Very large numbers of people still go without tools that already exist: 2.1 billion without safely managed drinking water, 2.1 billion cooking with polluting fuels, 2.2 billion offline, and at least 1 billion with vision problems that were preventable or have not been treated.[205]
- Several causes of death that existing or improved tools could cut are each linked to hundreds of thousands to millions of deaths a year: household smoke (about 2.9 million in 2021), road crashes (about 1.19 million), malaria (about 610,000 in 2024) and heat (about 546,000 a year).[206]
- Fusion ignition is real. Fusion electricity is not here.[207]
- Solar and batteries are already cheap, and about 70 percent of fossil fuel methane can be cut with existing technology.[208]

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[204] International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary. Accessed November 18, 2026. Gillian McGovern, Pharmacy Times, "FDA Approves Casgevy, Lyfgenia for the Treatment of Sickle Cell Disease", December 8, 2023. https://www.pharmacytimes.com/view/fda-approves-casgevy-lyfgenia-for-the-treatment-of-sickle-cell-disease. Accessed November 18, 2026. Intergovernmental Panel on Climate Change (page hosted by the European Commission, Knowledge4Policy), "AR6 Synthesis Report: Climate Change 2023", March 21, 2023. https://knowledge-for-policy.ec.europa.eu/publication/ar6-synthesis-report-climate-change-2023_en. Accessed November 18, 2026.

[205] World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef. Accessed November 18, 2026. World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026. International Telecommunication Union, "Global number of Internet users increases, but disparities deepen key digital divides", November 17, 2025. https://www.itu.int/en/mediacentre/Pages/PR-2025-11-17-facts-and-figures.aspx. Accessed November 18, 2026. World Health Organization, "Blindness and vision impairment (fact sheet)", February 10, 2026. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. Accessed November 18, 2026.

[206] World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health. Accessed November 18, 2026. World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/. Accessed November 18, 2026. Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain. Accessed November 18, 2026. World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025. https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report. Accessed November 18, 2026.

[207] David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone. Accessed November 18, 2026. Lawrence Livermore National Laboratory, "Annual Report 2025: National Ignition Facility", February 2026. pp. 8-9. https://annual.llnl.gov/sites/annual/files/2026-02/llnlannual25-3-national-ignition-facility.pdf. Accessed November 18, 2026.

[208] JP Casey, PV Tech, "IRENA: Solar LCOE falls 12% year-on-year, 90% since 2010", September 26, 2024. reporting IRENA, Renewable Power Generation Costs in 2023. https://www.pv-tech.org/irena-solar-lcoe-falls-12-year-on-year-90-since-2010. Accessed November 18, 2026. BloombergNEF (energy research firm), "Lithium-Ion Battery Pack Prices Fall to $108 Per Kilowatt-Hour, Despite Rising Metal Prices", December 9, 2025. https://about.bnef.com/insights/clean-energy/lithium-ion-battery-pack-prices/. Accessed November 18, 2026. International Energy Agency, "Global Methane Tracker 2026: Key findings", 2026. https://www.iea.org/reports/global-methane-

Reasonable inference

- Cheaper clean power would make water, cooling, cooking, fertilizer and connection cheaper. The direction is clear; the size of the effect is not measured here.
- For at least nine of the fifteen, delivery and cost matter more than new invention.
- The famous high-tech fields (fusion, autonomous AI science, quantum computing, space travel) will matter, but most of their payoff for ordinary people is further away than the payoff from spreading tools we already have.

Unresolved

- When fusion will put power on the grid.
- Whether AI research systems can be made reliable enough to trust without close human checking.
- Whether new antibiotics and antimalarials will keep pace with resistance.
- Whether direct air capture can reach its design scale at a cost the world can pay.
- Whether the goals of everyone covered by early warnings by 2027 and road deaths halved by 2030 will be met.

Blind spots that could change these findings

The record I could read favors English-language sources, the United States and Europe, and organizations that keep and publish good records. Global death figures for smoke, heat and drug resistance are model estimates. Company claims arrive before outside checks. And the ranking is mine: someone who weighs long-term breakthroughs above near-term lives would order this list differently, and could make a good case.

The answer to the central question

Which inventions should humanity work on next to help the most people? **Cheap clean power first, then the basics that keep people alive: clean water, protection from infectious disease, and medicine people can afford. After those, the tools that multiply everything else: AI that checks its own work and a connection for every learner.** The rest of the fifteen follow. The strongest lesson of the record is the one that runs through every chapter: for most of these problems, the hard part is no longer inventing. It is paying, building, checking and delivering.

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tracker-2026/key-findings. Accessed November 18, 2026.

Appendix A: Chronology

Every date below appears in a chapter of this book with its source.

Date	Event	Chapter
About 780 to about 850	Life of al-Khwarizmi, who worked at the House of Wisdom in Baghdad	6
1206	al-Jazari completes his Book of Knowledge of Ingenious Mechanical Devices	9
About 1455	Gutenberg Bible printed in Mainz; Korea had used movable metal type nearly a century earlier	6
About 1495	Leonardo da Vinci's mechanical knight, possibly built for the Duke of Milan	9
1824	Joseph Fourier describes how the atmosphere raises Earth's temperature	8
August 1831	Michael Faraday discovers electromagnetic induction	1
1843	Ada Lovelace publishes her notes, including Note G	5
1856	Eunice Foote's carbon dioxide experiment is presented, by Joseph Henry	8
May 18, 1859	John Tyndall records key results on heat absorption by gases	8
1882 and 1887	Nikola Tesla works out the rotating magnetic field (1882) and builds a two-phase AC motor (1887)	1
August 20, 1897	Ronald Ross finds the malaria parasite in a mosquito, Secunderabad, India	3
July 17, 1902	Willis Carrier designs the first modern air-conditioning system (company history)	14
1903	Konstantin Tsiolkovsky publishes rocket theory in Russian	16
1906	Ramon y Cajal and Golgi share the Nobel Prize in Physiology or Medicine	10
October 13, 1908	Fritz Haber files his ammonia patent	7
1913	First full-scale Haber-Bosch plant starts at Oppau, Germany	7
1915	Haber directs the first large-scale chlorine gas release, at Ypres	7
1919 to 1920	Robert Goddard's "A Method of Reaching Extreme Altitudes" (dated 1919; released early 1920 per the Smithsonian)	16
March 16, 1926	Goddard launches the first liquid-fuel rocket	16
September 3, 1928	Alexander Fleming notices penicillin killing bacteria	3
1945	Fleming, Florey and Chain share the Nobel Prize for penicillin	3
November 29, 1949	Harold Ridley performs the first intraocular lens surgery, St Thomas' Hospital, London	15
1950	Alan Turing publishes "Computing Machinery and	5

Date	Event	Chapter
	Intelligence"	
Summer 1952	Rosalind Franklin and Raymond Gosling's Photo 51	4
April 1953	Double helix papers in Nature	4
April 25, 1954	Bell Labs announces the silicon solar cell	1
1956	Mexico becomes self-sufficient in wheat	7
1959	Nils Bohlin perfects the three-point seat belt at Volvo	12
1960	Loeb and Sourirajan file for a reverse osmosis membrane patent	2
1961	First Unimate robot installed at General Motors, Trenton, New Jersey	9
1965	First large-scale reverse osmosis demonstration, Coalinga, California	2
1970	Norman Borlaug receives the Nobel Peace Prize	7
1978	Graeme Clark implants the first modern multichannel cochlear implant, Melbourne	15
Mid-1980s	Clarke, Devoret and Martinis show quantum behavior in an electric circuit	16
2006 and 2007	Shinya Yamanaka reprograms mouse, then human, cells into stem cells	4
2012	Doudna and Charpentier's CRISPR-Cas9 paper in Science	4
December 21, 2015	Falcon 9 first stage lands after an orbital launch	16
2022	UN Secretary-General launches Early Warnings for All	13
December 5, 2022	National Ignition Facility achieves fusion ignition (announced December 13)	1, 17
March 2023	IPCC Synthesis Report	8
May 2023	Helion and Microsoft fusion power purchase agreement	1, 17
Summer 2023	LK-99 superconductor claim spreads, then fails	16, 17
November 2023	A-Lab paper in Nature	5, 17
December 8, 2023	FDA approves Casgevy, the first CRISPR therapy, for sickle cell disease	4
2024	GRAM study in The Lancet forecasts more than 39 million drug-resistance deaths by 2050	3
January 16, 2024	Casgevy approved for transfusion-dependent beta thalassemia	4
July 2024	ITER moves full fusion fuel operation to 2039	1, 17
August 2024	UC Davis speech implant results; Department of Agriculture approves HB4 wheat	10, 7
October 2024	Nobel Prize in Chemistry for protein structure and design	5
December 2024	Google announces the Willow quantum chip	16

Date	Event	Chapter
January 25, 2025	Tim Andrews receives a pig kidney	4
February 2025	Baby KJ receives personalized gene editing; Microsoft announces Majorana 1	4, 16
April 7, 2025	NIF record: 8.6 MJ from 2.08 MJ of laser energy	1
May 2025	Heimildin reports Mammoth's first-ten-month total of 105 tons	8
June 2025	DARPA cancels the DRACO nuclear rocket	16
October 2025	Lancet Countdown reports an average of 546,000 heat deaths a year	14
October 2025	Nobel Prize in Physics to Clarke, Devoret and Martinis	16
November 2025	ITU reports 2.2 billion people offline	6
November 2025	WMO reports 119 countries with multi-hazard early warning systems	13
December 2025	WHO: 2.1 billion people cook with polluting fuels; 2.9 million deaths in 2021	11
2026	IEA Global Methane Tracker 2026: no sign fossil methane fell in 2025	8
February 2026	IEA publishes The State of Energy Innovation 2026	1
March 2026	WMO confirms 2025 at 1.43 degrees Celsius above the 1850-1900 average	8
April 1-10, 2026	Artemis II crew flies around the Moon	16
May 1, 2026	WHO: about 1.19 million road deaths a year	12
June 2026	Peer-reviewed critique of Microsoft's quantum chip published in Nature	16, 17
September 2026	Bloomberg reports Mammoth removed 675 tons in the first half of 2026	8
November 18, 2026	Information cutoff for this book	

Appendix B: Claims and Verdicts

Each factual claim from the original essay, the verdict, and the chapter where the evidence is laid out. "Before the List" is the chapter that checks the essay as a whole.

#	Claim in the essay	Verdict	Chapter
1	The IEA's 2026 review "identifies progress across fusion, geothermal, solar, and batteries"	True	1
2	Energy work should aim at "continuously available electricity, not just fusion"	True (the evidence supports this advice)	1
3	Faraday, Tesla, Einstein and Maxwell as the inspiration for clean energy	Partly true	1
4	AI research systems that propose hypotheses, design experiments and check results	Partly true: early systems exist, with documented errors	5
5	"Gene editing is already treating certain inherited diseases"	True	4
6	Replacing damaged organs	Partly true: in trials	4
7	"Slow specific mechanisms of age-related deterioration"	Inconclusive	4
8	Robots that construct housing and maintain infrastructure	Partly true: pilots only	9
9	Clean water and food: main challenge is "cost and distribution"	True	2
10	Haber, Bosch, Pasteur and Borlaug as the inspiration	True, with a missing caution about Haber	7
11	Useful fault-tolerant quantum computers	Inconclusive (a goal, not yet met)	16
12	New superconductors	Inconclusive	16
13	Restore communication lost to disease	Partly true: works in trials	10
14	"The IPCC documents the urgency of climate mitigation and adaptation"	True	8
15	Affordable carbon removal	Not achieved; scale at readiness 1	8
16	Fourier, Arrhenius, Darwin and Lovelock as the inspiration	Partly true	8
17	Cheaper launch systems and reusable transportation	Partly true	16
18	Nuclear-electric propulsion research	A sound choice; Inconclusive as an outcome	16
19	Expert-level education accessible to everyone	Not yet achieved	6
20	Gutenberg, al-Khwarizmi, Lovelace and	True	6

#	Claim in the essay	Verdict	Chapter
	Turing as the inspiration		
21	The planning table's main challenges	True for all ten	Before the List
22	The planning table's horizons	Partly true as a guide; Inconclusive as predictions	Before the List
23	Energy as the number-one choice	An opinion; not rated	Before the List

The sources behind each verdict are in the footnotes of the chapter named, and in Appendix D.

Appendix C: Charts and Visual Records

Visuals used in this book

All three figures were made for this book by the author from the data in the sources named. No outside image is reproduced.

Figure 1. Fusion energy out vs. energy in, National Ignition Facility

- Creator and date: Andrew Dominguez, 2026
- Data sources: Physics Today (Dec. 13, 2022); Lawrence Livermore National Laboratory Annual Report 2025
- Rights: Original work. All rights reserved.
- Placement: Chapter 1
- Alt text: Bar chart. In December 2022, fusion output of 3.15 MJ exceeded laser input of 2.05 MJ but was about 1% of roughly 300 MJ drawn from the grid. In April 2025, output was 8.6 MJ from 2.08 MJ of laser energy.

Figure 2. Mammoth direct air capture plant

- Creator and date: Andrew Dominguez, 2026
- Data sources: Latitude Media (2025); Heimildin (2025); Bloomberg (2026)
- Rights: Original work. All rights reserved.
- Placement: Chapter 8
- Alt text: Bar chart. Design capacity for six months is 18,000 tons; actual removal was 675 tons in the first half of 2026 and 105 tons in the first ten months of operation.

Figure 3. The Next Fifteen blueprint

- Creator and date: Andrew Dominguez, 2026
- Data sources: Chapters 1 to 16
- Rights: Original work. All rights reserved.
- Placement: Chapter 18
- Alt text: Diagram of fifteen cards in four groups (health, daily needs, safety and the planet, foundations), each with a readiness rating from 1 to 5, one proof point, the main barrier and documented roots, plus a watch-list card for quantum computing and space transportation.

Candidate visuals not used, with rights status

These images were considered and left out. They are listed so a later edition can use them after a rights check.

Portrait of Michael Faraday

- Creator and date: Thomas Phillips, oil on canvas, 1841-1842
- Holder: National Portrait Gallery, London (collection number 269)
- Rights status: Painter died 1845. Wikimedia Commons lists the photo of the painting as public domain under its PD-Art tag. Not downloaded or checked against the gallery's own terms.

- Recommendation: Usable after confirming the gallery's reuse terms for the specific photograph.

Watercolor portrait of Ada Lovelace

- Creator and date: About 1840, possibly by A. E. Chalon
- Holder: Science Museum Group (object 1995-796)
- Rights status: **Rights conflict.** Wikimedia Commons lists it as public domain, but the Science Museum licenses its image under CC BY-NC-SA 4.0, a Creative Commons license that bars commercial use,, with commercial use through the Science and Society Picture Library.
- Recommendation: Do not use in any sold edition without a license.

Robert Goddard with his 1926 rocket

- Creator and date: NASA photograph
- Holder: NASA
- Rights status: **Unverified.** NASA images are generally free to use, but I could not open the NASA rights page or the image record.
- Recommendation: Confirm on the NASA image record before use.

Appendix D: Full Source List

Every source cited in this book is listed here once, grouped by the five tiers explained in the Introduction. Sources were read on November 18, 2026.

Tier 1: Primary and official sources

- Archivist, London School of Hygiene and Tropical Medicine, for the U.S. Centers for Disease Control and Prevention, "Ross and the Discovery that Mosquitoes Transmit Malaria Parasites", undated. https://www.cdc.gov/malaria/about/history/ross.html.

- Australian Space Agency, "A century of lift-offs", 2026. https://www.space.gov.au/news-and-media/century-of-lift-offs.

- Food and Agriculture Organization of the United Nations, "SOFI 2025: FAO calls for urgent, coordinated and inclusive action to end global hunger", July 28, 2025. https://www.fao.org/newsroom/detail/sofi-2025--fao-calls-for-urgent--coordinated-and-inclusive-action-to-end-global-hunger.

- Intergovernmental Panel on Climate Change (page hosted by the European Commission, Knowledge4Policy), "AR6 Synthesis Report: Climate Change 2023", March 21, 2023. https://knowledge-for-policy.ec.europa.eu/publication/ar6-synthesis-report-climate-change-2023_en.

- International Telecommunication Union, "Global number of Internet users increases, but disparities deepen key digital divides", November 17, 2025. https://www.itu.int/en/mediacentre/Pages/PR-2025-11-17-facts-and-figures.aspx.

- ITER Organization, "Press Conference Summary: Summary of Presentation by Pietro Barabaschi, ITER Director-General", July 3, 2024. p. 2. https://iter.org/sites/default/files/media/2024-07/baseline_press_conference_summary_july-2024_b.pdf.

- Lawrence Livermore National Laboratory, "Annual Report 2025: National Ignition Facility", February 2026. pp. 8-9. https://annual.llnl.gov/sites/annual/files/2026-02/llnlannual25-3-national-ignition-facility.pdf.

- Library of Congress, "The Gutenberg Bible", undated. https://www.loc.gov/exhibits/bibles/interactives/gutenberg/index.html.

- U.S. Food and Drug Administration, "Important Patient and Consumer Information About Regenerative Medicine Therapies", content current as of April 8, 2024. https://www.fda.gov/vaccines-blood-biologics/consumers-biologics/important-patient-and-consumer-information-about-regenerative-medicine-therapies.

- World Health Organization, "Blindness and vision impairment (fact sheet)", February 10, 2026. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment.

- World Health Organization, "Climate inaction is claiming millions of lives every year, warns new Lancet Countdown report (news release)", October 29, 2025.

https://www.who.int/news/item/29-10-2025-climate-inaction-is-claiming-millions-of-lives-every-year--warns-new-lancet-countdown-report.

- World Health Organization, "Deafness and hearing loss (health topic page)", undated, read November 18, 2026. https://www.who.int/health-topics/hearing-loss.
- World Health Organization, "Household air pollution and health (fact sheet)", December 16, 2025. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health.
- World Health Organization, "Road traffic injuries (fact sheet)", May 1, 2026. https://www.who.int/mediacentre/factsheets/fs358/en/.
- World Health Organization and UNICEF, "1 in 4 people globally still lack access to safe drinking water", August 26, 2025. https://www.who.int/news/item/26-08-2025-1-in-4-people-globally-still-lack-access-to-safe-drinking-water---who--unicef.
- World Meteorological Organization, "State of the Global Climate 2025", March 23, 2026. https://wmo.int/publication-series/state-of-global-climate/state-of-global-climate-2025.
- World Meteorological Organization, "State of the Global Climate 2025: At a Glance", March 2026. https://wmo.int/sites/default/files/2026-03/State%20of%20the%20Climate%202025_1%20pager_final.pdf.
- World Meteorological Organization and UN Office for Disaster Risk Reduction, "Early warning systems reach new heights, but critical gaps jeopardize global progress (press release)", November 12, 2025. https://wmo.int/news/media-centre/early-warning-systems-reach-new-heights-critical-gaps-jeopardize-global-progress.

Tier 2: Nonpartisan analysis

- International Energy Agency, "Energy innovation enters security-focused phase as batteries dominate patent landscape", February 2026. https://www.iea.org/news/energy-innovation-enters-security-focused-phase-as-batteries-dominate-patent-landscape.
- International Energy Agency, "Global Methane Tracker 2026: Key findings", 2026. https://www.iea.org/reports/global-methane-tracker-2026/key-findings.
- International Energy Agency, "The State of Energy Innovation 2026: Executive Summary", February 2026. https://www.iea.org/reports/the-state-of-energy-innovation-2026/executive-summary.
- Martin De Simone, Federico Tiberti, Maria Barron Rodriguez, Federico Manolio, Wuraola Mosuro and Eliot Jolomi Dikoru, World Bank, "From Chalkboards to Chatbots: Evaluating the Impact of Generative AI on Learning Outcomes in Nigeria", May 20, 2025. Policy Research Working Paper 11125. https://openknowledge.worldbank.org/entities/publication/15e1ff08-15ae-4f7a-b2a8-d146e6c113ee/full.
- Thomas G. Roberts, CSIS Aerospace Security Project, "Space Launch to Low Earth Orbit: How Much Does It Cost?", updated September 1, 2022. https://aerospace.csis.org/data/space-launch-to-low-earth-orbit-how-much-does-it-cost/.

Tier 3: Scholarly sources

- Alan Chodos, APS News (American Physical Society), "April 25, 1954: Bell Labs Demonstrates the First Practical Silicon Solar Cell", April 2009. https://aps.org/apsnews/2009/04/bell-labs-silicon-solar-cell.

- Alan M. Turing, "Computing Machinery and Intelligence", 1950. Mind 59: 433-60; excerpt published by MIT OpenCourseWare 24.09x. https://openlearninglibrary.mit.edu/assets/courseware/v1/0c0db957c39184b538869f8d9e9a3b56/asset-v1:MITx+24.09x+3T2019+type@asset+block/5_turing_computing_machinery_and_intelligence.pdf.

- Allison Marsh, IEEE Spectrum, "In 1961, the First Robot Arm Punched In", August 30, 2022. https://spectrum.ieee.org/unimation-robot.

- American Institute of Physics, "2025 Nobel Prize Resources", October 2025. https://www.aip.org/nobel-prize-2025.

- Center for iPS Cell Research and Application, Kyoto University, "CiRA Director Shinya Yamanaka Wins the Nobel Prize in Physiology or Medicine", October 8, 2012. https://www.cira.kyoto-u.ac.jp/e/pressrelease/other/121008-183500.html.

- Encyclopaedia Britannica, "al-Khwarizmi", undated. https://www.britannica.com/biography/al-Khwarizmi.

- Encyclopaedia Britannica, "Alexander Fleming", undated. https://www.britannica.com/biography/Alexander-Fleming.

- Europeana, "Europe's First Printed Book", undated. https://www.europeana.eu/es/blog/europes-first-printed-book.

- Frank A. J. L. James, Physics Today, "The legacies of the Royal Institution", August 1, 2018. vol. 71, no. 8, pp. 36-43, doi:10.1063/PT.3.3996. https://physicstoday.aip.org/features/the-legacies-of-the-royal-institution.

- Greg Kestin, Kelly Miller, Anna Klales, Timothy Milbourne and Gregorio Ponti, "AI tutoring outperforms in-class active learning: an RCT introducing a novel research-based design in an authentic educational setting", June 3, 2025. Scientific Reports 15: 17458, doi:10.1038/s41598-025-97652-6. https://pmc.ncbi.nlm.nih.gov/articles/PMC12179260/.

- Jan Willem Erisman, Mark A. Sutton, James Galloway, Zbigniew Klimont and Wilfried Winiwarter, "How a century of ammonia synthesis changed the world", September 28, 2008. Nature Geoscience 1: 636-639, doi:10.1038/ngeo325. https://www.nature.com/articles/ngeo325.

- Joachim Pietzsch, NobelPrize.org, "Speed read: Exposing the forest", September 16, 2009. https://nobelprize.org/prizes/medicine/1906/speedread.

- Joyce P. K. Ho, Hannah North and Narinder P. Singh, "Forty years of "Waltzing Matilda": the history of the multichannel cochlear implant", December 3, 2018. Medical Journal of Australia 209, no. 11: 476-478. https://www.mja.com.au/journal/2018/209/11/forty-years-waltzing-matilda-history-multichannel-cochlear-implant.

- Marissa Locke Rottinghaus, ASBMB Today (American Society for Biochemistry and Molecular Biology), "Nobel for 'breakthrough in biochemistry'", October 9, 2024. https://www.asbmb.org/asbmb-today/science/100924/nobel-for-breakthrough-in-biochemistry.
- Michael J. Neufeld and Frank H. Winter, Smithsonian National Air and Space Museum, "Robert Goddard: Secret Space Visionary", March 16, 2026. https://www.airandspace.si.edu/stories/editorial/robert-goddard-secret-space-visionary.
- Nadine A. Yehya, UC Davis Health, "New brain-computer interface allows man with ALS to 'speak' again", August 14, 2024. https://health.ucdavis.edu/welcome/news/headlines/new-brain-computer-interface-allows-man-with-als-to-speak-again/2024/08.
- NobelPrize.org, "Albert Einstein: Facts", undated. https://www.nobelprize.org/prizes/physics/1921/einstein/facts.
- NobelPrize.org, "Norman Borlaug: Facts", undated. https://www.nobelprize.org/prizes/peace/1970/borlaug/facts/.
- Notices of the American Mathematical Society, "An Enchantress of Number? Reassessing the Mathematical Reputation of Ada Lovelace", March 2024. https://www.ams.org/journals/notices/202403/noti2890/noti2890.html.
- Penn Medicine and Children's Hospital of Philadelphia, "World's first patient treated with personalized CRISPR gene editing therapy at Children's Hospital of Philadelphia", May 15, 2025. https://www.pennmedicine.org/news/worlds-first-patient-treated-with-personalized-crispr-therapy.
- Rob Mitchum, University of Illinois Chicago, "Despite medical advances, life expectancy gains are slowing", October 7, 2024. on Olshansky et al., Nature Aging (2024). https://today.uic.edu/despite-medical-advances-life-expectancy-gains-are-slowing/.
- Robert Sanders, UC Berkeley (University of California), "Jennifer Doudna wins 2020 Nobel Prize in chemistry", October 7, 2020. https://www.universityofcalifornia.edu/news/jennifer-doudna-wins-2020-nobel-prize-chemistry.
- Roland Jackson, Royal Institution, "Who discovered the greenhouse effect?", May 17, 2019. https://www.rigb.org/explore-science/explore/blog/who-discovered-greenhouse-effect.
- Science Museum Group Collection, "James Ephraim Lovelock", undated. https://collection.sciencemuseumgroup.org.uk/people/ap20636/lovelock-james-ephraim.
- Selina Hurley, Science Museum, "A visionary innovation: Harold Ridley and the first intra-ocular surgery", November 29, 2024. https://blog.sciencemuseum.org.uk/a-visionary-innovation-harold-ridley-and-the-first-intra-ocular-surgery/.
- Sidney Perkowitz, Distillations, Science History Institute, "How Two Outsider Scientists Saw Inside Climate Change", September 22, 2021. https://www.sciencehistory.org/stories/magazine/how-two-outsider-scientists-saw-inside-climate-change/.

- Sonja Soo, University of British Columbia Computer Science, "Researchers create an 'AI Scientist' that conducts its own scientific research", March 25, 2026. on Lu et al., Nature (2026), doi:10.1038/s41586-026-10265-5. https://www.cs.ubc.ca/news/2026/03/ai-scientist.
- UCLA Samueli School of Engineering, "Clean Water for All", March 19, 2019. https://samueli.ucla.edu/clean-water/.
- William B. Ashworth Jr., Linda Hall Library, "Scientist of the Day: Rosalind Franklin", July 25, 2018. https://www.lindahall.org/about/news/scientist-of-the-day/rosalind-franklin/.

Tier 4: Journalism

- AABB (Association for the Advancement of Blood and Biotherapies), "FDA Expands Gene Therapy Approval to Include Beta-Thalassemia", January 17, 2024. https://www.aabb.org/news-resources/news/article/2024/01/17/fda-expands-gene-therapy-approval-to-patients-with-beta-thalassemia.
- Akshat Rathi and Alastair Marsh, Bloomberg (republished by Energy Connects), "Carbon Removal Pioneer Climeworks Increases CO2 Capture Sixfold", September 10, 2026. https://www.energyconnects.com/news/renewables/2026/september/carbon-removal-pioneer-climeworks-increases-co2-capture-sixfold/.
- Anu Bhambhani, TaiyangNews, "IRENA: Solar Power Averaged $0.043/kWh Globally In 2024", July 24, 2025. reporting IRENA, Renewable Power Generation Costs in 2024. https://taiyangnews.info/business/irena-renewable-power-generation-costs-in-2024-report.
- Chemistry World, "New analysis raises doubts over autonomous lab's materials 'discoveries'", 2024. https://chemistryworld.com/news/new-analysis-raises-doubts-over-autonomous-labs-materials-discoveries/4018791.article.
- Chris Dall, CIDRAP (University of Minnesota), "Study forecasts more than 39 million deaths from antimicrobial resistance by 2050", undated (on the GRAM study in The Lancet, 2024). https://www.cidrap.umn.edu/antimicrobial-stewardship/study-forecasts-more-39-million-deaths-antimicrobial-resistance-2050.
- Chris Dall, CIDRAP (University of Minnesota), "WHO celebrates progress against malaria, but warns that hurdles remain", undated (on the WHO World Malaria Report 2025). https://www.cidrap.umn.edu/malaria/who-celebrates-progress-against-malaria-warns-hurdles-remain.
- Claudia Flavell-While, The Chemical Engineer (IChemE), "Fritz Haber and Carl Bosch: Feed the World", March 1, 2010. https://www.thechemicalengineer.com/features/cewctw-fritz-haber-and-carl-bosch-feed-the-world.
- collectSPACE, "SpaceX returns to flight, and to the launch site: Falcon 9 stage lands at Cape", December 21, 2015. https://www.collectspace.com/news/news-122115c-spacex-falcon9-launch-landing.html.
- Danny Gallagher, Engadget, "A robotics company has 3D printed nearly a hundred homes in Texas", August 8, 2024. https://www.engadget.com/home/a-robotics-company-has-3d-printed-nearly-a-hundred-homes-in-texas-225830931.html.

- DatacenterDynamics, "Helion begins work at fusion plant, expects to deliver power to Microsoft by 2028", 2025. https://datacenterdynamics.com/en/news/helion-begins-work-at-fusion-plant-expects-to-deliver-power-to-microsoft-by-2028/.
- David Kramer, Physics Today, "National Ignition Facility surpasses long-awaited fusion milestone", December 13, 2022. https://physicstoday.aip.org/news/national-ignition-facility-surpasses-long-awaited-fusion-milestone.
- Elise Reuter, MedTech Dive, "Precision Neuroscience receives FDA clearance for brain implant", April 21, 2025. https://www.medtechdive.com/news/precision-neuroscience-brain-implant-fda-cleared/745913/.
- Emily Conover, Science News, "Physicists are mostly unconvinced by Microsoft's new topological quantum chip", March 27, 2025. https://www.sciencenews.org/article/microsoft-topological-quantum-majorana.
- Evan Andrews, HISTORY, "7 Early Robots and Automatons", October 28, 2014, updated May 27, 2025. https://www.history.com/articles/7-early-robots-and-automatons.
- Francisco Pires, Tom's Hardware, "Science Journal Says LK-99 Superconductor Dream is Over", August 17, 2023. https://www.tomshardware.com/news/science-journal-says-lk-99-superconductor-dream-is-over.
- GeekWire, "Inside the race to power AI data centers with fusion energy, and the surprise detours along the way", 2026. https://www.geekwire.com/2026/inside-the-race-to-power-ai-data-centers-with-fusion-energy-and-the-surprise-detours-along-the-way/.
- Gillian McGovern, Pharmacy Times, "FDA Approves Casgevy, Lyfgenia for the Treatment of Sickle Cell Disease", December 8, 2023. https://www.pharmacytimes.com/view/fda-approves-casgevy-lyfgenia-for-the-treatment-of-sickle-cell-disease.
- Hugo Rojas, GCN, "Fervo Energy's Cape Station delivers first power from a utility-scale enhanced geothermal plant", October 1, 2026. https://gcn.com/enhanced-geothermal-fervo-energy-cape-station/22087/.
- John E. Dunn, CIO, "Researchers cast new doubt on Microsoft's quantum computing advance", June 25, 2026. https://www.cio.com/article/4189626/researchers-cast-new-doubt-on-microsofts-quantum-computing-advance-3.html.
- JP Casey, PV Tech, "IRENA: Solar LCOE falls 12% year-on-year, 90% since 2010", September 26, 2024. reporting IRENA, Renewable Power Generation Costs in 2023. https://www.pv-tech.org/irena-solar-lcoe-falls-12-year-on-year-90-since-2010.
- Maeve Allsup, Latitude Media, "On the ground at Climeworks' biggest DAC project", June 11, 2025. https://www.latitudemedia.com/news/on-the-ground-at-climeworks-biggest-dac-project.
- Matthias Bastian, The Decoder, "Google Deepmind's AI Co-Scientist now plans experiments, runs lab equipment, and writes scientific papers", August 28, 2026. https://the-decoder.com/google-deepminds-ai-co-scientist-now-plans-experiments-runs-lab-equipment-and-writes-scientific-papers/.

- Resultsense (republished from The Conversation), "Two new Nature papers show AI co-scientists' real limits", May 20, 2026. https://www.resultsense.com/news/2026-05-20-ai-scientists-nature-papers-limits/.
- Roni Caryn Rabin, The New York Times (republished by GV Wire), "In a First, a Pig Kidney Kept a Patient Alive Until He Got a Human One", September 3, 2026. https://gvwire.com/2026/09/14/in-a-first-a-pig-kidney-kept-a-patient-alive-until-he-got-a-human-one/.
- Skye Jacobs, TechSpot, "Quantinuum unveils Helios, claims a massive leap toward practical quantum computing", November 2025. https://www.techspot.com/news/110188-quantinuum-claims-massive-leap-toward-practical-quantum-computing.html.
- Srishti Gupta, Interesting Engineering, "The humanoid robot reality check", July 31, 2026. https://interestingengineering.com/research/the-humanoid-robot-reality-check.
- Steve Gorman and Joey Roulette, Reuters (republished by GV Wire), "Splashdown! Artemis II Astronauts Conclude 10-Day Moon Mission", April 10, 2026. https://gvwire.com/2026/04/10/splashdown-artemis-ii-astronauts-conclude-10-day-moon-mission/.
- TechSpot, "The people building humanoid robots say the hype is running ahead of reality", undated. https://www.techspot.com/news/110738-people-building-humanoid-robots-hype-running-ahead-reality.html.
- Theresa Hitchens, Breaking Defense, "DARPA's DRACO nuclear propulsion project ROARs no more", June 27, 2025. https://breakingdefense.com/2025/06/darpas-draco-nuclear-propulsion-project-roars-no-more/.
- Valur Grettisson, Heimildin, "Climeworks' capture fails to cover its own emissions", May 15, 2025. https://heimildin.is/sxgw2/climeworks-capture-fails-to-cover-its-own-emissions/.
- W. Bernard Carlson, National Geographic, "Edison and Tesla's cutthroat 'Current War' ushered in the electric age", September 27, 2019. https://www.nationalgeographic.com/history/history-magazine/article/edison-tesla-current-war-ushered-electric-age.
- World Grain, "HB4 wheat gains USDA approval", August 2024. https://world-grain.com/articles/20392-hb4-wheat-gains-usda-approval.
- World Nuclear News, "US researchers achieve historic fusion ignition", December 13, 2022. https://world-nuclear-news.org/Articles/US-researchers-achieve-historic-fusion-ignition.

Tier 5: Industry and advocacy

- bciintel.com (independent tracker, secondary source), "BCI FDA Approval Tracker: Every Brain Implant in the Pipeline (2026)", May 2026. https://bciintel.com/bci-fda-approval-tracker/.
- Benjamin Todd, 80,000 Hours (nonprofit career advice group), "Shrinking AGI timelines: a review of expert forecasts", March 21, 2025, updated February 4, 2026. https://80000hours.org/2025/03/when-do-experts-expect-agi-to-arrive/.

- BloombergNEF (energy research firm), "Lithium-Ion Battery Pack Prices Fall to $108 Per Kilowatt-Hour, Despite Rising Metal Prices", December 9, 2025. https://about.bnef.com/insights/clean-energy/lithium-ion-battery-pack-prices/.
- Carrier, "Invention of Air Conditioning", undated. https://www.carrier.com/us/en/history/invention-of-air-conditioning/.
- Hartmut Neven, Google Quantum AI, "Meet Willow, our state-of-the-art quantum chip", December 9, 2024. https://blog.google/technology/research/google-willow-quantum-chip/.
- International Federation of Robotics (industry association), "Global Robot Demand in Factories Doubles Over 10 Years", September 25, 2025. https://ifr.org/ifr-press-releases/news/global-robot-demand-in-factories-doubles-over-10-years.
- International Federation of Robotics (industry association), "World Robotics 2025: Industrial Robots, Executive Summary", 2025. pp. 13-18. https://ifr.org/img/worldrobotics/Executive_Summary_WR_2025_Industrial_Robots.pdf.
- National Kidney Foundation (patient advocacy group), "Pig Kidney Transplants in Humans: Xenotransplantation Explained by Experts", April 9, 2026. https://www.kidney.org/news-stories/pig-kidney-transplants-humans-xenotransplantation-explained-experts.
- Vertex Pharmaceuticals, "Vertex Announces US FDA Approval of CASGEVY (exagamglogene autotemcel) for the Treatment of Transfusion-Dependent Beta Thalassemia", January 16, 2024. https://news.vrtx.com/node/31811.
- Volvo Group, "The three points that saved one million lives", November 23, 2023. https://www.volvogroup.com/en/about-us/heritage/three-point-safety-belt.html.