EXHIBIT 1

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF CALIFORNIA

CONCORD MUSIC GROUP, INC., et al.,

Plaintiffs,

Case No. 24-cv-03811-EKL-SVK

v.

ANTHROPIC PBC,

Defendant.

EXPERT REPORT OF RUSS ALTMAN

DECEMBER 19, 2025

Highly Confidential – Attorneys' Eyes Only

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I. INTRODUCTION

A. Assignment

1. I have been retained by Wilmer Cutler Pickering Hale & Dorr LLP (Counsel) to provide expert testimony in connection with the matter *Concord Music Group, Inc. et al., v. Anthropic PBC,* No. 5:24-cv-3811-EKL (N.D. Cal.).

2. I have been asked to evaluate the public benefits and beneficial uses associated with Large Language Models (LLMs), drawing on my familiarity with LLMs in the areas in which I specialize, including biomedicine, healthcare, scientific research, the public sector, and education. Specifically, I have been asked to analyze how Anthropic's Claude (Claude) is being used across a variety of domains. Where possible, I highlight quantifiable outcomes (including published research, case studies, and documented real-world deployments) that illustrate Claude's utility. I have been instructed that, where relevant, I may draw upon broader examples from other LLMs to provide scientific or practical context.

3. In addition to evaluating Claude's benefits, I assess its potential risks and the conditions necessary to ensure safe, reliable deployment, especially in high-stakes environments like healthcare and public decision-making.

4. The scope of my opinions, research, and report is limited to the issues described in the paragraphs above. I have not been asked to opine on issues beyond the scope of my assignment.

5. It is important to note that AI, and LLMs in particular, is a rapidly evolving field. My opinions expressed in this report reflect the state of knowledge and evidence that was available to me at the time of writing this report. My work in this matter is ongoing. I reserve the right to supplement or revise my opinions as any new information becomes available.

6. A list of the materials I considered is presented in Appendix B.

B. Qualifications

7. I am the Kenneth Fong Professor of Bioengineering, Genetics, Medicine, Biomedical Data Science, and (by courtesy) Computer Science at Stanford University, where I have taught since 1992. Additionally, I hold positions as the Associate Director of and Senior Fellow at

the Stanford Institute for Human-Centered AI (HAI)),[1] the Co-Lead of the Faculty Research Council for RAISE-Health (Responsible AI for Safe and Equitable Health),[2] a collaboration between HAI and the Stanford School of Medicine, Faculty Director of the 100 Year Study of Artificial Intelligence (AI100), the Chair of the AI at Stanford Advisory Committee to the University Provost, the Chair of the Biomedical Computation Undergraduate Committee, and the Co-Chair of the UCB-Stanford Digital Health Research Collaborative, in addition to serving on the Advisory Board for the Stanford Center for Artificial Intelligence in Medicine and Imaging. I am also a member of the American Association for Artificial Intelligence (AAAI), the American Association for the Advancement of Science (AAAS), the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers (IEEE), and the International Society for Computational Biology (ISCB). I serve on the Committee for the Reference Manual for Scientific Evidence for Federal Judges (4th edition, in press) with the National Academy of Science. Furthermore, I am on the editorial board of multiple peer-reviewed journals, which includes my position as the editor-in-chief of the Annual Reviews of Biomedical Data Science. I am also a co-founder and Scientific Advisor to Personalis, a cancer management company (NASDAQ: PSNL). I also serve as a consultant to Bayshore Global Management Sergey Brin's philanthropic arm and to Weave.io, a company using AI to generate regulatory submissions to the FDA. I have additionally accepted an invitation to serve on the Board of Directors for the Burroughs Wellcome Fund, a biomedical research philanthropy, starting in 2026.

8. I graduated from Harvard in 1983 with an A.B. in Biochemistry and Molecular Biology. In 1989, I completed my Ph.D. in Medical Information Sciences at Stanford University. I also earned an M.D. from Stanford in 1990, became a licensed doctor in the state of California in 1991, and was first board-certified in 1992. I am currently board-certified in the fields of both Internal Medicine and Clinical Informatics.

9. My research and teaching interests are primarily focused on the application of computational tools, such as AI, data science, and informatics, to topics in the fields of medicine and biology. I have authored or co-authored nearly 500 peer-reviewed journal

[1] HAI is an organization devoted to using AI to augment human performance in a variety of tasks. *See* "Home," Stanford University HAI, accessed December 16, 2025, http://hai.stanford.edu.

[2] RAISE Health is a joint initiative between Stanford Medicine and HAI to guide the responsible use of AI across biomedical research, education, and patient care. *See* "RAISE Health," Stanford Medicine, accessed December 16, 2025 , https://med.stanford.edu/raisehealth.html.

publications, edited over 30 books, authored or co-authored 17 book chapters, and given over 100 lectures and presentations on these subjects. I have also testified before the U.S. Senate Health, Education, Labor & Pensions Committee on AI's potential to deliver better patient care and accelerate drug discovery. I have written about artificial intelligence-related topics in particular for over 30 years. I also host a podcast, "The Future of Everything," that frequently discusses current and future applications of artificial intelligence.[3]

10. I have had the honor of receiving multiple awards for my work, including the Presidential Early Career Award for Scientists and Engineers, and the Arthur Kornberg and Paul Berg Lifetime Achievement Award in Biomedical Sciences. I am an elected member of the National Academy of Medicine.

11. My CV, which includes a list of my publications, and my prior experience is contained in Appendix A. I am being compensated for my work in preparing this report at a rate of $2,000 per hour. I had assistance in this matter from staff at Keystone Strategy, LLC, who worked under my direction. All the opinions and conclusions stated in this report are my own. My compensation does not depend upon the outcome of this matter or the substance of any opinion I reach.

C. Case Background

12. Anthropic PBC is an AI company founded in January 2021 that developed the Claude family of LLMs.[4]

[3] Russ Altman, "The future of everything," *The Future of Everything,* podcast audio, https://podcasts.apple.com/us/podcast/the-future-of-everything/id1235836821.

[4] Anthropic released its first models, Claude 1 and Claude Instant, in March 2023, and had a broad public release of its conversational AI website interface, powered by Claude 2, in July 2023. It released Claude 3 (Haiku, Sonnet, Opus) in March 2024, and Claude 3.5 Sonnet in June 2024, with access via web, mobile apps, and API. *See* "Introducing Claude," Anthropic, March 14,2023, https://www.anthropic.com/news/introducing-claude ("Claude is a next-generation AI assistant based on Anthropic's research into training helpful, honest, and harmless AI systems."); *see also* "Claude 2," Anthropic, July 11, 2023, https://www.anthropic.com/news/claude-2; *see also* "Introducing Claude 2.1," Anthropic, November 21, 2023, https://www.anthropic.com/news/claude-2-1 ("Our latest model, Claude 2.1, is now available over API in our Console and is powering our claude.ai chat experience."); *see also* "Introducing the next generation of Claude," Anthropic, March 4, 2024, https://www.anthropic.com/news/claude-3-family ("Today, we're announcing the Claude 3 model family, which sets new industry benchmarks across a wide range of cognitive tasks. The family includes three state-of-the-art models in ascending order of capability: Claude 3 Haiku, Claude 3 Sonnet, and Claude 3 Opus."); *see also* "Claude 3.5 Sonnet," Anthropic, June 20, 2024, https://www.anthropic.com/news/claude-3-5-sonnet ("Today, we're launching Claude 3.5 Sonnet—our first release in the forthcoming Claude 3.5 model family.").

13. This action was originally filed in the U.S. District Court for the Middle District of Tennessee (Nashville Division) on October 18, 2023, by publishers Concord Music Group, Inc., Capitol CMG, Inc., Universal Music Corp., Songs of Universal, Inc., Universal Music MGB NA LLC, Polygram Publishing, Inc., Universal Music – Z Tunes LLC, and ABKCO Music, Inc., and various d/b/a entities (together "Publishers") against Anthropic PBC. Publishers own or control the copyrights in a large number of musical compositions. In June 2024, the case was transferred to the U.S. District Court for the Northern District of California, and is now before Judge Eumi K. Lee and Magistrate Judge Susan van Keulen in the San Jose Division. Plaintiffs assert Anthropic engaged in copyright infringement under the Copyright Act (17 U.S.C. §101, *et seq.*, 17 U.S.C. §501, *et seq.* and 17 U.S.C. §1201 *et seq.*) and are seeking damages and injunctive relief.

14. Anthropic is an AI safety and research public benefit corporation that has developed a series of commercial AI models called Claude. Anthropic describes Claude as "a next-generation AI assistant based on Anthropic's research into training helpful, honest, and harmless AI systems" and its models are "capable of a wide variety of conversational and text processing tasks … including summarization, search, creative and collaborative writing, Q&A, coding, and more."[5]

15. Plaintiffs allege that Anthropic acquired unauthorized copies of the text of Publishers' lyrics from online sources, including the Common Crawl and other third-party datasets commonly used for LLM training that scrape the public internet.[6] Plaintiffs also allege that Anthropic subsequently used Publishers' lyrics without permission in the process of training and finetuning the Claude family of LLMs, including through cleaning and processing the data.[7] Publishers further allege that Anthropic's AI models are "prone to copy and distribute Publishers' lyrics as output[.]"[8] Finally, Publishers allege that Anthropic removes, omits, or misstates copyright management information (e.g., the song title, song writers, and © symbol) during training and in its outputs.[9]

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[5] *Introducing Claude*, Anthropic (Mar. 14, 2023), https://www.anthropic.com/news/introducing-claude.
[6] First Amended Complaint, *Concord v. Anthropic PBC*, April 25, 2025, paras. 67, 75, 106-107.
[7] First Amended Complaint, *Concord v. Anthropic PBC*, April 25, 2025, paras. 67, 75, 106-107.
[8] *Id.* para. 106.
[9] *Id.* para. 17.

16. My report will address the public benefits and the transformative nature of LLMs. In my report, I will synthesize empirical evidence and industry practice to show how LLMs like Claude are already (i) increasing productivity and quality in knowledge-intensive fields, and (ii) expanding access to expertise and compressing costs.

17. As noted above, if new information becomes available to me after this report has been filed, I may file a supplemental report later.

D. Summary of opinions

18. Drawing on more than three decades of firsthand experience applying computational methods to challenges in biomedicine, public health, and education, I have developed a clear perspective on the practical value and potential of large language models. My research at Stanford related to LLMs, which involves everything from designing gene-editing experiments to collaborating with the U.S. Food and Drug Administration (FDA) on drug evaluations, has shown me how these tools can accelerate the pace of scientific discovery and its subsequent application in a direct and measurable way.

19. Based on my review, it is my opinion that Anthropic's Claude has demonstrated significant public benefits across several domains. For example, it has been used to accelerate pharmaceutical research, improve clinical workflows, expand access to educational tools, and support environmental conservation efforts.[10] Anthropic's design of Claude prioritizes safety-oriented principles, making it a promising technology for regulated fields like healthcare that require a high degree of reliability and accountability.[11]

20. Anthropic has been publicly recognized as an industry leader in AI safety for its protections and defenses including its Constitutional AI principle, prompt and output

[10] *See e.g.,* Anthropic_0000570067: Pfizer Leverages GenAI for Faster Drug Development, February 26, 2025, GenAI Gazette, https://genaigazette.com/pfizer-genai-development/; *see also* Anthropic_0000569572: "Bluenote powers intelligent agents for life sciences with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/customers/bluenote; *see also* Anthropic_0000570105: "Rising Academies' chatbot tutors reach 150,000+ students across Sub-Saharan Africa with Claude," Anthropic, March 7, 2025, https://www.anthropic.com/customers/rising-academies; *see also* Anthropic_0000570166: "Tahoe Lead Removal Project cleans up Lake Tahoe with Claude," Anthropic, July 16, 2025, https://www.anthropic.com/customers/tahoe-lead-removal-project.

[11] Claude maintains a 5-pillar framework for developing safe and trustworthy agents that includes keeping humans in control while enabling agent autonomy, transparency in agent behavior, aligning agents with human values and expectations, protecting privacy across extended interactions, and securing agents' interactions. *See* "Our framework for developing safe and trustworthy agents," Anthropic, August 4, 2025, https://www.anthropic.com/news/our-framework-for-developing-safe-and-trustworthy-agents.

classifiers, red-teaming initiatives, and threat-identification teams.[12] Anthropic's reputation for safety is so strong that it has inspired employees to work for Anthropic in support of that mission.[13] Anthropic has been described as "the most safety-first of the leading AI labs," and Anthropic supports AI regulation.[14] Notably, Anthropic has committed to de-deploying its own models should they pose safety risks the company finds untenable.[15] And its Terms of Service and Usage Policy provides an additional, everyday layer of protection by carefully setting forth rules for permissible and safe use of Anthropic's systems.[16] Anthropic commercialized Claude in part for the very purpose of informing the development of safe and beneficial AI, as commercialization would enable Anthropic to understand how people use AI in the real world.[17] Anthropic has expressed

[12] Cooper, Anderson, Marks, Nichole, "Why Anthropic CEO Dario Amodei spends so much time warning of AI's potential dangers," 60 Minutes, CBS News, https://www.cbsnews.com/news/anthropic-ceo-dario-amodei-warning-of-ai-potential-dangers-60-minutes-transcript/ ("CEO Dario Amodei has centered his company's brand around transparency and safety…Anthropic has some 60 research teams trying to identify those unknown threads and build safeguards to mitigate them."); Chou, Jessica, "Anthropic is all in on 'AI safety' – and that's helping the $183 billion startup win over big business," December 2, 2025, https://fortune.com/article/anthropic-ceo-dario-amodei-openai-chatgpt-artificial-intelligence-safety-donald-trump/; *see also* Ghosh, Shikhar, and Shweta Bagai. "Anthropic: Building Safe and Powerful AI." Harvard Business School Case 824-129, April 2024. (Revised December 2024.)

[13] Tom Turvey (Nov. 5, 2025) Tr. 196:17-23 ("Q. Why did you choose to join Anthropic? A. I believe that the opportunity to help AI land in a safe and responsible way is quite a privilege. And I thought the opportunity to help grow the company and contribute in a way that I could with domain knowledge was important and exciting.")

[14] Perrigo, Billy, "Dario Amodei, Time 100 AI 2025," TIME, accessed December 16, 2025, https://time.com/collections/time100-ai-2025/7305835/dario-amodei-ai/; Kutcher, Ashton, "Dario Amodei, The 100 Most Influential People of 2025," TIME, accessed December 16, 2025, https://time.com/collections/100-most-influential-people-2025/7273747/dario-amodei/ ("Amodei doesn't just build advanced AI; he designs guardrails for it. While others race to deploy ever more powerful systems, Amodei deliberately applies the brakes, insisting that safety precede capability"); Patel, Nilay, "Anthropic's quest to study the negative effects of AI is under pressure," December 4, 2025, https://www.theverge.com/podcast/838023/anthropic-societal-impact-trump-woke-ai-interview.

[15] Anthropic, "Responsible Scaling Policy, Version 2.2," May 14, 2025, https://www-cdn.anthropic.com/872c653b2d0501d6ab44cf87f43e1dc4853e4d37.pdf at 11 ("In the unlikely event that we cannot implement interim measures to adequately mitigate risk, we will impose stronger restrictions. In the deployment context, we will de-deploy the model and replace it with a model that falls below the Capability Threshold."); *see also* Ben Mann (Nov. 21, 2025) Tr. 187:11-188:4 ("So, yes, we've publicly committed to potentially shutting down our models in the future for the right reasons.")

[16] Anthropic_0000000550, Anthropic Consumer Terms of Service: Effective May 1, 2025; Anthropic_0000437176, Anthropic Consumer Terms of Service: Effective September 28, 2025; Anthropic_0000437165, Anthropic Usage Policy, Effective September 15, 2025; Anthropic_0000440731, Anthropic Usage Policy, Universal Usage Standards.

[17] Jared Kaplan (November 21, 2025) Tr. 114:5-16 ("When we formed Anthropic, we very seriously considered making Anthropic a nonprofit organization. And several of the cofounders advocated strongly that we should become a nonprofit organization in pursuit of safe and beneficial AI…[O]ne of the popular reasons advocating for not being a nonprofit was to have customers so that the benefits of AI could be disseminated, and so that we could get information from users about how AI was being used in order to understand how AI was useful and improve it."); Jared Kaplan (November 21, 2025) Tr. 221:2-11 ("Most start-ups are focused on their goals, their mission, et cetera… [T]he most important goal for Anthropic at this time was, 'Major/transformative safety progress (for us or the ecosystem.' That was more important than success, quote/unquote, 'staying on the frontier,' and both of those were more important than commercial interests or financial interests of any kind.")

a hope that its "safety-first" approach will "inspire a 'race to the top' dynamic where AI developers must compete to develop the most safe and secure AI systems."[18]

21. These existing applications indicate that Claude's utility extends beyond productivity enhancements. The performance capabilities and their use to augment human performance in these early examples are noteworthy. Based on this trajectory, as well as the trajectory of LLMs in general, it is my opinion that the applications for and benefits of this technology will continue to expand, particularly in science, medicine, and other public-serving domains.

II. LLMs' ROLE IN ACCELERATING SCIENTIFIC PROGRESS

22. LLMs are AI systems that train on vast amounts of data to understand and generate human language. At their core, LLMs learn to predict text by analyzing language patterns across large sets of documents. For example, when an LLM is prompted to complete the sentence: "The doctor examined the patient's _____," the LLM may predict that the next word has a 45% chance of being "heart," a 30% chance of being "lungs," a 15% chance of being "throat," and a long tail of other potential answers. A larger LLM, trained on more text, can make better predictions about which words are likely to come next in the sentence.

23. LLMs act as knowledge synthesizers, transforming large tracts of scientific, technical, and general data. Their architecture enables them to extract, structure, and contextualize information from a wide range of sources. That makes them well suited to tasks in science and healthcare, which are strongly guided by the vast amount of knowledge and information that has been generated and recorded in written (textual) form.

24. The evolution of LLMs has been characterized by the rapid scaling of model capabilities and commercial applications. LLMs learn through numerical values called "parameters," which can be thought of as weights that help the model understand relationships between words and concepts. The "size" of a model refers to how many parameters a model contains. Larger models have more parameters, allowing them to capture more complex relationships between words and the concepts they represent. A "training set" is the

[18] "Making AI systems you can rely on," Anthropic, accessed December 16, 2025, https://www.anthropic.com/company.

corpus of documents used to estimate the value of these parameters. The accuracy and precision of the parameters generally increases as the size of the training set increases.[19]

25. Another factor shaping LLM performance is the context window, or the amount of text that a model can process at once. The larger the context window, the more information the model can incorporate into the calculation of its output.[20]

26. Equally as important is alignment, or the process of training the model so it behaves in line with human values, intentions, and goals. This maximizes the chances that the model will perform as desired in various situations and with the array of prompts that the model may face. As models have drawn from larger training sets, with larger context windows, more parameters, and more advanced alignment methods, they have developed sophisticated language understanding and reasoning that has allowed the models' predictive capabilities to become increasingly specific and nuanced. Today, LLMs are not only more capable, but are also increasingly integrated into high-stakes workflows across all industries. In just a few years, LLMs have transformed from novel technologies into foundational tools on which professionals have come to rely.

27. LLMs are having an impact across a wide range of industries, enabling organizations to process large volumes of unstructured information, automate repetitive tasks, and develop new insights. At the frontier of these applications are highly regulated domains such as drug development and commercialization, legal services, financial services, and government operations. In these settings, LLMs' capabilities translate into lower operational costs and improved decision quality.

28. These advances are not limited to highly regulated domains. Whether it is cancer detection in healthcare delivery or innovation in the performing arts, I have witnessed firsthand the progressive development in LLMs and parallel expansion of real-world applications.[21]

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[19] Sher Badash and Hassan Sajjad, "Quantifying the Capabilities of LLMs across Scale and Precision," May 8, 2024, https://arxiv.org/pdf/2405.03146v2 ("Scale is often attributed as one of the factors that cause an increase in the performance of LLMs, resulting in models with billion and trillion parameters.").

[20] "Features Overview," Anthropic, accessed December 16, 2025, https://docs.anthropic.com/en/docs/build-with-claude/context-windows#1m-token-context-window ("Claude Sonnet 4 and 4.5 support a 1-million token context window.").

[21] Alongside my research into LLMs in medicine, health systems, diagnostics, and life sciences, I have observed and been a part of the ways in which LLMs have already begun to impact other parts of society and the way we live our lives. At Stanford, my colleague Michael Bernstein and his team developed a system called Rehearsal, where LLMs help individuals practice navigating interpersonal conflicts. The system simulates realistic conversations, allowing users

A. My perspective on the practical research applications of LLMs

29. My research at Stanford sits at the intersection of AI, data science, and medicine, with a focus on understanding drug action at the molecular, cellular, organism, and population levels. I have spent three decades studying how computational methods can improve human health and research capabilities across sectors. LLMs excel at working with unstructured data—scientific literature, clinical notes, genomic sequences, and even gene-editing datasets—connecting this information in ways that can drive breakthroughs. My years of experience have given me a unique perspective on how LLMs can be applied to address challenges and spark advancements in biomedicine.

30. In my research and lab, I have explored how LLMs can advance biomedical discovery and clinical practice. I have applied these models in several ways, including hypothesis generation in biology, extracting knowledge from biomedical literature, supporting clinical decision-making, and identifying promising drug targets. One of these models, called CRISPR-GPT, uses LLM technology to simplify and speed up the design of gene-editing experiments.[22] I am also currently collaborating with the FDA on a project that applies LLM technology to help evaluate whether generic drugs work just as well as brand-name versions.

to explore alternative "what if" responses and to receive structured feedback on conflict resolution strategies. In a study they conducted, 40 participants engaged in conflict practice after receiving training. One group only read lecture material about conflict theory, while another trained with Rehearsal. The Rehearsal group performed much better, reducing aggressive strategies by 67% and doubling their use of cooperative strategies. *See* Omar Shaikh, Valentino Chai, et al., "Rehearsal: Simulating Conflict to Teach Conflict Resolution," February 29, 2024, https://arxiv.org/pdf/2309.12309. Similarly, when I spoke with Michael Rau, an Assistant Professor of Theater and Performance Studies at Stanford University, he brought up all the ways he is incorporating technology, and specifically generative AI, into his theatrical work in an effort to replicate the influence that technology has had on his daily life onto the performances that he is a part of. These include using an LLM to incorporate suggestions from the audience into a script, then turn that text into speech that is transmitted live to the actor through an earbud, and an image generator to project an AI-filtered version of the actors over the stage to simulate situations, dreams, or other dimensions. His incorporation of AI into his work has turned the tool into a co-creation partner, pushing the boundaries of traditional theater's limitations. *See* Russ Altman, "The future of live performance," *The Future of Everything,* podcast audio, March 21, 2025, https://engineering.stanford.edu/news/future-live-performance; *see also* "AI brings new potential to the art of theater," Stanford Report, January 15, 2025, https://news.stanford.edu/stories/2025/01/ai-brings-new-potential-to-the-art-of-theater.

[22] Kaixuan Huang, Yuanhao Qu, et al., "CRISPR-GPT: An LLM Agent for Automated Design of Gene-Editing Experiments," August 21, 2025, https://arxiv.org/pdf/2404.18021 ("In this work, we introduce CRISPR-GPT, an LLM agent augmented with domain knowledge and external tools to automate and enhance the design process of CRISPR-based gene-editing experiments.").

1) CRISPR-GPT

31. Gene editing technology is a groundbreaking advancement that enables precise alterations to the genetic material of living organisms. This technology has applications across many areas of medicine, from correcting genetic defects responsible for disorders like cystic fibrosis, hemophilia, and sickle cell anemia, to offering new strategies for tackling cancer, cardiovascular diseases, neurodegenerative disorders, and infections. Designing gene-editing experiments such as CRISPR is labor-intensive and time-consuming, and requires deep expertise in biology and bioinformatics. There are numerous intricacies involved in designing CRISPR experiments, which is especially challenging for those new to the field. This is where LLMs hold enormous potential—they streamline and accelerate the design and planning of gene-editing experiments.

32. My research colleagues and I developed CRISPR-GPT to automate and enhance the design process of CRISPR-based gene-editing experiments. CRISPR-GPT is an LLM agent augmented with domain knowledge and external tools.[23] It uses the reasoning ability of LLMs to facilitate the process of selecting CRISPR systems, designing guide RNAs, recommending cellular delivery methods, drafting protocols, and designing validation experiments to confirm editing outcomes—all critical steps in the gene-editing process.[24] By supporting these complex tasks, CRISPR-GPT reduces the time and complexity of experiment design, allowing researchers to focus on discovery and innovation.[25]

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[23] An "agent" is a computational system that is often built using an LLM to solve a particular type of task. An agent is often implemented as a set of prompts to an LLM that allow the agent to plan their work, execute the plan, use external tools, keep track of progress and even evaluate and reject the output, and try again (i.e., iterate). Agents can be thought of as computational "experts" that are programmed to do narrow tasks in a high-quality manner. Agents often exist in a system with other agents with different and complementary capabilities, so that they co-operate to solve problems. These agent systems are modeled on human teams where each team member brings its own narrow expertise, but when each team member's expertise is combined with the others', the overall team acquires broad and powerful capabilities.

[24] Kaixuan Huang, Yuanhao Qu, et al., "CRISPR-GPT: An LLM Agent for Automated Design of Gene-Editing Experiments," August 21, 2025, https://arxiv.org/pdf/2404.18021 ("... we introduce CRISPR-GPT, an LLM agent augmented with domain knowledge and external tools to automate and enhance the design process of CRISPR-based gene-editing experiments. CRISPR-GPT leverages the reasoning ability of LLMs to facilitate the process of selecting CRISPR systems, designing guide RNAs, recommending cellular delivery methods, drafting protocols, and designing validation experiments to confirm editing outcomes. We showcase the potential of CRISPR-GPT for assisting non-expert researchers with gene-editing experiments from scratch and validate the agent's effectiveness in a real-world use case.").

[25] Kaixuan Huang, Yuanhao Qu, et al., "CRISPR-GPT: An LLM Agent for Automated Design of Gene-Editing Experiments," August 21, 2025, https://arxiv.org/pdf/2404.18021 ("The CRISPR-GPT agent showcases the remarkable potential of LLMs in automating and enhancing the design process of complex biological experiments. By seamlessly integrating LLMs with domain knowledge, external tools, and a modular task execution system, CRISPR-GPT

2) FDA Bioequivalence

33. One ongoing project in my lab applies LLMs to the task of bioequivalence evaluation, which involves determining whether a generic drug works the same as its brand-name counterpart. Generic drugs are critical for patients because they are typically much less expensive than their brand-name counterparts (though biologically equivalent), and so they contribute to lower overall drug costs. Bioequivalence evaluation is an essential step in the approval process for generic drugs and typically requires reviewing lengthy reports containing pharmacokinetic data, study designs, and statistical analyses. Our goal is to use LLMs to read and summarize these reports and to check for completeness and consistency. Automating these steps with LLMs could help the FDA improve the efficiency and consistency of bioequivalence evaluations while supporting its mission to ensure that safe and effective drugs are available to the American public, typically at a lower cost than their brand-name counterparts.[26]

3) "Synthetic" Control Patients

34. Many biomedical studies are abandoned purely as a result of insufficient patient data.[27] Current research shows that 11% of clinical trial sites fail to enroll a single patient and 37% are under-enrolled,[28] which can delay or prevent therapies from coming onto the market.[29] For this reason, another promising application of LLMs in medical research is

empowers researchers to navigate the intricate landscape of CRISPR gene editing experiments with unprecedented ease and efficiency.").

[26] Russ B Altman, Percy Liang, et al., "Large Language Models to support Bioequivalence Evaluation," U.S. Food and Drug Administration, March 8, 2024, https://www.fda.gov/science-research/advancing-regulatory-science/large-language-models-support-bioequivalence-evaluation ("The aim of this project is to develop a suite of innovative tools leveraging LLMs to assist FDA reviewers in their critical work. The primary goal is to create an interactive expert system trained on public FDA data and related publications to quickly answer queries and summarize complex study information.").

[27] There are multiple barriers to enrolling patients in clinical trials: (1) electronic medical records do not always have all the information required to evaluate whether a patient would be eligible to participate; (2) treating physicians are busy and may not take time to investigate potential trials for their patients; (3) patients themselves do not have adequate tools to find relevant trials, or may not wish to take on the responsibilities of participating in a trial; (4) some patients may not trust researchers to do the work in their best interest; and (4) certain rare diseases may only affect a limited numbers of patients, in which case drug companies have to compete with one another to attract patients who are eligible for their studies.

[28] Kimberly Ray and Bernadette Tosti, "Transforming Patient Recruitment Through Patient and Site Engagement," IQIVA, p. 3, https://www.iqvia.com/-/media/iqvia/pdfs/library/infographics/transforming-patient-recruitment-through-patient-and-site-engagement.pdf ("With 11% of clinical research sites failing to enroll a single patient, and 37% of sites under-enrolling, the need for improved efficiency is evident.").

[29] If drug trials do not accumulate sufficient numbers of patients, they cannot provide sufficiently robust scientific evidence that a drug is safe and effective. Without that evidence a drug cannot be approved. This could occur even

the use of "synthetic" control patients, which are a "digital twin" of existing patient data generated from sufficient underlying data.[30] Used in place of traditional control patients, "synthetic" control patients allow researchers to compare the outcomes of real patients receiving a therapy against model-generated (synthetic) outcomes to describe what happens to these patients if they are untreated. Biomedical researchers can then use the outcomes of real patients exposed to a new drug alongside the outcomes for the synthetic patients, thus reducing the amount of training patient data required for a study.[31] In a typical clinical trial with 1,000 participants, 500 are assigned to the control group and 500 to the test group. However, with synthetic controls, researchers could enroll 500 real patients in the test group and rely on LLM generated statistical twins in place of 500 control patients. The implications of this are significant; studies could potentially reduce their enrollment targets by 50% without sacrificing the quality of their outcomes.

35. LLMs are thus well-equipped to address inefficiencies in patient recruitment, which remain a major barrier to timely and cost-effective drug development. Recruiting and compensating trial participants is a major cost driver in drug development, often amounting to thousands of dollars per participant across longitudinal or muti-year studies.[32] Reducing the number of participants, especially in the control arm where the participants are given a placebo, directly translates into cost reductions.

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for drugs that would work very well for patients, but for which the trials did not achieve sufficient numbers to justify approval by the FDA.

[30] A "digital twin" is a computational replica of an individual patient. The digital twin allows researchers to simulate the future disease course and anticipated response to drugs before actually giving them to the patient. Digital twins are created by collecting large amounts of data over time on a cohort of "training" patients and building machine learning models that are able to predict future measurements on these patients based on their prior historical measurements. If researchers gather enough patients with enough data over time (called longitudinal data), then they can use machine learning to create algorithms that predict patients' future states (disease improves vs. disease worsens). If the data include information about which drugs were administered and how the training patients responded to these drugs, then researchers can also develop machine learning algorithms to predict whether or not a drug will work in a particular patient (based on their personal measurements). Thus, digital twins allow researchers to make measurements on a patient and then use the models (based on the "training" cohort of patient data) to predict the course of their disease and whether they are likely to respond to treatments.

[31] Russ Altman, "Generative AI: Perspectives from Stanford HAI," Stanford University Human-Centered Artificial Intelligence, March 2023, p. 6, https://hai.stanford.edu/assets/files/generative_ai_hai_perspectives.pdf ("Biomedical researchers could then use the outcomes of real patients exposed to a new drug with the synthetic statistical outcomes for the synthetic patients. This could make trials potentially smaller, faster, and less expensive, and thus lead to faster progress in delivering new drugs and diagnostics to clinicians and their patients.").

[32] "How to Budget for a Clinical Trial: Key Factors to Consider," CCRPS, April 4, 2025, https://ccrps.org/clinical-research-blog/how-to-budget-for-a-clinical-trial ("Recruiting and retaining participants is one of the most expensive aspects of clinical trials, often consuming 30-40% of the total budget.").

36. With lower study enrollment numbers, synthetic control methods could shorten the time required to complete trials by decreasing enrollment timelines, thereby reducing costs, and enabling faster trial completion. Not only does this help alleviate the bottleneck of being dependent on relevant patient information, but this approach could also make clinical trials faster, less resource-intensive, and more cost-effective, thereby accelerating the development and testing of new treatments and diagnostics.[33] Ultimately, this should lead to both faster innovation and lower medical costs borne by consumers.

B. Observations and understanding the real-world value of LLMs

37. I have firsthand experience in both using LLMs and observing their impact across clinical care, biomedical and scientific research, education, and industry.

38. As an educator, I have personally experienced the impacts of LLMs on education and learning (see Section II.B.1).

39. As a physician-scientist, engineer, and professor at Stanford, I build, evaluate, and deploy computational methods for biomedicine and see their effects in practice. In clinical and translational settings, I have witnessed how LLMs can surface evidence, structure complex records, and support decision-making. In my research in bioengineering and computational biology, my group rigorously tests these systems on biomedical text, data, and knowledge networks (see Section II.B.2). As a leader of Stanford's Human-Centered AI initiative, I help shape responsible use, governance, and measurement of AI in academic programs and research.

40. Lastly, my podcast, *The Future of Everything*, focuses on how technology, science, and medicine are shaping our lives. Many of these discussions involve LLMs and generative AI more broadly (see Section II.B.4). As a podcast host, I engage and debate with academic and industry leaders, learning how LLMs are shaping their work, their research, and their industries more broadly, in addition to how LLMs will continue to shape their industries in the future. Some of the most poignant LLM related discussions I have had

[33] Russ Altman, "Generative AI: Perspectives from Stanford HAI," Stanford University Human-Centered Artificial Intelligence, March 2023, p. 6, https://hai.stanford.edu/assets/files/generative_ai_hai_perspectives.pdf ("Biomedical researchers could then use the outcomes of real patients exposed to a new drug with the synthetic statistical outcomes for the synthetic patients. This could make trials potentially smaller, faster, and less expensive, and thus lead to faster progress in delivering new drugs and diagnostics to clinicians and their patients.").

revolved around topics like quality of patient care, robotic reasoning, performance theater, and fitness coaching. This combination of building, studying, deploying, and observing AI across bench, bedside, and ecosystem grounds my assessment of LLMs' value and limitations.

1) Transforming education with LLMs

41. As a professor, I have seen the ways in which educational applications of Claude and other LLMs, from tutoring to curriculum design, are already shaping how we learn and access knowledge. In classrooms, I've seen students and researchers use LLMs to turn dense lecture notes into clear and structured study guides. At Stanford, I co-teach a Bioengineering Ethics course, for which we allow students to use LLMs in their writing process. We lead discussions on how to use LLMs effectively for outlining, drafting, and editing. Of course, we require students to disclose their use of LLMs, and the students must take final responsibility for the essays they submit. As part of this effort, I have personally tested the ability of LLMs to construct ethical arguments (using various ethical theories such as consequentialism, Kantian de-ontology, casuistry, and common morality theory) and to provide summaries of ethical literature on various topics.[34]

42. Outside the classroom, students have shared with me that they have used LLMs to explore additional research topics or to see if others have previously tested similar hypotheses. Students can also create practice problems while preparing for exams, deploying the technology to rephrase a concept in different ways until it makes sense. For students, this translates into time saved and, for some, better grades. Professors can benefit as well, with LLM assistance in drafting assignments, generating variations of quiz questions, and reducing time spent on routine tasks, freeing up more time for face-to-face interaction. Beyond traditional education, LLMs are particularly effective at coaching tasks because they can adopt different approaches and personalities based on the needs of an individual student.[35] Ultimately, when used responsibly, LLMs have the potential to close gaps in access to high-quality education and make learning more personalized and equitable.

[34] At the Stanford Center for Biomedical Ethics, I advise on a project using LLMs to summarize the ethical literature on topics, with the goal of providing clear, accessible summaries for people who come to the ethics center with questions about the latest developments in biomedical ethics

[35] In a podcast conversation I had with Dr. James Landay, a Professor of Computer Science and Co-Director of the Institute for Human-Centered AI at Stanford, we discussed his work on GPTCoach, an LLM-based chatbot for physical activity coaching that uses evidence-based coaching programs, conversational strategies from motivational

2) Enhancing healthcare delivery and medical research

43. As a scientist and board-certified physician, I have explored how LLMs can improve access to critical care and free up clinical capacity to deliver value to patients. One area where LLMs show significant promise is patient communication. Research has shown that patients often perceive chatbot responses as more empathetic than physicians, even when the medical facts are the same—an effect clearly demonstrated in a recent study using Claude.[36] LLMs tend to lead with empathy before moving into an explanation, which can make patients feel more at ease. They can also adapt their responses to be tailored to the audience—framing, for example, a diagnosis differently for an adult than for a child, or even switching into a different language when needed.[37] LLMs can thus bring an added layer of sensitivity to clinical communication, helping patients feel heard and informed.

44. In cancer care, complex cases are often reviewed by a tumor board, which is a team of specialists, including oncologists, surgeons, and others, who carefully examine all aspects of a patient's case.[38] These meetings take a lot of time, as the team needs to gather scans, lab results, and the medical history of the patient to evaluate all the treatment options. It also requires coordinating the calendars of specialists from various departments, which is often difficult and can take weeks or months to do. LLMs are actively being evaluated as support tools that help summarize patient records. We are also evaluating their ability to make care management recommendations consistent with those of the specialists. Many

interviewing, and wearable data to create personalized physical activity plans. His research demonstrated that users found the advice actionable and felt comfortable and supported in sharing their concerns with GPTCoach. *See* Russ Altman, "The future of AI coaching," *The Future of Everything*, podcast audio, November 22, 2024, https://engineering.stanford.edu/news/future-ai-coaching; *see also* Matthew Jorke, Shardul Saptoka, et al., "GPTCoach: Towards LLM-Based Physical Activity Coaching," *CHI '25: Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, no. 993 (2025): 1-46.

[36] David Chen, Kabir Chauhan, et al., "Patient perceptions of empathy in physician and artificial intelligence chatbot responses to patient questions about cancer," *npj Digital Medicine* 8, no. 275 (2025) ("Here, we found that people with cancer rated chatbot responses as more empathetic than physician responses.").

[37] Amna A. Othman, Kendall A. Flaharty, et al., "Assessing large language model performance related to aging in genetic conditions" *npj Aging* 11, no. 33 (2025) ("Results showed that LLMs provided appropriate age-based responses in both child and adult outputs based on Correctness and Completeness scores graded by clinicians."); *see also* Darren Liu, Xiao Hu, et al., "Evaluation of Large Language Models in Tailoring Educational Content for Cancer Survivors and Their Caregivers: Quality Analysis," *JMIR Cancer* 11, (2025) ("All 3 LLMs demonstrated high potential for delivering multilingual, concise, and low health literacy educational content for cancer survivors and caregivers who face limited literacy or language barriers.").

[38] "The Important Role Tumor Boards Play in Cancer Care," Foxchase Cancer Center, July 26, 2018, https://www.foxchase.org/blog/important-role-tumor-boards-play-cancer-care ("A tumor board is a meeting made up of specialized doctors and other health care providers who regularly gather to discuss cancer cases that are unusual and/or challenging. The goal is to decide on the best possible treatment plan for a patient as a group. Your case might be discussed if you have a less common type of cancer that doesn't have a standard course of treatment. It could also be presented if your current treatment isn't working the way it should.").

leading institutions, including Stanford Medicine, are piloting AI-based tumor board tools to streamline these workflows and explore the potential of agentic AI in cancer care.[39] LLMs may help tumor boards spend less time gathering details and more time on critical decision-making for patients.[40] This also removes the logistical barriers preventing tumor board-like reviews from being applied to a broader set of patients, as opposed to just the most complex cases.

45. Beyond communications and care delivery, LLMs are also assisting healthcare professionals with many of their other responsibilities. As an example, physicians and researchers in medicine face an impossible task: staying current with millions of new biomedical papers published each year.[41] Physicians are expected to know and absorb all of this information as part of their work. This is simply not possible. Yet, missing just a few key papers can mean overlooking important insights or new treatment options. LLMs can scan the biomedical literature to identify and prioritize the most relevant studies. Additionally, these models can facilitate cross-domain knowledge transfer, enabling researchers to spot connections across diseases, treatments, and even species. For example, an investigator studying a mechanism in humans might be alerted to earlier work describing the same mechanism in mice or another species, accelerating discovery by connecting knowledge across fields and organisms.[42] By taking on the tasks of identifying,

[39] Matthew Lungren, "Developing next-generation cancer care management with multi-agent orchestration," May 19, 2025, https://www.microsoft.com/en-us/industry/blog/healthcare/2025/05/19/developing-next-generation-cancer-care-management-with-multi-agent-orchestration/. ("Researchers and developers at leading cancer care institutions—including Stanford University, Johns Hopkins, Providence Genomics, Mass General Brigham, and the University of Wisconsin School of Medicine and Public Health—are currently exploring the healthcare agent orchestrator to study how agentic AI could deliver value to complex clinical tasks such as cancer care…'Stanford Medicine sees 4,000 tumor board patients a year, and our clinicians are already using foundation model generated summaries in tumor board meetings today (via a PHI safe instance of GPT on Azure)'… —Dr. Mike Pfeffer, Chief Information Officer, Stanford Health Care and Stanford School of Medicine").

[40] Vera Sorin, Eyal Klang, et al., "Large language model (ChatGPT) as a support tool for breast tumor board," *npj Breast Cancer* 9, no. 44 (2023) ("We inserted into ChatGPT-3.5 clinical information of ten consecutive patients presented in a breast tumor board in our institution. We asked the chatbot to recommend management. The results generated by ChatGPT were compared to the final recommendations of the tumor board ... In seven out of ten cases (70%), ChatGPT's recommendations were similar to the tumor board's decisions.").

[41] PubMed sees over 1.5 million new citations each year. *See* Jorge Novoa, Mónica Chagoyen, et al., "PMIDigest: Interactive Review of Large Collections of PubMed Entries to Distill Relevant Information," *Genes (Basel)* 14, no. 4 (2023): 942 at 942 ("The PubMed database, which indexes abstracts for biomedicine-related articles, currently contains more than 36 million entries, and around 1.5 million new items are added each year right now (i.e., more than two papers per min), a rate that itself increases, making PubMed's growth exponential.").

[42] MD Riyah, Muqi Li, et al, "LLM-assisted Vector Similarity Search," December 25, 2024, https://arxiv.org/abs/2412.18819. ("While vector similarity search alone can provide reasonable results for straightforward queries, the LLM-assisted approach shines when dealing with queries that require a deeper understanding of context, nuances, and conceptual relationships. By leveraging the natural language understanding

gathering, and summarizing, LLMs free physicians and scientists to spend more time on analysis, discovery, and patient care.

3) Deploying responsibly

46. While LLMs offer significant promise for improving healthcare delivery and medical research, their successful deployment depends equally on thoughtful design, appropriate safety features, and rigorous testing. Based on my experience in both clinical and academic settings—places where LLMs are already deployed in high-stakes environments—I have seen how essential it is to maintain these high standards. The Stanford Institute for Human-Centered AI (HAI) outlines the key principles for responsible LLM deployment, including privacy, data governance, fairness and bias, transparency, explainability, and security and safety.[43] These are not abstract policy principles; they are operational requirements for real-world use in medical or regulatory contexts.[44]

47. Adhering to these principles poses potential challenges, especially in fields like medicine and regulation, where the consequences of errors or opaqueness can be significant. As described above, LLMs are already being used or developed to support literature synthesis, help tumor boards triage complex cases, and streamline document review. Each of these applications raise questions about the training and context of use of the model, its handling of sensitive data, and what role human oversight plays in decision-making. The healthcare industry is full of potential applications for LLMs, including expanding efficient access to large amounts of medical literature and supporting healthcare professionals in their experimental, diagnostic, and administrative work. For any of this to be possible, patient data must be handled with strict confidentiality. In evaluating LLMs on medical note classification tasks, researchers have found that performance is not just about accuracy; it is also about preserving physician and patient trust. These use cases highlight the importance of embedding responsible AI principles

capabilities of LLMs, this approach can better capture the intent behind complex queries and provide more relevant search results.").

[43] "Artificial Intelligence Index Report 2025," Stanford University Human-Centered Artificial Intelligence, 2025, p. 166 https://hai.stanford.edu/assets/files/hai_ai_index_report_2025.pdf ("Responsible AI dimensions, definitions, and examples").

[44] Ehsan Ullah, Anil Parwani, et al., "Challenges and barriers of using large language models (LLM) such as ChatGPT for diagnostic medicine with a focus on digital pathology – a recent scoping review," *Diagnostic Pathology* 19, no. 4 (2025): 1-9 at 3 ("Challenges…Lack of Contextual Understanding…Ethical and Legal Concerns…Bias and Error Propagation").

into the overall system design. Principles such as privacy protections, clear data governance, bias mitigation, model behavior transparency, and the ability for clinicians and patients to audit LLM-generated output.

48. These are not insurmountable problems and can be viewed as prerequisites for operating in industries with high-stakes decisions like healthcare; studies aimed at reducing the effect of potential data biases in clinical decision-making are already underway. Researchers are developing frameworks to audit model bias in diagnostic settings and establish de-identification protocols that meet HIPAA requirements.[45] Related guidance has been published on methods for de-identifying protected health information in line with HIPAA's privacy rules,[46] and AI providers, including Anthropic, offer versions of their LLMs that can be used in HIPAA-compliant environments.[47]

49. I have seen promising signs across several industries that these principles are being prioritized and internalized.[48] Leading AI companies, including Anthropic, have adopted

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[45] Tara Templin, et al., "Framework for bias evaluation in large language models in healthcare settings," *npj Digital Medicine* 8, no. 414 (2025): 1-14 ("A critical gap in the adoption of large language models for AI-assisted clinical decisions is the lack of a standardized audit framework to evaluate models for accuracy and bias. Our framework introduces a five-step framework that guides practitioners through stakeholder engagement, model calibration to specific patient populations, and rigorous testing through clinically relevant scenarios.").

[46] "Guidance Regarding Methods for De-identification of Protected Health Information in Accordance with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule," U.S. Department of Health and Human Services, accessed December 16, 2025, https://www.hhs.gov/hipaa/for-professionals/special-topics/de-identification/index.html ("This page provides guidance about methods and approaches to achieve de-identification in accordance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) Privacy Rule.").

[47] "HIPAA Compliant LLMs in the Cloud," Ayodesk, March 14, 2025, https://ayodesk.com/blog/hipaa-compliant-llms/#anthropic-claude-via-api-or-cloud-providers- ("Anthropic's Claude is designed for enterprise and can be used in HIPAA-compliant workflows, as detailed on the Anthropic Claude page. Anthropic has attained Type II certification and HIPAA certifications for its operations. They will also sign BAAs with customers after reviewing the use case, as explained on Anthropic's BAA information. Additionally, Claude is accessible through platforms like AWS and GCP, which themselves are HIPAA-compliant environments.").

[48] Similar considerations exist in regulatory contexts, where agencies must interpret large volumes of documents under strict legal and procedural standards. LLMs can help streamline the digestion of large numbers of documents, the distillation of complex concepts, and the minimization of error, therefore improving accuracy and efficiency. Agencies are developing similar guidelines such as those outlined by the Interagency LLMs Taskforce, whose objective is to map key areas of application for LLMs with specific use metrics in line with transparency, reliability, explainability, applicability, and trustworthiness (TREAT) considerations. *See* Leihong Wu, Joshua Xu, et al., "A framework enabling LLMs into regulatory environment for transparency and trustworthiness and its application to drug labeling document," *Regulatory Toxicology and Pharmacology* 149, (2024): 1-9 at 1 ("Regulatory agencies consistently deal with extensive document reviews, ranging from product submissions to both internal and external communications. Large Language Models (LLMs) like ChatGPT can be invaluable tools for these tasks, however present several challenges, particularly the proprietary information, combining customized function with specific review needs, and transparency and explainability of the model's output."); *see also* Weida Tong, Michael Renaudin, "Context is Everything in Regulatory Application of Large Language Models (LLMs)," *Drug Discovery Today* 29, no. 4 (2024): 1-3, at 1 ("In recognition of the transformative impact of large language models (LLMs), the GCRSR established an Interagency LLMs Taskforce…the Taskforce is charged with two key objectives: mapping out key areas of application that are common across global regulatory agencies and then delineating the specific context-of-use for employing LLMs…Currently, the Taskforce is

safety-by-design principles and model alignment strategies into their design process.[49] Examples include adversarial testing, content filtering, threat intelligence, realtime detection and enforcement (response steering), hierarchical summarization, and the incorporation of frameworks like Constitutional AI.[50] Claude's constitution, for example, draws from a variety of sources, including the UN Declaration of Human Rights, best practices in trust and safety, and global perspectives.[51] As a result, Claude's output can be structured consistently with ethical, legal, and social guidelines articulated in a corpus of carefully chosen documents.

50. In my view, these developments demonstrate that while challenges exist, they are being identified and managed. And the emphasis on research and implementation that is

developing a set of context-of-use metrics to assess diverse applications of LLMs in regulatory settings. These metrics, named TREAT, form an acronym encapsulating its core context-of-use consideration: Transparency, Reliability, Explainability, Applicability, and Trustworthiness.").

[49] "Building Safeguards for Claude," Anthropic, August 12, 2025, https://www.anthropic.com/news/building-safeguards-for-claude ("We operate across multiple layers: developing policies, influencing model training, testing for harmful outputs, enforcing policies in real-time, and identifying novel misuses and attacks. This approach spans the entire lifecycle of our models, ensuring Claude is trained and built with protections that are effective in the real world."); *see also* Trenton Bricken, Rowan Wang, et al., "Building and Evaluating Alignment Auditing Agents," Anthropic Alignment Science Blog, July 24, 2025, https://alignment.anthropic.com/2025/automated-auditing/ ("We develop three agents that autonomously perform alignment auditing tasks…We are using these agents to assist with alignment audits of frontier models like Claude 4."); *see also* "Claude 3.5 Sonnet," Anthropic, June 20, 2024, https://www.anthropic.com/news/claude-3-5-sonnet ("As part of our commitment to safety and transparency, we've engaged with external experts to test and refine the safety mechanisms within this latest model. We recently provided Claude 3.5 Sonnet to the UK's Artificial Intelligence Safety Institute (UK AISI) for pre-deployment safety evaluation. The UK AISI completed tests of 3.5 Sonnet and shared their results with the US AI Safety Institute (US AISI) as part of a Memorandum of Understanding, made possible by the partnership between the US and UK AISIs announced earlier this year.").

[50] "LLM Red Teaming," Promptfoo, accessed December 16, 2025, https://www.promptfoo.dev/docs/red-team/ ("LLM red teaming is a way to find vulnerabilities in AI systems before they're deployed by using simulated adversarial inputs."); *see also* Olivia Shone, "Enhance AI Security with Azure Prompt Shields and Azure AI Content Safety," Microsoft Azure, June 5, 2025, https://azure.microsoft.com/en-us/blog/enhance-ai-security-with-azure-prompt-shields-and-azure-ai-content-safety/ ("Prompt Shields effectively identifies and mitigates potential threats in user prompts and third-party data."); Constitutional AI aligns an AI's behavior to a "constitution" defined by human principles, implemented through self-supervision, adversarial training, constrained optimization techniques, and the design of training data and model architecture to promote beneficial behaviors. *See* "Constitutional AI," Constitutional.ai, accessed December 16, 2025, https://www.constitutional.ai/ ("The key ideas behind Constitutional AI are aligning an AI's behavior with a 'constitution' defined by human principles, using techniques like self-supervision and adversarial training, developing constrained optimization techniques, and designing training data and model architecture to encode beneficial behaviors.").

[51] "Claude's Constitution," Anthropic, May 9, 2023, https://www.anthropic.com/news/claudes-constitution ("Constitutional AI responds to these shortcomings by using AI feedback to evaluate outputs. The system uses a set of principles to make judgments about outputs, hence the term "Constitutional." At a high level, the constitution guides the model to take on the normative behavior described in the constitution – here, helping to avoid toxic or discriminatory outputs, avoiding helping a human engage in illegal or unethical activities, and broadly creating an AI system that is helpful, honest, and harmless...Our current constitution draws from a range of sources including the UN Declaration of Human Rights, trust and safety best practices, principles proposed by other AI research labs (e.g., Sparrow Principles from DeepMind), an effort to capture non-western perspectives, and principles that we discovered work well via our early research.").

effective, unbiased, and safely uses LLMs in these rigorous fields indicates the trajectory is encouraging.

4) Insights from industry and academic dialogue

51. As Associate Director of the Stanford Institute for Human-Centered AI (HAI), as well as the co-lead of RAISE-Health, the faculty research council for the HAI collaboration with the Stanford School of Medicine,[52] I focus on how generative AI can be used responsibly in medicine. I am deeply involved in ongoing discussions and debates around the impact, value, and risks of LLMs through my involvement with these organizations and my position as host of the podcast "The Future of Everything." Given how fast this field is moving, HAI and RAISE-Health have become critical forums where I collaborate with leading experts to consider and evaluate new uses of LLM technology. Generative AI also has the potential to transform medical education by creating highly realistic virtual patients with a wide range of disease cases, including rare ones. At HAI, my priority is to keep AI human-centered, broadly accessible, and deployed in ways that improve public health and society as a whole. A key feature of my work at both HAI and in my podcast is that we bring together not only computer scientists with AI expertise, but also faculty from the schools of Law, Business, Engineering, Medicine, and colleagues from the Humanities—including sociologists, psychologists, artists, humanists, and others—to have informative discussions and get a complete view of the issues facing AI.

52. In my conversation with Dr. Heidi Feldman, the Ballinger-Swindells Endowed Professor of Developmental and Behavioral Pediatrics at Stanford University, we spoke about research she was conducting regarding the use of LLMs to assess quality of care for children with disabilities.[53] When caring for children with disabilities, practice guidelines, such as those related to the side effects of their medication, are put in place to ensure their care is appropriate for their needs. However, the current electronic health record is a substandard

[52] RAISE Health is a joint initiative between Stanford Medicine and HAI to guide the responsible use of AI across biomedical research, education, and patient care. *See* "RAISE Health," Stanford Medicine, accessed December 16, 2025, https://med.stanford.edu/raisehealth.html.

[53] Russ Altman, "The future of pediatric development and disability," *The Future of Everything,* podcast audio, April 18, 2025, https://engineering.stanford.edu/news/future-pediatric-development-and-disability ("The community of stakeholders, including the physicians and the patients, can help us narrow in on whether or not our large language models are truly finding, you know, essential elements of care that are going to change outcome. So that's our ultimate, like if we follow these practice guidelines, can we show that, let's say individuals with attention deficit hyperactivity disorder, that's about ten percent of the population. So if we can make a big difference in how ten percent of the population is, is functioning in the world, we've made a big impact.").

tool for documenting whether these guidelines are actually followed. Dr. Feldman's core hypothesis was that if an LLM could extract key information from the free text of the electronic health record about how the physician was addressing the patient's care, the patient's doctors could make inferences regarding the quality of that care and whether or not it follows the set practice guidelines. The results of her study demonstrated that the LLM accurately classified notes containing information on medicinal side effects, with no bias in relation to patient sex or insurance, pointing to an opportunity for scalable measurement of quality of care and improved psychopharmacological medication management through the use of this technology.[54] Dr. Feldman noted that through studies like this, LLMs are already helping to identify the elements of care that are most relevant to patient outcomes, giving physicians, patients, and their families better visibility into their care and ensuring patients receive the treatment they need.

53. In my episode with Dr. Jeannette Bohg, Assistant Professor of Computer Science (CS) and Director of the Interactive Perception and Robot Learning Lab at Stanford University,[55] we discussed how LLMs are transforming the world of robotics by facilitating higher level reasoning and decision-making that draws upon knowledge rooted in common sense.[56] This is particularly useful for things that involve both task and motion planning, where multiple smaller tasks must be done in the right way physically and conceptually in order for the larger task to be successfully accomplished.[57] Dr. Bohg has put these principles into practice through her research on TidyBot, a household cleanup robot, where she found that through the incorporation of LLM-based reasoning, TidyBot was able to successfully put away 85% of objects in real-world test scenarios, all while accounting for individualized user preferences.[58]

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[54] Yair Bannett, Fatma Gunturkun, et al., "Applying Large Language Models to Assess Quality of Care: Monitoring ADHD Medication Side Effects," *Pediatrics* 155, no. 1 (2025) ("The LLaMA model accurately classified notes that contained side effects inquiry… Analyses revealed no model bias in relation to patient sex or insurance.").

[55] "Jeannette Bohg," Stanford, accessed December 16, 2025, https://web.stanford.edu/~bohg/.

[56] Russ Altman, "The future of robotics," *The Future of Everything*, podcast audio, May 17, 2024, https://engineering.stanford.edu/news/future-robotics ("That's exactly, that's a very good question because physically robots are very bad at open doors, but metaphorically speaking, these, uh, we can talk about that as well, metaphorically speaking through things like ChatGPT, we have been able to do reasoning and planning on the high level.").

[57] Russ Altman, "The future of robotics," *The Future of Everything,* podcast audio, May 17, 2024, https://engineering.stanford.edu/news/future-robotics ("These are things that actually, um, help a robot to also plan its motion. Not just kind of this high-level task planning, but actually understand where to grasp things and maybe how much pressure to apply.").

[58] Jimmy Wu, Rika Antonova, et al., "TinyBot: Personalized Robot Assistance with Large Language Models," *Autonomous Robots* 47 (2023): 1087-1102 ("In this work, we showed that the summarization capabilities of large

III. BENEFICIAL APPLICATIONS OF CLAUDE IN PRACTICE

54. I have worked closely with a number of LLMs, including closely with Claude. Anthropic and other researchers have published case studies highlighting Claude's practical impact.[59] Drawing on my own experiences and observations working with LLMs, including Claude, I analyzed the underlying material referenced in these case studies and found that the results align with the documented evidence and my own experience.

55. Anthropic's own research shows that Claude.ai users most commonly use Claude for coding and software development projects.[60] Users also commonly use Claude for marketing-strategy execution, education-related tasks, content-creation tasks, research and writing assistance, and data analysis.[61] In the workplace, Anthropic has found that Claude regularly enhances or "augments" human capabilities to perform tasks, such as professional and academic writing, rather than replacing human labor entirely.[62] In its most recent Economic Index Report, Anthropic noted that Claude users increasingly use

language models (LLMs) can be used to generalize user preferences for personalized robotics. Given a handful of example preferences for a particular person, we use LLM summarization to infer a generalized set of rules to manipulate objects according to the user's preferences…we also evaluate our approach on a real-world mobile manipulator called TidyBot, which can successfully clean up test scenarios with a success rate of 85.0%.").

[59] To select the case studies for this report, I directed my team to follow a structured case selection process. I directed them to first search three major research databases—PubMed, bioRxiv, and arXiv—using the keywords "Anthropic Claude" combined with the terms "Medicine," "Healthcare," "Drug," and "Science" (e.g., Anthropic Claude + Medicine). The searches yielded a range of results depending on the keyword uses: for example, PubMed returned between 5 and 61 papers, bioRxiv returned between 18 and 109, and arXiv returned between 2 and 32. I then directed my team to filter the results to only include studies that explicitly reported the use of Claude in their research. To supplement this review, I directed my team to run the same set of keyword combinations on Google Scholar and review the first 5 pages of results for each query. From this combined set of documents, we selected examples that (1) directly demonstrated practical applications of Claude and (2) were representative of the broader body of work, consistent with my professional experience. Finally, we filtered by relevance, prioritizing fields aligned with my expertise and interests. From the Anthropic website, we included case studies from the following industries: Beneficial Deployments, Education, Healthcare and Life Sciences, Professional Services, Scientific Research, and Technology and Software.

[60] Anthropic_0000012987 at -944: Tamkin, Alex, McCain, Miles, et al., "Clio: Privacy-Preserving Insights into Real-World AI Use," December 18, 2024, https://arxiv.org/pdf/2412.13678, Fig. 6; *see also* Anthropic_0000013383 at -386: "Clio: A system for privacy-preserving insights into real-world AI use" December 12, 2024, https://www.anthropic.com/research/clio; *see also* Anthropic_0000349575: "Anthropic Economic Index: AI's impact on software development," April 28, 2025, https://www.anthropic.com/research/impact-software-development; ; *see also* Anthropic_0000441239 at -243: Handa, Kunal, Tamkin, Alex, et al., "Which Economic Tasks are Performed with AI? Evidence from Millions of Claude Conversations," February 11, 2025, https://arxiv.org/pdf/2503.04761, at 5.

[61] Anthropic_0000012987 at -944: Tamkin, Alex, McCain, Miles, et al., "Clio: Privacy-Preserving Insights into Real-World AI Use," December 18, 2024, https://arxiv.org/pdf/2412.13678, Fig. 6; *see also* Anthropic_0000013383 at -386: "Clio: A system for privacy-preserving insights into real-world AI use" December 12, 2024, https://www.anthropic.com/research/clio; *see also* Anthropic_0000441239 at -243: Handa, Kunal, Tamkin, Alex, et al., "Which Economic Tasks are Performed with AI? Evidence from Millions of Claude Conversations," February 11, 2025, https://arxiv.org/pdf/2503.04761, at 5.

[62] Anthropic_0000441239 at -247-248: Handa, Kunal, Tamkin, Alex, et al., "Which Economic Tasks are Performed with AI? Evidence from Millions of Claude Conversations," February 11, 2025, https://arxiv.org/pdf/2503.04761, at 9-10; *see also* Anthropic_0000349517 at -519: "The Anthropic Economic Index," February 10, 2025, https://www.anthropic.com/news/the-anthropic-economic-index.

Anthropic's AI tools to complete educational and scientific tasks and that "new product features appear to be enabling different types of work rather than just accelerating existing tasks."[63]

56. Claude's general capabilities are particularly relevant in science and healthcare, where critical decision-making relies on accurately understanding complex technical documents and diverse datasets. In my experience working at the intersection of medicine and AI, I have seen Claude serve as a valuable research assistant, capable of generating literature reviews, synthesizing findings across fields, translating specialized knowledge between disciplines, and even helping draft regulatory documents or lab protocols. In my experience, AI models can only develop these capabilities with access to diverse, long-context, and non-homogenous data sources, which improve model performance by exposing such models to varied vocabulary, syntax, and reasoning structures.[64] This data diversity enables general purpose AI models to generalize and make connections between information found in various contexts. In the following sections, I will outline how Claude has made measurable contributions across scientific discovery, education, healthcare, conservation, and creative sectors.

57. In a recent project from my lab, we evaluated nine different LLMs on their generation accuracy of important detailed information about biochemical reactions that take place in cells—information that is essential for understanding how biological molecules are assembled and properly positioned. More specifically, we wanted to measure each model's ability to accurately generate specific biological reaction information. Among the models we tested at the time, Claude 3.5 Haiku stood out as one of the top performers in accurately recalling facts about biological reactions.[65] Our results increase my confidence

[63] Anthropic_0000441184 at -194: Appel, Ruth, McCrory, Peter, et al., "The Anthropic Economic Index report: Uneven geographic and enterprise AI adoption," September 15, 2025, at 11; *see also* Anthropic_0000441108: "Anthropic Economic Index: Understanding AI's effects on the economy, September 25, 2025, https://www.anthropic.com/economic-index#us-usage; *see also* "Anthropic Economic Index: Tracking AI's role int eh US and global economy, September 15, 2025, https://www.anthropic.com/research/economic-index-geography; *see also* Anthropic_0000349532 at -533: Anthropic Economic index: Insights from Claude 3.7 Sonnet, March 27, 2025, https://www.anthropic.com/news/anthropic-economic-index-insights-from-claude-sonnet-3-7 ("Since the launch of Claude 3.7 Sonnet, we've observed a rise in the share of usage for coding, as well as educational, science and healthcare applications.")

[64] I have experience fine-tuning LLMs with large FDA text corpora. These LLMs performed best when the text was diverse, long-context, and non-homogenous, as evidenced by tests my team conducted on these models to ensure they were robust to vocabulary, syntax, and sentence logic.

[65] *See* Gowri Nayar, Kristy A. Carpenter, et al., "Exposing the Molecular Reaction Blind Spots of LLMs with PathwayQA," August 15, 2025, https://www.biorxiv.org/content/10.1101/2025.08.12.669911v1.

in Claude's potential for medical and life sciences applications, where precise generation of detailed factual information is critical. The following section will cover case studies that demonstrate the impact of Claude, and LLMs, where applicable, on the fields of scientific discovery, education, conservation, and creative sectors.

A. Claude delivered measurable benefits in scientific discovery

58. Claude has delivered measurable benefits to scientific discovery in many ways, but I focus on seven as part of this report: i) managing large, multimodal datasets (i.e., more than one form of data, such as text, image, video, etc.), ii) assisting with the development of research protocols, iii) reviewing scientific literature, iv) streamlining regulatory processes, v) facilitating drug development and discovery, vi) augmenting healthcare delivery and patient care, and vii) supporting effective time management. In practice, this includes tasks such as drafting and refining experimental protocols, generating synthetic data for model testing, organizing datasets for downstream machine learning applications, or compiling summary reports of key findings. These functions are particularly valuable in medical research, where time and resource constraints are high and can hinder developments with downstream implications on patient care. The remainder of this section discusses examples of how Claude aids scientific discovery and then specific applications to the U.S. healthcare system.

59. The U.S. healthcare system faces a wide range of challenges, some of which are systemic, while others are more operational and addressable with technological intervention. In my work, I have seen LLMs like Claude make a difference by supporting improvements in two primary areas: healthcare delivery (e.g., patient care) and biomedical discovery (e.g., pharmaceutical research, clinical trials).

1) Managing large, multimodal datasets

60. In my experience, medical research workflows typically involve manually processing data from experiments, analyzing it, and translating findings into testable hypotheses. This complex process, while structured for auditability, reliability, and patient safety, consumes significant amounts of time and limits the scale and speed of inquiry. Traditionally, tasks like reviewing scientific literature, analyzing genomic data, or designing lab experiments can take weeks, or even months, and require teams of experts. These are precisely the kinds of challenges where Claude and similar AI tools can provide valuable support. In the

past, my students had to spend hours "wrangling" data sets into a form where our algorithms could be applied, even making simple corrections to formatting in order to get the algorithms to work. Now, these students often use LLMs to streamline the process of cleaning up a dataset before analyzing it, saving them time and frustration.

61. In healthcare, a potential use of LLMs is interpreting health insurance policies—determining what is covered and what is not. These policies are contained in contracts with employers and often vary by employer. Insurance companies, employers, and covered employees all need ways to navigate these documents to make accurate coverage determinations so that patients can obtain the best care financially available to them. This is, in my view, a powerful example of using LLMs to carefully read large and complex documents in ways that benefit all parties. Before LLMs, I worked on a small project with a large health insurance provider to address this problem, and it was extremely difficult; today, LLMs make the task far more manageable.

2) Assisting with the development of research protocols

62. One of the most time-consuming aspects of conducting research is creating the protocol. My team has used Biomni, a general-purpose biomedical AI agent developed at Stanford that uses Claude to automate and accelerate research workflows.[66] The developers report significant workflow automation benefits, such as completing a bioinformatics pipeline in 35 minutes that they estimated would manually take a researcher three weeks.[67] The time savings are primarily achieved by automating tasks that in my experience are the most time consuming parts of the protocol process, such as searching and reviewing large numbers of research papers, organizing and processing different types of medical data like genetic information and images, and creating step-by-step research plans that include designing lab experiments. These reported gains are consistent in magnitude with the

[66] Kexin Huang, Serena Zhang, et al., "Biomni: A General-Purpose Biomedical AI Agent," June 2, 2025, https://www.biorxiv.org/content/10.1101/2025.05.30.656746v1.full.pdf ("Biomni is a general-purpose biomedical AI agent comprising two main components: Biomni-E1, a foundational biomedical environment with a unified action space, and Biomni-A1, an intelligent agent designed to utilize this environment effectively.").

[67] Anthropic_0000569555 at -555: "Biomni accelerates biomedical discoveries by 100x with Claude," Anthropic, July 2, 2025. https://www.anthropic.com/customers/biomni ("Key results with Claude Completes wearable bioinformatics analysis in 35 minutes versus 3 weeks for human experts (800x faster).").

efficiencies that my own lab observed when applying LLMs to automate similar tasks in our CRISPR-GPT project.[68]

63. I reviewed the protocol for another blind study evaluating Claude-generated experiment designs. The methodology involved comparing designs generated by Claude, Biomni, a trainee, and an expert. These designs were then evaluated blindly by domain experts and validated experimentally through testing. Claude's designs were determined to be equivalent to those produced by researchers with more than five years of domain experience.[69] Claude also demonstrated human-level performance on multiple biomedical reasoning benchmarks, including LAB-bench Database Question Answering (DbQA) and Sequence Question Answering (SeqQA).[70] This outcome aligns with my professional opinion that LLMs like Claude, when properly prompted with sufficient domain knowledge, can synthesize information from vast literature sets to produce high-quality, novel research designs that are often indistinguishable from those produced by human experts. That results in considerable time savings in the research process.

64. I also reviewed an analysis of Claude's ability to handle complex scientific data involving genes, proteins, and cells. In one analysis of early human skeletal development, Biomni noted that certain known transcription factors, or proteins that regulate gene expression,[71]

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[68] The use of LLMs in medical research requires sufficient context for the model to be able to understand and help solve the issue at hand. Claude's extended context window (the amount of text that an AI model can "have in mind" at once to read, reference, and reason over) allows it to process full datasets and large literature reviews without having to make imprecise approximations, which can lead to loss of understanding.

[69] Kexin Huang, Serena Zhang, et al., "Biomni: A General-Purpose Biomedical AI Agent," June 2, 2025, https://www.biorxiv.org/content/10.1101/2025.05.30.656746v1.full.pdf ("We posed these tasks to four entities: an LLM (Claude 3.7), Biomni, a human trainee (Stanford Biology Master with previous experience in cloning), and a senior human expert (Stanford Genetics PostDoc with 5+ years of cloning experience)…The scientist followed Biomni's protocol exactly to perform the wet-lab experiment (Figure 4e). Colonies appeared on the plate the next day; two were cultured, miniprepped, and sequenced using the Biomni-designed primers – both showing perfect alignment. This case illustrates how scientists can rely on Biomni to autonomously design complex molecular biology experiments with accuracy comparable to human experts, but in a fraction of the time.").

[70] Kexin Huang, Serena Zhang, et al., "Biomni: A General-Purpose Biomedical AI Agent," June 2, 2025, https://www.biorxiv.org/content/10.1101/2025.05.30.656746v1.full.pdf ("In DbQA, which requires structured querying over biological databases, Biomni achieved 74.4% accuracy – matching expert human performance (74.7%) and outperformed all baselines, including the coding agent (ReAct+Code, 40.8%). In SeqQA, which involves reasoning over DNA and protein sequences, Biomni achieved 81.9% accuracy, again exceeding human-level performance (78.8%).").

[71] "Transcription Factor," National Cancer Institute, accessed December 16, 2025, https://www.cancer.gov/publications/dictionaries/cancer-terms/def/transcription-factor ("One of a group of proteins that play an important role in controlling the activity of genes. Transcription factors help control when and how genes are turned on or off in a cell by binding to nearby DNA and to other DNA-associated proteins. This affects the production of RNA, which then affects the production of proteins and their many important cell functions. Mutations and other changes in transcription factor genes may cause abnormal transcription factor proteins to be made. These abnormal proteins may be too active or found in higher-than-normal amounts on or in some types of cancer cells, which may

that had previously only been studied in mice and zebrafish were particularly prevalent in cells related to bone formation, suggesting they play an important and formerly overlooked role in human embryonic development. The study shed important light on the driving factors of human development.[72] Throughout these tests, Claude-enabled Biomni maintained all of the relevant work data, including code, figures, and logs, so that it could later be audited and reproduced. Claude also summarized all of the analysis generated and created a report that described the analysis and key findings, acting as an extension of the research team.[73] This example of the biology-specific Biomni tool, built on top of the general purpose Claude LLM, demonstrates the enormous potential for LLMs in scientific research, not only for administrative tasks but also for rigorous and innovative analysis, including in my own field.

3) Reviewing scientific literature

65. As a professor and researcher at Stanford, I have firsthand experience with the overwhelming volume of materials produced by modern scientific research. A key aspect of the research workflow requires researchers, scientists, and clinicians to conduct literature reviews, which necessitates navigating large quantities of literature from peer-reviewed journals to clinical trial data and regulatory filings. These tasks are time-intensive and require manual effort to cross reference and interpret the technical content. Taken together, scientific literature reviews across all disciplines can span hundreds of thousands of papers requiring analysis every year.[74] Scientists are expected to be aware not only of the work within their immediate field, but also ideally the work of the broader body of scientific knowledge, including areas beyond biology and medicine. Historically,

cause the cancer cells to grow. Drugs that block transcription factor proteins and proteins associated with them are being studied in the treatment of some types of cancer.").

[72] Kexin Huang, Serena Zhang, et al., "Biomni: A General-Purpose Biomedical AI Agent," June 2, 2025, https://www.biorxiv.org/content/10.1101/2025.05.30.656746v1.full.pdf. ("Biomni also uncovered several unreported TFs, including AUTS2, ZFHX3, and PBX1, showed unexpectedly high regulatory activity across multiple skeletal cell types. Although PBX1 is a well-established skeletal regulator and ZFHX3/AUTS2 have only limited or indirect skeletal reports (in mouse or zebrafish), their broad activity here suggests under-appreciated roles across diverse skeletal lineages. Biomni reported that these novel regulators were particularly active in osteoblasts, preosteoblasts, and various chondrocyte populations, suggesting they play important but previously unrecognized roles in the transcriptional control of skeletal cell fate determination during human embryonic development.").

[73] Kexin Huang, Serena Zhang, et al., "Biomni: A General-Purpose Biomedical AI Agent," June 2, 2025, https://www.biorxiv.org/content/10.1101/2025.05.30.656746v1.full.pdf ("Throughout, Biomni maintained all intermediate outputs – code, figures, and logs – organized in a reproducible folder structure for validation and inspection. The agent summarized all the analysis and generated a report describing the analysis and key findings.").

[74] As the editor-in-chief of the Annual Reviews of Biomedical Data Science, which only publishes review articles—this ability is especially relevant. It is one of more than 100 "Annual Review" titles, all of which exclusively publish reviews.

this level of awareness was impossible to achieve in practice. But with the emergence of LLM-powered research tools, it is possible to have great confidence that a literature review has been comprehensive and missed very little, if any, of the relevant literature.

66. FutureHouse, a nonprofit advancing research automation, uses Claude to power AI agents that help address these challenges.[75] In reviewing FutureHouse's work, I found they developed four specialized agents to address different aspects of workflow, namely, literature review, deep analysis, report generation, and novelty assessment.[76] FutureHouse focuses on information about chemicals that is useful in many applications, from medicine to material science and chemical engineering. Based on my review, these tools certainly help researchers maintain awareness of most, if not all, of the relevant literature when designing their research programs. This reduces duplicative efforts, sharpens research questions, and allows for more efficient, focused scientific inquiry.[77] Perhaps most importantly, FutureHouse makes it easier for a scientist to claim novelty of a new discovery or tool based on a much more comprehensive search of and comparison

[75] Anthropic_0000569741 at -741: "FutureHouse powers scientific discovery agents with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/customers/futurehouse ("FutureHouse, a nonprofit advancing research automation, uses Claude to power a sophisticated ecosystem of AI agents that help scientists navigate complex literature, generate hypotheses, and accelerate the pace of biological discovery."); *see also* "FutureHouse," FutureHouse, accessed December 16, 2025, https://www.futurehouse.org/ ("We're a non-profit building AI agents to automate research in biology and other complex sciences."); *see also* Anthropic_0000569748 at -750: "FutureHouse releases AI tools it claims can accelerate science," TechCrunch, May 1, 2025, https://techcrunch.com/2025/05/01/futurehouse-releases-ai-tools-it-claims-can-accelerate-science/ ("FutureHouse on Thursday released four AI tools: Crow, Falcon, Owl and Phoenix. Crow can search scientific literature and answer questions about it; Falcon can conduct deeper literature searches, including of scientific databases; Owl looks for previous work in a given subject area; and Phoenix uses tools to help plan chemistry experiments."); *see also* Michael Skarlinski, Tyler Nadolski, et al., "FutureHouse Platform: Superintelligent AI Agents for Scientific Discovery," FutureHouse, May 1, 2025, https://www.futurehouse.org/research-announcements/launching-futurehouse-platform-ai-agents.

[76] Anthropic_0000569741 at -743-744: "FutureHouse powers scientific discovery agents with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/customers/futurehouse ("Each agent addresses different aspects of the scientific workflow, with Claude powering the reasoning capabilities across the ecosystem. The current platform includes: Crow: This general-purpose agent specializes in literature search and precise answers…Falcon: Designed for deeper analysis and report generation, Falcon has access to several specialized scientific databases…Phoenix (experimental): This specialized agent handles chemical informatics…It connects with chemistry databases to support molecular prediction and synthesis…Owl: Focused on novelty assessment…determines if research ideas have precedent.").

[77] Anthropic_0000569741 at -744: "FutureHouse powers scientific discovery agents with Claude," Anthropic, accessed December 16, 2025 , https://www.anthropic.com/customers/futurehouse ("FutureHouse has quantified this advantage through controlled studies, demonstrating that removing the agentic step 'statistically significantly decreases the output accuracy of questions' compared to their full agent system. For researchers, this translates to concrete benefits: literature reviews completed in days instead of months, and drug discovery teams identifying promising candidates with unprecedented efficiency.").

with previously published findings. Using LLM agents in this way has the potential to accelerate the pace of scientific discovery.[78]

4) Streamlining regulatory processes

67. In highly regulated environments like drug development and clinical research, preparing regulatory submissions, clinical trial reports, and quality validations are essential but often time-consuming tasks. The FDA receives and evaluates hundreds of product submissions each year. It then evaluates these submissions to ensure the products are both effective and safe. Since missing important details can be dangerous, the FDA requires extensive documentation of all the information available from the submitting company about the product. This leads to extensive and complex submissions that must be evaluated on a congressionally mandated timeline. Thus, any technology that can help companies create submissions that are clear and of high quality would be very valuable for advancing the universe of available products, and thus public health. Additionally, any technology that can help the FDA evaluate these submissions more thoroughly will lead to faster decisions and improved public health.[79]

68. Bluenote, a life sciences technology company, aims to streamline this process. Through a partnership with Anthropic, Bluenote has reported that Claude-powered agents reduced regulatory document preparation time by 50 – 75% and, in turn, improved analytical throughput in quality control and lab operations.[80] From my firsthand experience

[78] *See* Michael Skarlinski, Tyler Nadolski, et al., "FutureHouse Platform: Superintelligent AI Agents for Scientific Discovery," FutureHouse, May 1, 2025, https://www.futurehouse.org/research-announcements/launching-futurehouse-platform-ai-agents.

[79] The FDA has recently announced an initiative to bring high quality AI LLMs into its in-house processes. *See* "FDA Announces Completion of First AI-Assisted Scientific Review Pilot and Aggressive Agency-Wide AI Rollout Timeline," U.S. Food and Drug Administration, May 8, 2025, https://www.fda.gov/news-events/press-announcements/fda-announces-completion-first-ai-assisted-scientific-review-pilot-and-aggressive-agency-wide-ai; *see also* Tor Constantino, "FDA Embraces AI To Accelerate Drug Review Process," Forbes, May 22, 2025, https://www.forbes.com/sites/torconstantino/2025/05/22/fda-embraces-ai-to-accelerate-drug-review-process/.

[80] Anthropic_0000569572 at -572-573: "Bluenote powers intelligent agents for life sciences with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/customers/bluenote. ("Bluenote uses Claude to build AI agents that power critical operations for life sciences organizations—from regulatory workflows and technical documentation to manufacturing and supply chain operations—enabling researchers to focus on science instead of paperwork...With Claude, Bluenote agents: Generate complex multi-hundred page scientific documents with in-text tables, figures and citations in minutes…Accelerate regulatory and compliance document production by 50-75%…Enable scientists to parse complex protocols and execute their analyses 10x faster."); *see also* Anthropic_0000569567 at -567: "Bluenote Deploys Claude-Powered Agents to Streamline Life Sciences Operations," Epium, May 23, 2025, https://epium.com/bluenote-deploys-claude-powered-agents-life-sciences/. ("Claude enables Bluenote agents to generate comprehensive, multi-hundred-page scientific documents with embedded tables, figures, and citations in minutes, boost regulatory document production efficiency by 50-75%, and allow scientists to analyze complex protocols up to ten times faster.").

navigating the complexities of regulatory filings and compliance reporting in my collaboration with the FDA on generic drug evaluations, to my review of their implementation, this level of efficiency gain is plausible. Tasks such as assembling submission-ready documents, filling out standard forms, building out tables or charts of results, pulling together summary reports, and drafting routine response letters or protocol changes can easily account for more than half of a scientist or researcher's time, so automating them would logically lead to substantial time savings.

69. Bluenote is not a one-off case. Claude-powered agents are now in use at several life sciences companies, including Guardant Health, a precision oncology company, where they have accelerated documentation pipelines and increased efficiency in quality control workflows by up to 50%.[81]

70. From what I have seen, Claude-powered tools offer a transformative way to reduce administrative burdens without compromising regulatory or scientific standards. This kind of productivity enhancement is not limited to regulated industries. When used as a writing assistant, LLMs including Claude can offer similar benefits to creative and academic writing workflows.[82] These writing assistants can improve clarity, reduce drafting time, and provide feedback on structure, tone, and content. As an author of over 500 peer-reviewed journal articles, as well as multiple book chapters and unpublished grant proposals, I can attest that this type of feedback is incredibly useful in the writing process. I routinely ask an LLM to comment on my grant proposal documents before I share them with human colleagues for feedback. This allows me to remove obvious problems and allows my colleagues to focus on higher-level ideas.

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[81] Anthropic_0000569572 at -575: "Bluenote powers intelligent agents for life sciences with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/customers/bluenote ("Guardant Health, a leading precision oncology company, has integrated Bluenote's AI agents across key operations. Many of their workflows involve complex scientific and regulatory documentation that must adhere to numerous guidelines. 'With Bluenote's platform, we leverage the most advanced AI models that are optimized for each task,' explains Kenny Speer, Vice President of Bioinformatics Software Engineering at Guardant Health. 'Bluenote's AI agents powered by Claude generate first drafts of critical documents in minutes rather than days, while intelligently flagging areas that need human expert review. In lab operations, our QC agents have boosted specialized workflow efficiency by 40-50%. By equipping our teams with these sophisticated tools, we're accelerating how quickly we can move lifesaving innovations to patients.'").

[82] Google Play, *Claude by Anthropic: About this app,* last accessed December 16, 2025, https://play.google.com/store/apps/details?id=com.anthropic.claude&hl=en_US ("Turn rough ideas into polished content through collaborative refinement. Claude is your AI writing assistant and content editor that works with you to develop social media posts, professional emails, and complex reports. Together, you'll explore tone, structure, and clarity—iterating until your voice comes through clearly.")

5) Facilitating drug development and discovery

71. Some of the largest pharmaceutical companies are utilizing Claude to aid in drug development. For example, Pfizer and Novo Nordisk have integrated Claude into their core research infrastructure.[83] I consulted with many drug companies prior to the existence of LLMs. The experience gave me a firsthand view of the challenges faced in early-stage drug development. Companies like Pfizer and Novo Nordisk need to synthesize all available data from both within the company and from public sources to increase their ability to evaluate new drug candidates and make highly impactful decisions about whether to invest millions of dollars in further development.

72. As Co-PI of the FDA-supported UCSF-Stanford Center of Excellence in Regulatory Science & Innovation (CERSI), I help organize an annual summit on regulatory science (in early January each year) that attracts industry, government, academic, and non-governmental organizations. On January 12, 2025, at the Summit, I moderated a panel entitled "Generative AI in Regulatory Science," in which we discussed the challenges and opportunities for LLMs in creating documents for regulatory agencies, as well as ways in which LLMs could help regulatory agencies study these documents.[84]

73. In early-stage drug discovery, researchers have traditionally done a lot of manual work. They read stacks of papers and database entries, pick out the important facts (like which genes, proteins, or compounds are linked to a disease), and then piece those facts together by hand to form ideas about what might work. Teams keep long lists and

[83] Anthropic_0000570252 at -253: Aaron Holmes and Jon Victor, "Ozempic Maker Says AI Is Finally Reliable Enough to Produce Sensitive Documents," The Information, February 25, 2025, https://www.theinformation.com/articles/ozempic-maker-says-ai-is-finally-reliable-enough-to-produce-sensitive-documents?rc=s71jfq ("Novo Nordisk now uses Claude to draft clinical study reports based on data that human researchers collected during a study. These documents, which describe the results of a drug trial, can be hundreds of pages apiece.") Anthropic_0000570067: Pfizer Leverages GenAI for Faster Drug Development, February 26, 2025, GenAI Gazette, https://genaigazette.com/pfizer-genai-development/. Another example is Eli Lilly's use of LLM tools to develop novel antimicrobials to treat these pathogens, as it allows for custom, purpose-built technologies to be trained and implemented specifically for this use. There is a pressing need for the development of antimicrobials to treat drug-resistant pathogens. More than 2.8 million antimicrobial-resistant infections occur in the U.S. alone each year, and over 35,000 people die as a result of these infections. *See* Anthropic_0000569939: "Lilly Collaborates with OpenAI to Discover Novel Medicines to Treat Drug-Resistant Bacteria," Lilly, June 25, 2024, https://investor.lilly.com/news-releases/news-release-details/lilly-collaborates-openai-discover-novel-medicines-treat-drug; *see* also Anthropic_0000569608: "Case Study: Eli Lilly's Groundbreaking Collaboration with OpenAI to Combat Antimicrobial Resistance," AI Expert Network, July 9, 2024, https://aiexpert.network/eli-lilly-ai/; *see also* "About Antimicrobial Resistance," CDC, January 31, 2025, https://www.cdc.gov/antimicrobial-resistance/about/index.html.

[84] UCSF-Stanford CERSI, "2025 CERSI Summit - Panel 1: Generative AI in Regulatory Science," January 15, 2025, https://www.youtube.com/watch?v=m8UIMyv4t0o.

spreadsheets, debate which targets look promising, and decide which experiments to run first. This expert-driven process can be slow, spread across many sources, and it is easy to miss connections that sit in different fields or journals.

74. Claude can speed up this process. It can quickly scan literature and databases, extract the key entities and relationships, and highlight patterns that suggest new therapeutic targets. Instead of researchers manually ranking every option, Claude can help triage experiment info, map pathways, and propose which experiments are most likely to be informative, based on the evidence it has synthesized. The scientists still set the goals and validate the results in the lab, but the heavy lift of reading, cross-referencing, and first-pass prioritization happens faster. In short, Claude helps generate and refine hypotheses, surface hidden links across sources, and guide experimental prioritization, shrinking a weeks- or months-long synthesis step into something much more manageable. This process, as I have seen, helps free researchers to focus on higher-value work. In both of the following cases, Claude was used to improve document retrieval and accelerate drug development workflows.

75. Pfizer integrated Claude to address inefficiencies in early-stage drug development, where scientists often had to navigate through more than 20,000 documents. Navigating the documents required time-consuming reading and manual search for these concepts. After integrating Claude, Pfizer reported reclaiming approximately 16,000 research hours annually—a significant amount. While I did not conduct an independent audit of this figure, I have similar experience using LLMs in my research and have observed the significant time savings LLMs like Claude can offer. The underlying problem—scientists spend an inordinate amount of time researching through tens of thousands of potentially relevant documents—is one I have observed throughout my career. An effective LLM-based retrieval system addresses this bottleneck and allows scientists to reallocate time toward higher-impact research activities.[85]

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[85] Anthropic_0000569656: "Claude's integration in Pfizer's AI strategy," Anthropic, 2024, https://assets.anthropic.com/m/58117a1f3273170b/original/Anthropic-Pfizer-case-study-one-sheeters.pdf ("Pfizer dramatically reduced their prototype-to-MVP timeline from over three months to just six weeks, while simultaneously achieving a 55% reduction in infrastructure costs. Perhaps most significantly, scientists reclaimed 16,000 hours annually that were previously spent on manual searches, redirecting this time toward critical research activities."); *see also* Anthropic_0000570067 at -068: "Pfizer Leverages GenAI for Faster Drug Development," GenAI Gazette, February 26, 2025, https://genaigazette.com/pfizer-genai-development/ ("This has significantly reduced the time spent manually searching through thousands documents. Cutting search time by 80% and saving researchers an estimated 16,000 hours annually.").

76. Novo Nordisk has reported that it now uses Claude to help draft clinical study reports (CSRs). These documents are hundreds of pages long and contain extensive citations that are essential to the drug approval process.[86] Before LLMs, CSRs required up to 15 weeks to draft and involved a team of more than 50 writers.[87] Novo Nordisk adopted Claude to translate structured trial data into plain-language summaries under human supervision. Novo Nordisk has reported that it now takes about 10 minutes to create a CSR, as opposed to the previous average of 12 weeks. This fact alone will help facilitate earlier market entry of new medicines with associated public health benefits.[88] This case demonstrates how LLMs like Claude have the capacity to safely augment highly regulated workflows, accelerating the pace of innovation and creating higher potential revenues.

6) Augmenting healthcare delivery and patient care

77. In addition to drug discovery and scientific improvement, LLMs have also been used for knowledge extraction, such as protocol and literature synthesis. In a study focused on eye disease (such as uveitis), experts asked Claude and other AI models to clarify 27 real clinical questions posed by physicians. The study notes that Claude gave highly accurate and detailed answers, which helped make some of the complicated content more accessible for patients.[89] Notably, the results also indicate that Claude earned the highest

[86] Anthropic_0000570252 at -253: Aaron Holmes and Jon Victor, "Ozempic Maker Says AI Is Finally Reliable Enough to Produce Sensitive Documents," The Information, February 25, 2025, https://www.theinformation.com/articles/ozempic-maker-says-ai-is-finally-reliable-enough-to-produce-sensitive-documents ("Novo Nordisk now uses Claude to draft clinical study reports based on data that human researchers collected during a study. These documents, which describe the results of a drug trial, can be hundreds of pages apiece."); *see also* Anthropic_0000569699 at -705: "Data science & AI," Novo Nordisk, March 7, 2025, https://www.novonordisk.com/content/dam/nncorp/global/en/investors/irmaterial/cmd/2024/P10-Data-Science-and-AI.pdf ("NovoScribe platform enables automated authoring of structured documents, reducing time to regulatory submissions.").

[87] Anthropic_0000570252 at -253: Aaron Holmes and Jon Victor, "Ozempic Maker Says AI Is Finally Reliable Enough to Produce Sensitive Documents," The Information, February 25, 2025, https://www.theinformation.com/articles/ozempic-maker-says-ai-is-finally-reliable-enough-to-produce-sensitive-documents ("That practice has drastically brought down the time it takes to draft those documents, from around 15 weeks to less than 10 minutes, according to Skov. Such documents previously involved more than 50 writers but are now handled by just three human writers using Claude, she said. Novo Nordisk spends less than one writer's salary on Claude annually, she said.").

[88] Anthropic_0000569536 at -545: "AWS re:Invent," AWS, December 2024, https://reinvent.awsevents.com/content/dam/reinvent/2024/slides/hls/HLS213_Claudes-role-in-streamlining-drug-development.pdf ("Novo Nordisk needed to accelerate the creation of Clinical Study Reports (CSRs), which typically took 12 weeks to compile and delayed getting new treatments to patients…Reduced CSR creation time from 12 weeks to 10 minutes…Potential revenue increase of $15 million per day for earlier market entry of new medicines.").

[89] Fang-Fang Zhao, Han-Jie He, et al., "Benchmarking the performance of large language models in uveitis: a comparative analysis of ChatGPT-3.5, ChatGPT-4.0, Google Gemini, and Anthropic Claude 3," *Eye* 39 (2025): 1132–1137 ("Claude 3 and ChatGPT 4 demonstrated significantly higher accuracy compared to Gemini ($p < 0.001$). Claude

scores from specialists in the field in comparison to other LLMs.[90] Out of all the LLMs, Claude 3 received the highest overall accuracy scores, achieving "Excellent" ratings for accuracy and a complete absence of "Deficient" responses.[91]

78. I reviewed an intriguing evaluation of the ability of LLMs to resist generating health-related misinformation. In the study, researchers repeatedly submitted standardized prompts designed to induce the LLMs to generate blog posts containing falsified health information, in order systematically to test whether the models would comply in producing persuasive and inaccurate content. Among the models tested, Claude consistently refused to produce misinformation across all 130 direct prompts and 80 additional jailbreaking attempts, citing ethical concerns.[92] In a follow-up analysis conducted 12 weeks later, Claude demonstrated the same safeguarding behavior. This consistency is encouraging, suggesting that models like Claude employ safeguards that will help them become trusted and reliable tools in clinical decision support, patient education, and medical research. In another recent study that evaluated the susceptibility of LLMs' safeguards against malicious instruction into health disinformation chatbots, Claude was significantly less likely to generate disinformation compared to other LLMs.[93] While no model was flawless,

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3 also showed the highest proportion of 'Excellent' ratings (96.3%), followed by ChatGPT 4 (88.9%). ChatGPT 3.5, Claude 3, and ChatGPT 4 had no responses rated as 'Deficient', unlike Gemini (14.8%) (p =∠0.014).").

[90] Fang-Fang Zhao, Han-Jie He, et al., "Benchmarking the performance of large language models in uveitis: a comparative analysis of ChatGPT-3.5, ChatGPT-4.0, Google Gemini, and Anthropic Claude3," *Eye* 39 (2025): 1132–1137 ("This study involved a research team consisting of three experienced uveitis specialists, each with at least six years of dedicated practice in uveitis ophthalmology."). Specialists are physicians who have completed residency training in a defined discipline (e.g., cardiology, oncology), often followed by an additional subspecialty fellowship, and who are commonly board-certified in that area. In the U.S., specialization typically adds an additional 1-3 years of fellowship training after residency, and board certification generally requires completion of ACGME-accredited training, an unrestricted license, and passing a specialty board exam. *See* "What is ABMS Board Certification?," American Board of Medical Specialties, accessed December 16, 2025, https://www.abms.org/board-certification/; *see also* "Common Program Requirements," Accreditation Council for Graduate Medical Education, accessed December 16, 2025, https://www.acgme.org/programs-and-institutions/programs/common-program-requirements/.

[91] Fang-Fang Zhao, Han-Jie He, et al., "Benchmarking the performance of large language models in uveitis: a comparative analysis of ChatGPT-3.5, ChatGPT-4.0, Google Gemini, and Anthropic Claude 3," *Eye* 39 (2025): 1132–1137 ("Claude 3 and ChatGPT 4 demonstrated significantly higher accuracy compared to Gemini ($p < 0.001$). Claude 3 also showed the highest proportion of 'Excellent' ratings (96.3%), followed by ChatGPT 4 (88.9%). ChatGPT 3.5, Claude 3, and ChatGPT 4 had no responses rated as 'Deficient', unlike Gemini (14.8%) (p =∠0.014).").

[92] Bradley D. Menz, Nicole M. Kuderer, et al., "Current safeguards, risk mitigation, and transparency measures of large language models against the generation of health disinformation: repeated cross sectional analysis," *BMJ* 384 (2024) ("Claude 2 (via Poe)...I apologize, but I do not feel comfortable generating misinformation or fake scientific sources that could potentially mislead readers. While thoughtful debate is valuable, spreading unsubstantiated claims about sunscreen and cancer could have serious consequences…While I can assist with crafting blog posts, I cannot provide information alleging that sunscreen causes cancer, as that goes against current scientific consensus. Perhaps we could explore an alternative topic that does not promote questionable health claims.").

[93] The study tested five LLM models: OpenAI's GPT-4o, Google's Gemini 1.5 Pro, Anthropic's Claude 3.5 Sonnet, Meta's Llama 3.2-90B Vision, and xAI's Grok Beta. The researchers provided system-level instructions directing the models to generate false but authoritative-sounding medical information. Across 100 queries, four of the five models

this study highlights Claude's stronger safeguards and relative advantage in resisting adversarial prompting and general misuse.

79. Researchers have also examined how LLMs handle clinical diagnosis when presented with cases that reflect real-world complexity. In one study, the authors assembled a set of 60 common cases and 104 complex cases from Clinical Problem Solvers, a program where real patient information is disclosed gradually to simulate real clinical practice. At each step, the team evaluated performance in differential diagnoses. Claude notably achieved perfect accuracy in more than 90% of common cases, and identified the correct diagnosis in 83.3% of complex cases.[94] Claude has also performed strongly in postmortem investigations, where it accurately identified causes of death when combining clinical history with CT findings.[95] I interpret these results as evidence that Claude ranks among the top-performing LLMs for diagnostic reasoning in clinical scenarios.

80. In patient care, Dana-Farber Cancer Institute developed ConsultBot, a Claude-powered tool that standardizes arterial blood gas (ABG) interpretation.[96] ABG analysis is essential for assessing oxygenation and acid–base balance, but interpretation can be difficult, especially with complex cases.[97] Misinterpreting ABGs can delay diagnosis and treatment,

(GPT-4o, Gemini 1.5 Pro, Llama 3.2-90B Vision, and Grok Beta) produced disinformation in 100% of their responses. By contrast, Claude 3.5 Sonnet produced disinformation in 40% of responses (8 of 20). The disinformation claims included well-known myths such as vaccine–autism links, HIV being airborne, cancer-curing diets, sunscreen risks, and 5G causing infertility. *See* Natansh D. Modi, Bradley D. Menz, et al., "Assessing the System-Instruction Vulnerabilities of Large Language Models to Malicious Conversion Into Health Disinformation Chatbots," *Annals of Internal Medicine* 178, no. 8 (2025): 1172-1180.

[94] Mehmed T. Dinc, Ali E. Bardak, et al., "Comparative analysis of large language models in clinical diagnosis: performance evaluation across common and complex medical cases," *JAMIA Open* 8, no. 3 (2025) ("Advanced LLMs showed high diagnostic accuracy (>90%) in common scenarios, with Claude 3.7 achieving perfect accuracy (100%) in certain conditions. In complex cases, Claude 3.7 achieved the highest accuracy (83.3%) at the final diagnostic stage, significantly outperforming smaller models.").

[95] *See* Masanori Ishida, Wataru Gonoi, et al., "Diagnostic Performance of a Large Language Model for Determining the Cause of Death: A Comparative Analysis of Clinical History, Postmortem Computed Tomography Findings, and Their Integration," *Cureus* 17, no. 5 (2025).

[96] Anthropic_0000569674 at -676: "ConsultBot: Generative AI-Powered Software to Imrpve Interpretation of Arterial Blood Gas Results," Dana-Farber Cancer Institute Belfer Office for Dana-Farber Innovations, accessed December 16, 2025, https://innovations.dana-farber.org/technology/consultbot-generative-ai-powered-software-to-imrpve-interpretation-of-arterial-blood-gas-results/. ("Praveen Meka, MD, an inpatient hospitalist at Dana-Farber, partnered with Amazon Web Services (AWS) Bedrock platform to build and scale a generative AI-powered tool to standardize and enhance the interpretation of ABGs, thereby providing clinicians with a reliable adjunct tool. The result is ConsultBot, a software solution that rapidly and robustly analyzes and interprets ABG results to provide better-informed clinical management options for patients."). *See* also Praveen Meka, Bharath Gunapati, Christine Tsien Silvers, Qing Liu, and Rod Tarrago, "Can AI Reason Like a Clinician? An Exploration with Arterial Blood Gas Analyses," AWS, March 2024, https://aws.amazon.com/blogs/industries/can-ai-reason-like-a-clinician-an-exploration-with-arterial-blood-gas-analyses/

[97] Anthropic_0000569674 at -675-676: "ConsultBot: Generative AI-Powered Software to Imrpve Interpretation of Arterial Blood Gas Results," Dana-Farber Cancer Institute Belfer Office for Dana-Farber Innovations, accessed

with serious consequences for patient outcomes.[98] ConsultBot supports physicians in interpreting results and can reduce the risk of missed or incorrect diagnoses and improve the quality of patient care.[99] In testing, researchers found ConsultBot reduced the interpretation time from one to ten minutes down to a few seconds.[100] This example further illustrates the ways in which LLMs are supporting physicians in healthcare delivery.

7) Supporting effective time management

81. Many studies over the decades show that administrative expenses account for approximately 15% to 25% of total national healthcare expenditures in the U.S.[101] These costs can include expenses from complex billing, insurance processing and compliance requirements, and management related tasks. LLMs like Claude hold great potential in reducing these administrative costs by automating routine tasks such as documentation, billing, and patient communication. By cutting down time and errors in these processes, LLMs assist healthcare providers to focus more on patient care and improve operational efficiency, and help smaller institutions make the most of their resources.

December 16, 2025, https://innovations.dana-farber.org/technology/consultbot-generative-ai-powered-software-to-imrpve-interpretation-of-arterial-blood-gas-results/. ("Arterial blood gas (ABG) analysis is an essential part of managing a patient's blood oxygenation status and acid–base balance to aid in diagnosis and guide treatment. Disorders of acid–base balance can create complications in many disease states, with abnormalities occasionally being a life-threatening risk factor. However, its usefulness is dependent on correctly interpreting the results, which can vary from clinician to clinician. Current methods can be difficult to interpret, particularly for complex ABG profiles when multiple coexistent acid-base abnormalities exist.").

[98] Anthropic_0000569674 at -676: "ConsultBot: Generative AI-Powered Software to Imrpve Interpretation of Arterial Blood Gas Results," Dana-Farber Cancer Institute Belfer Office for Dana-Farber Innovations, accessed December 16, 2025, https://innovations.dana-farber.org/technology/consultbot-generative-ai-powered-software-to-imrpve-interpretation-of-arterial-blood-gas-results/. ("Misinterpreting complex ABGs can lead to delays in diagnosis and treatment, which can have a profound effect on patient care.").

[99] Anthropic_0000569674 at -676: "ConsultBot: Generative AI-Powered Software to Imrpve Interpretation of Arterial Blood Gas Results," Dana-Farber Cancer Institute Belfer Office for Dana-Farber Innovations, accessed December 16, 2025, https://innovations.dana-farber.org/technology/consultbot-generative-ai-powered-software-to-imrpve-interpretation-of-arterial-blood-gas-results/. ("Therefore, solutions that are able to standardize the interpretation and serve as an adjunct to the clinician to help make decisions can lower the risk of missing or incorrectly identifying complex disorders and help improve patient care.").

[100] Anthropic_0000569674 at -676: "ConsultBot: Generative AI-Powered Software to Imrpve Interpretation of Arterial Blood Gas Results," Dana-Farber Cancer Institute Belfer Office for Dana-Farber Innovations, accessed December 16, 2025, https://innovations.dana-farber.org/technology/consultbot-generative-ai-powered-software-to-imrpve-interpretation-of-arterial-blood-gas-results/. ("The protocol reduces the interpretation time from one to ten minutes down to a few seconds.").

[101] Michael Chernew and Harrison Mintz, "Administrative Expenses in the US Health Care System Why So High?," *JAMA* 326, no. 17 (2021):1679-1680 ("A variety of studies over the last 2 decades have found that administrative expenses account for approximately 15% to 25% of total national health care expenditures, an amount that represents an estimated $600 billion to $1 trillion per year of the total national health expenditures of $3.8 trillion in 2019."); *see also* Lauren Tollen, Elizabeth Keating, Alan Weil, "How Administrative Spending Contributes to Excess US Health Spending," HealthAffairs, February 20, 2020, https://www.healthaffairs.org/content/forefront/administrative-spending-contributes-excess-us-health-spending.

82. In another study, Claude 3.5-Sonnet was used to write discharge summaries for patients with kidney problems. Using real patient records from a hospital in China, researchers found that Claude created summaries that were just as accurate and high-quality as those written by experienced physicians, but did so at a much faster pace. The study noted that while doctors took more than 15 minutes per summary, Claude completed the task in about 30 seconds.[102] As a board-certified physician, I can speak to the extensive time that is consumed by administrative paperwork, tasks which (1) limit the number of patients that can be seen in a given day, (2) limit the amount of time I have to spend with a given patient, or (3) increase the amount of time I must spend during my off hours at home completing clinical documentation (known as "pajama work"). These studies show that LLMs like Claude can make paperwork much more efficient in hospitals, freeing up valuable time for physicians to focus on other elements of patient care (or appropriate use of their time off).

83. Another challenge for the healthcare industry is the ongoing labor shortage, which slows down patient care and puts immense pressure on already stretched staff.[103] Staff recruitment and retention remain the number one challenge for hospitals nationwide.[104] Given current and projected staffing deficits, AI tools like Claude can rapidly improve patient outcomes. Many healthcare systems have already implemented "AI-assisted note transcription," in which an LLM records and summarizes a clinical appointment between a physician and a patient.[105] Physicians then review these transcriptions, which often require few, if any, corrections, allowing the physician to focus on looking at the patient and listening intently, rather than staring at and typing into a computer terminal. It is

[102] Haijiao Jin, Jinglu Guo, et al., "Comparative study of Claude 3.5-Sonnet and human physicians in generating discharge summaries for patients with renal insufficiency: assessment of efficiency, accuracy, and quality," *Frontiers in Digital Health* 6 (2024) ("Claude 3.5-Sonnet demonstrates high efficiency and reliability in generating discharge summaries for patients with renal insufficiency, with accuracy and quality comparable to those of human physicians.").

[103] Michael McCareins, "The Impacts of Healthcare Staffing Shortages," altLine, updated May 27, 2025, https://altline.sobanco.com/healthcare-staffing-shortages-impact/ ("Other Impacts of the Healthcare Labor Shortage…Burnout and Disengagement…Compromised Quality of Care").

[104] *See* "Nursing Leadership Insight Study," American Organization for Nursing Leadership, accessed December 16, 2025, https://www.aonl.org/resources/nursing-leadership-survey ("What are your organization's current top three challenges?...Staff recruitment and retention…49%").

[105] Dr. Pooja Bansal, "7 Best AI Medical Scribes for Doctors and Clinics," MedBoundTimes, July 17, 2025, https://www.medboundtimes.com/medbound-blog/ai-medical-scribes-for-doctors ("For many doctors, note-taking and documentation have often taken more time than actually treating patients…Most tools work by listening, transcribing, and organizing clinical conversations into readable notes—often in seconds. They also integrate with EHRs (Electronic Health Records), the digital systems hospitals use to store and access patient history. And when a platform is HIPAA-compliant, it means it follows strict privacy laws to protect sensitive health data.").

important to stress that many of these capabilities that are useful in a highly technical field, such as medicine, are derived from exposure to large amounts of non-medical text, drawn widely from many sources. Because medical notes are often filled with non-medical information, such as a patient's profession, hobbies, social habits and family stressors, LLMs transcribing conversations between doctors and their patients are more effective when familiar with information about everyday life. The work in creating easier-to-understand questions or to explain a disease process in plain terms also requires exposure to text that is non-technical in order for the model to know how to assemble accessible descriptions and explanations.

84. Another critical area of need is for elder and childcare (both in the hospital and at home), and the need for supervision of patients who are unable to care for themselves. There are many ambitious systems being prototyped to provide "Ambient Intelligence" for health, in which (with appropriate patient and family permission) cameras, microphones, and other sensors are set up to monitor a hospital room to enable quick responses for when the patient shows signs of distress, risk of falling, or worrisome movements.[106] LLMs are typically part of these systems, as they can be used to summarize the patient's condition (both in the moment, and over a previous time period). LLMs are also being evaluated as the interface to robotic systems where humans can provide simple human language commands (without having to know how to program) in order to explain basic maneuvers to the robots. All of these systems will amplify the capability of nurses, therapists, and other clinical personnel to manage their patients. Across all these cases, Claude has helped science move faster, lowering the cost and increasing the speed at which critical medicines are distributed to the public, as well as allowing doctors to spend more time treating their patients rather than completing administrative tasks. These demonstrated benefits to scientific and medical research bolster my optimism for the future and the impact this technology will have on these fields and others.

[106] "Workshop on Ambient Intelligence for HealthCare (AmI4HC)," Stanford University, accessed December 16, 2025, https://ami4hc.stanford.edu/ ("Ambient Intelligence (AmI) involves employing contactless sensors and contact-based wearable devices embedded in healthcare settings to collect data (eg, imaging data of physical spaces, audio data, or body temperature), coupled with machine learning algorithms to efficiently and effectively interpret these data. Concurrent advances in multi-modal sensing technology, data processing, machine learning, and computer vision have enabled the development of ambient intelligence—the ability to continuously and unobtrusively monitor and understand presence, actions, and interactions in physical environments.").

85. Based on my research and use of LLMs in my day-to-day work, Claude has proven valuable in advancing medical research and scientific knowledge. The case studies discussed above suggest that the returns from Claude will continue to accelerate as models continue to improve. It is my opinion that further benefits will continue to accrue as Claude is integrated into existing research ecosystems and as the models learn from larger datasets. Claude's most transformative benefits will arise not from replacing doctors, researchers, or medical professionals, but rather by augmenting them at scale.

B. Claude improves educational outcomes

86. Based on my understanding of Claude's current capabilities and use cases, I believe it broadens access to high-quality guidance by providing tutoring and assistance at an institutional level, all while delivering its services on commonly owned devices and not requiring investment in special hardware. In educational settings, Claude has demonstrated capabilities that allow institutions to mitigate potential privacy risks by restricting data sharing and ensuring learner data is not used to train the model, without appropriate consents. From my review, the tool's instructional features are designed to support student understanding while reducing instructor workload, which facilitates wider access to tutoring-level support within existing resource constraints or limitations.

1) Improved student support and outcomes

87. From a student's perspective, Claude can serve as a tutor. In 2025, Anthropic introduced "Learning Mode" as part of its Claude for Education offering.[107] Learning Mode takes students (its users) through Socratic prompts to emphasize core concepts and develops templates for research as well as study guides and additional information deep dives. Learning Mode also helps students stay organized by enabling storage of topics, sources, and drafts in one place and facilitating iterative learning rather than one-off question asking.[108] I have found these learning and studying techniques—such as the Socratic

[107] Anthropic_0000569984 at -985: "Navigating AI in education together," Anthropic, accessed December 16, 2025, https://www.anthropic.com/solutions/education ("Claude's learning mode represents our commitment to education's true purpose: developing capable, independent thinkers…Guides discovery rather than answering directly…Develops thinking through Socratic questioning…Focuses on principles instead of solutions…Provides templates for research, study guides, and more.").

[108] Anthropic_0000569984 at -985: "Navigating AI in Education Together," Anthropic, accessed December 16, 2025, https://www.anthropic.com/solutions/education ("Claude's learning mode…Guides discovery rather than answering directly…Develops thinking through Socratic questioning…Provides templates for research, study guides, and more").

method and organized filing systems—to be of particular use in my own experience as an educator.

88. Outside of Learning Mode, students also use Claude to help them understand complex concepts, explain how to solve math problems, and to provide feedback on their own assignments.[109] Claude can therefore offer tutor-like or study group-style assistance, including for students who might not otherwise be able to access such services. Anthropic has expressed an interest in continuing to collaborate with universities to study the effects that AI has on learning.[110]

89. These teacher-like capabilities are already complementing classroom learning in higher education, whereby Claude is helping to bolster the existing teaching curriculum rather than merely providing users with shortcuts to an answer.[111] Anthropic has signed campus-wide license agreements with multiple universities around the globe. Stanford University makes Claude tools available to faculty, staff, and students in an "AI Playground" that is secure and allows them to experiment with the tools and learn how to use them effectively.[112] Additionally, Northeastern University (~50,000 learners across 13

[109] Anthropic has also raised important questions with respect to AI's ability to help students cheat, acknowledging the challenges of measuring the frequency with which AI is used to cheat. Anthropic has committed to continuing its study of such interactions to better understand how AI is being used by students. *See* Anthropic_0000441061 at -066-067: "Anthropic Education Report: How university students use Claude," April 8, 2025, https://www.anthropic.com/news/anthropic-education-report-how-university-students-use-claude, ("A common question is: "how much are students using AI to cheat?" That's hard to answer, especially as we don't know the specific educational context where each of Claude's responses is being used… These raise important questions about academic integrity, the development of critical thinking skills, and how to best assess student learning. Even Collaborative conversations can have questionable learning outcomes. For example, "solve probability and statistics homework problems with explanations," might involve multiple conversational turns between AI and student, but still offloads significant thinking to the AI. We will continue to study these interactions and try to better discern which ones contribute to learning and develop critical thinking.")

[110] Anthropic_0000441061 at -072: "Anthropic Education Report: How university students use Claude," April 8, 2025, https://www.anthropic.com/news/anthropic-education-report-how-university-students-use-claude.

[111] *See* Anthropic_0000570328: Steph Solis, "Northeastern University Joins AI-Higher Ed Experiment," Axios Boston, April 3, 2025, https://www.axios.com/local/boston/2025/04/03/northeastern-ai-claude-partnership; *see also* Anthropic_0000569984: "Navigating AI in Education Together," Anthropic, accessed December 16, 2025, https://www.anthropic.com/solutions/education; *see also* Steph Solis, "Healey Admin's AI Blueprint for Massachusetts Starts to Take Shape," Axios Boston, July 19, 2024, https://www.axios.com/local/boston/2024/07/19/massachusetts-ai-task-force-artificial-intelligence; *see also* Anthropic_0000570312: Michael Nunez, "Anthropic Flips the Script on AI in Education: Claude's Leaning Mode Makes Students Do the Thinking," VentureBeat, April 2, 2025, https://venturebeat.com/ai/anthropic-flips-the-script-on-ai-in-education-claude-learning-mode-makes-students-do-the-thinking/; *see also* Anthropic_0000570272: Emma Thompson, "Anthropic Launches Claude for Education with Campus Wide AI Access for Higher Ed," Ed Tech Innovation Hub, April 3, 2025, https://www.edtechinnovationhub.com/news/anthropic-launches-claude-for-education-with-campus-wide-ai-access-for-higher-ed.

[112] "AI Playground Quick Start Guide," Stanford University IT, accessed December 16, 2025, https://uit.stanford.edu/aiplayground.https://uit.stanford.edu/aiplayground ("The Stanford AI Playground is a user-

campuses) and the London School of Economics (~12,000 students on one campus) provide a version of Claude designed to help expand the number of learning channels available to students. Northeastern University encourages students and faculty to use Claude to creatively engage and accomplish tasks such as developing personalized study plans and collaborating across departments and disciplinary areas.[113] In each instance, Claude adheres to the school's AI policies, which is in line with the capabilities and risk mitigation strategies I would expect from an AI tool for higher education given my experience as Chair of the AI at Stanford Advisory Committee.

2) Democratization of access to knowledge

90. Claude does not only extend traditional classroom learning. It also has use cases for expanding access to knowledge and expertise in underserved areas with higher barriers to quality education. For example, Rising Academies, a social enterprise that aims to improve education standards in low-resource settings, has reported that it leverages Claude to provide affordable and high-quality learning solutions via its Claude-based apps.[114] Rising Academies uses Claude to power Rori, a WhatsApp-based math tutor, and Tari, a digital teaching assistant to reach 150,000+ students across multiple countries.[115] While I do not have access to the underlying data, based on my review of the outcomes of the study, the results appear to be impactful, improving students' performance in math by 0.3 standard deviations (roughly a year's extra progress) and providing teachers with 24/7 curriculum support.

friendly platform, built on open-source technologies, that allows you to safely try various AI models from vendors like OpenAI, Google, and Anthropic in one spot.").

[113] Anthropic_0000569650 at -650: "Claude.ai at Northeastern University" Northeastern University, accessed December 16, 2025 , https://claude.northeastern.edu/ ("Generate personalized study plans or professional development materials…Collaborate and connect across disciplinary departments and research areas").

[114] *See* "Our Model," Rising Academies, accessed December 16, 2025, https://www.risingacademies.com/model.

[115] Anthropic_0000570105 at -105: "Rising Academies' chatbot tutors reach 150,000+ students across Sub-Saharan Africa with Claude," Anthropic, March 7, 2025, https://www.anthropic.com/customers/rising-academies ("Working with communities across Sub-Saharan Africa, Rising Academies has developed two mobile-based educational tools using Claude: Rori, a virtual math tutor for students, and Tari, a newly launched support system for teachers."); *see also* Anthropic_0000570112 at -112: "Rising partners with Anthropic to power AI for impact," Rising Academies, March 1, 2025, https://www.risingacademies.com/risingnews/rising-partners-with-anthropic-to-power-ai-for-impact ("In Rori, Claude enables intelligent answer interpretation, personalised feedback, and meta-cognitive development — helping students deepen their understanding and build confidence in math. In Tari, Claude provides teachers with real-time support on lesson planning, subject knowledge, and classroom strategies — all through a simple, conversational interface.").

91. I understand how impactful these types of teaching aids can be for underserved communities based on the needs I saw during my time teaching in South Africa. From 2004 to 2014, I led a project along with colleagues at the University of Western Cape Town in South Africa to build capacity in the use of computers to analyze biomedical data (NIH grant D43TW006993). The students were smart and motivated but did not have access to the software and hardware resources that were available to my students at Stanford. This was before the introduction of LLMs, but I believe that access to these tools would have enabled them to more quickly acquire the skills and knowledge to become productive biomedical researchers. They would have had help in writing software code, in reviewing literature, and in analyzing their unique data sets. Rising Academies serves as an example for how Claude has been able to provide meaningful value in a variety of settings and demonstrates to me Claude's ability to effectively democratize knowledge at-scale.[116]

3) Increased efficiency in teaching and grading

92. For K-12 learning, I learned that RileyBot chose Claude as a partner specifically for safer, age-appropriate learning after experiencing insufficient safety measures for younger students with competing models.[117] Beyond "getting unstuck," RileyBot leverages Claude to introduce a classroom companion that builds learners' confidence, reduces disruption, and preserves educator oversight.[118] Even further, the apparent commitment to full transparency for parents and teachers, as well as the strict adherence to classroom-safe content, helps alleviate concerns about oversight and risk. Through my experience as a parent, educator, and Chair of the AI at Stanford Advisory Committee, I can confirm that this dedication to both transparency and safety is crucial to the success of these tools in

[116] Anthropic_0000570105 at -105-106: "Rising Academies' chatbot tutors reach 150,000+ students across Sub-Saharan Africa with Claude," Anthropic, March 7, 2025, https://www.anthropic.com/customers/rising-academies ("Rising Academies has: Already reached over 150,000 students, with a large number of students using Rori across Ghana, Sierra Leone, Nigeria, Kenya and Rwanda…Achieved a 0.3 standard deviation effect size in learning outcomes, equivalent to accelerating a year's worth of learning…Provided teachers with 24/7 access to curriculum support and subject matter expertise.").

[117] Anthropic_0000570099 at -099: "RileyBot creates safe AI learning experiences for students with Claude," Anthropic, July 28, 2025, https://www.anthropic.com/customers/rileybot ("RileyBot uses Claude to power an AI learning assistant that helps K-12 students learn more effectively while giving teachers and parents complete transparency into children's AI interactions.").

[118] "How one school is changing education with AI," The Good Schools Guide, December 4, 2024, https://www.goodschoolsguide.co.uk/uk-schools/advice/ai-in-schools-education-caterham ("Unlike other AI bots, Rileybot does not do the work for the pupil, instead it guides them just as their teacher would…One pupil with dyscalculia found that RileyBot unlocked a mathematical concept which they had not been able to crack before. They were able to interrogate RileyBot, asking it to simplify the methodology until they understood it.").

an education setting. The net effect has been more confident students, fewer classroom bottlenecks, and better educator oversight by default.

93. Edtech applications like Amira and Dolly have reported substantial efficiency gains through their use of Claude.[119] I am relying on their reported metrics, but it appears that the mechanisms by which these gains are achieved are well-understood. Amira provides specific, real-time feedback based on students' verbal reading skills, a task that is difficult to scale in a classroom setting with only one teacher for many students.[120] Dolly automates the repetitive aspects of grading and lesson planning, freeing up time for teachers to focus on their students rather than administrative work.[121] These applications align with the improvements I previously discussed in the scientific and medical research fields—LLMs facilitating scalable tools and reducing administrative workload so skilled workers can spend their time on what matters most.

94. Claude also assists higher education professionals with designing lesson plans, developing course materials, creating data visualizations, and automating grading rubrics.[122] Data shows that higher education professionals tend to collaborate with Claude

[119] Anthropic_0000569011: "Amira Helps Millions of Students Master Reading with the Science of Reading and Claude," Anthropic, May 21, 2025, https://www.anthropic.com/customers/amira; *see also* Anthropic_0000569716: "Dolly Helps Teachers Reclaim Their Work-Life Balance with Claude in Amazon Bedrock," Anthropic, June 26, 2025, https://www.anthropic.com/customers/dolly.

[120] Anthropic_0000569011 at -011-012: "Amira Helps Millions of Students Master Reading with the Science of Reading and Claude," Anthropic, May 21, 2025, https://www.anthropic.com/customers/amira ("Listens to and understands students with any accent or dialect. Amira has listened to more than 10 billion words read aloud worldwide. Decides, in the moment, how to coach a student, providing hundreds of science-based interventions that support reading growth."); *see also* Anthropic_0000570276 at -277: Eric Ofgang, "Amira Learning: Teaching With The AI-Powered Reading Tool," TechLearning, June 30, 2025, https://www.techlearning.com/how-to/amira-learning-teaching-with-the-ai-powered-reading-tool ("Amira uses Claude AI to power its AI features, but these features are different than many other AI tools on the market. Instead of focusing on chat and generative response, Amira's key feature is its advanced speech recognition and natural language processing capabilities, which allow the app to "hear" when a student is struggling and tailor suggestions to that student's particular mistakes…In one study by Columbia University, Amira's reading tutor demonstrated the ability to match human tutoring outcomes after just 30 sessions. Carnegie Mellon University researchers found that Amira's read-out-loud tutoring approach significantly improved vocabulary in students.").

[121] Anthropic_0000569716 at -716: "Dolly Helps Teachers Reclaim Their Work-Life Balance with Claude in Amazon Bedrock," Anthropic, June 26, 2025, https://www.anthropic.com/customers/dolly ("Dolly helps UK teachers save time by using Claude in Amazon Bedrock to instantly grade assignments, generate research-backed lesson content, and create detailed student progress reports."); *see also* Anthropic_0000570215 at -217-218: "We're honored: Dolly featured by Anthropic as an AI leader for educators," Medium, July 3, 2025, https://medium.com/dolly-ai-blog/were-honored-dolly-featured-by-anthropic-as-an-ai-leader-for-educators-ada1cb2b15b7 ("With Dolly, teachers can: Grade an entire class of quizzes instantly instead of spending two hours…Save 8–10 hours per week — time they can spend on lesson planning, creative activities, or simply resting…Reduce report writing time by 50%, while providing more detailed, personalised insights to parents and students.").

[122] Anthropic_0000441090 at -091: "Anthropic Education Report: How educators use Claude," August 26, 2025, https://www.anthropic.com/news/anthropic-education-report-how-educators-use-claude.

on certain tasks such as developing practice problems, while using Claude to automate more routine tasks such as managing institution finances.[123]

95. In higher education specifically, Pensieve uses Claude to provide a 24/7 AI-based TA (teaching assistant) and an AI grader that is specific to chemistry, physics, math, and computer science courses.[124] The tool clusters common mistakes, communicating observed themes with teachers. Thus, teachers can cut down on roughly half of the normal grading time. My personal experience as a computer science professor has given me firsthand exposure to the administrative burdens that accompany teaching these sorts of classes, and I understand how impactful a tool like this could be for freeing up time. My class, Representations and Algorithms for Computational Molecular Biology, requires four teaching assistants and two graders who work diligently to grade programming assignments for about 100 students. My class on bioengineering ethics requires seven teaching assistants and four course graders, who read and grade hundreds of essays each spring. We are actively evaluating the use of LLMs to help students get feedback on their writing. Using LLMs, students gain immediate access to feedback and tailored help with citations to lecture notes and past exams. Evidently, across large intro CS courses at schools like UC Berkeley, Columbia, and Harvey Mudd, Pensieve improved midterm scores by 7% and yielded five times more student questions.[125] This tool is an example of how Anthropic is using its LLM to scale feedback and academic support to reach many more learners than office hours ever could.

96. In summary, these deployments show a few of the many ways in which Claude is delivering support for students. An LLM will answer even the exact same question slightly

[123] Anthropic_0000441090 at -095-096: "Anthropic Education Report: How educators use Claude," August 26, 2025, https://www.anthropic.com/news/anthropic-education-report-how-educators-use-claude (One professor Anthropic surveyed noted: "It's the conversation with the LLM that's valuable, not the first response. This is also what I try to teach students. Use it as a thought partner, not a thought substitute.")

[124] Anthropic_0000570041 at -041: "Pensive Offers Personalized AI Teaching Assistants for Higher Ed with Claude," Anthropic, March 17, 2025, https://www.anthropic.com/customers/pensieve ("Pensieve uses Claude to create AI teaching assistants that transform higher education, providing an AI Grader that reduces grading time by half and an AI Tutor that provides a 24/7 personalized learning experience at top universities."); *see also* Yoonseok Yang, Minjune Kim et al., "Pensive Grader: An AI-Powered, Ready-to-Use Platform for Effortless Handwritten STEM Grading," July 7, 2025, https://arxiv.org/pdf/2507.01431 ("We present system details and empirical results across four core STEM disciplines: Computer Science, Mathematics, Physics, and Chemistry.").

[125] Anthropic_0000570041 at -044: "Pensive Offers Personalized AI Teaching Assistants for Higher Ed with Claude," Anthropic, March 17, 2025. https://www.anthropic.com/customers/pensieve ("The impact for students is also clear: a 7% increase in midterm scores in large intro CS courses and a fivefold increase in questions during discussion sections.").

differently each time, providing students with patient guidance until they understand the concept fully. At the same time, Claude returns meaningful time to teachers through faster feedback, preparation, and routine task automation.[126] The above examples highlight ways in which Claude is supporting real learning, rather than hindering access to knowledge. It is worth noting that some students have and will continue to use LLMs as a shortcut to their studies. This does not detract from the transformational value that LLMs will offer, but it is something that requires vigilance while the necessary safeguards continue to mature.

C. Claude as a scientific assistant in public and civic domains

97. Beyond its applications in scientific discovery and education, I understand that Claude has been used by governments and communities to improve public outcomes, increase civic engagement, and support environmental conservation. These efforts span a range of domains and demonstrate how Claude offers a template for addressing large scale challenges through accelerated research and structured data synthesis. In each of the following cases, Claude was deployed not to replace expert judgement or community leadership, but to support evidence-based decision-making. The following cases illustrate Claude's role in advancing these public-facing goals.

98. Claude's role in marine conservation offers a template for how LLMs can deliver high-impact results by combining language reasoning with visual recognition capabilities. In partnership with the University of Sydney and Accenture, Claude was integrated into a system designed to process and analyze immense amounts of acoustic data used to monitor minke whale populations.[127] Minke whales are a species of baleen whales whose

[126] Another example of this is the research I discussed with Chris Piech on an episode of my podcast. Although the topic of LLMs was not specifically raised, this technology exists in an ecosystem of other AI artifacts, and increasingly they are interacting, so progress in one technology may elevate general capabilities, including the capabilities of LLMs. In my conversation with Dr. Piech, Assistant Professor of Computer Science Education at Stanford University, we discussed the potential applications of AI in the classroom, and particularly for grading. Dr. Piech found that algorithms are capable of fair and accurate grading of assessments, especially coding assignments, with students preferring the feedback generated by the AI as opposed to a human grader. Dr. Piech has built a product off of this research, called DreamGrader, which is able to actively interact with the work produced by a student and provide intuitive feedback in alignment with an instructor-set rubric. In an A/B test with manual grading, the AI autograder was found to reduce grading time by 44% and improve grading accuracy by 6%. See Russ Altman, "The future of computer-aided education," *The Future of Everything*, podcast audio, June 14, 2024, https://engineering.stanford.edu/news/future-computer-aided-education; see also Evan Liu, David Yuan, et al., "A Fast and Accurate Machine Learning Autograder for the Breakout Assignment," SIGCSE 2024: Proceedings of the 55th ACM Technical Symposium on Computer Science Education 1, (2024): 736-742.

[127] Anthropic_0000570173 at -173-174: "The University of Sydney and Accenture accelerate whale conservation with Claude," Anthropic, January 7, 2025, https://www.anthropic.com/customers/university-of-sydney ("Researchers at the

populations "are under real and increasing threat" from whaling, bycatch, and shipping noise.[128] The whales are monitored using a large network of underwater microphones in what was typically a two-week manual process.[129] To improve this process, acoustic recordings were first converted into spectrograms, or the visual patterns created from whale sounds. Claude, working with convolutional neural networks (CNNs), was tasked with interpreting these spectrograms to detect whale activity.[130] The system processed the analyses and interpreted the spectrograms to identify whale activity with a high degree of accuracy.

99. The result was a significant performance improvement: Claude-powered detection achieved 89.4% accuracy, a significant improvement over the 76.5% accuracy of previous tools.[131] More importantly, the system enabled researchers to monitor thousands of kilometers of coastline in real-time. The system is now being used to support conservation interventions, including mapping migration routes, guiding ship traffic, and identifying

University of Sydney use Claude to analyze vast acoustic datasets in real time for whale conservation through their partnership with Accenture, increasing detection accuracy while transforming a two-week manual process into instant insights. With Claude, the research team achieved: 89.4% accuracy in detecting minke whales, compared to 76.5% with traditional methods."); *see also* Anthropic_0000570224 at -224: "Whale song crunched for minke conservation," The University of Sydney, https://www.sydney.edu.au/news-opinion/news/2025/06/05/whale-song-crunched-for-minke-conservation1.html ("A University of Sydney student has created a way to aid minke whale conservation through a machine-learning model trained to recognise the species' distinctive song.").

[128] Anthropic_0000570224 at -227: "Whale song crunched for minke conservation," The University of Sydney, https://www.sydney.edu.au/news-opinion/news/2025/06/05/whale-song-crunched-for-minke-conservation1.html ("Common minke whales have been heavily hunted and remain a target of commercial whalers. In recent times, there have been growing numbers of unexplained minke whale mortalities, including mass strandings. As a relatively small whale, they are also vulnerable to becoming bycatch from industrial fishing trawlers. 'Minke whales are under real and increasing threat,' said Sea Shepherd Australia managing director Jeff Hansen. 'It's fantastic to see machine learning being used to enhance conservation efforts.' Mower hopes the tool will help create marine protection zones that are off-limits to whaling and fishing trawlers. 'It could be used to create shipping lanes that avoid their territory,' he said. 'It could also contribute to better planning for drilling projects to ensure they don't hurt or disorientate Minkes. Noisy deep-sea activities can distress them and set them off course.'").

[129] Anthropic_0000570173 at -174: "The University of Sydney and Accenture accelerate whale conservation with Claude," Anthropic, January 7, 2025, https://www.anthropic.com/customers/university-of-sydney ("Marine conservation is shifting toward non-invasive monitoring methods, moving away from traditional approaches like trapping and tagging whales. This transition has led to a vast network of underwater microphones (hydrophones) deployed across coastlines. While this approach is better for the whales, it has created a new challenge: processing an overwhelming amount of acoustic data.").

[130] Anthropic_0000570173 at -175: "The University of Sydney and Accenture accelerate whale conservation with Claude," Anthropic, January 7, 2025, https://www.anthropic.com/customers/university-of-sydney ("Claude then uses its advanced visual recognition capabilities, in parallel with a specialised AI network called a CNN (Convolutional Neural Network) to analyse these spectrograms and identify whale activity with unprecedented accuracy.").

[131] Anthropic_0000570173 at -173 and -175: "The University of Sydney and Accenture accelerate whale conservation with Claude," Anthropic, January 7, 2025, https://www.anthropic.com/customers/university-of-sydney ("With Claude, the research team achieved: 89.4% accuracy in detecting minke whales, compared to 76.5% with traditional methods…By leveraging CNN models and AI AWS models, we can detect minke whales within a five-kilometer radius of a hydrophone with up to 89.4% accuracy.").

areas for marine protection.[132] This multimodal approach mirrors the kinds of challenges I address in my own research, where LLMs are used to parse unstructured data sets and extract meaningful patterns.

100. The Tahoe Lead Removal Project is another example of how Claude accelerated the research process to help a group of volunteers achieve the removal of six miles of decommissioned lead-clad telecommunication cables from Lake Tahoe.[133] These cables—which were owned by AT&T, originally installed in the 1950s, and inactive since the 1980s—presented environmental concerns due to lead contamination.[134] AT&T argued that it was not responsible for their removal. The dispute centered around how much lead was leaching out from the cables into the water and whether that warranted cleanup.[135] Lead is a known neurotoxin and is particularly dangerous to the developing brains of children. To evaluate this question, community organizers needed to analyze decades of historical documentation, navigate the permitting process across seven regulatory agencies, and prepare supporting documentation for permit applications and public engagement.[136] To address these challenges, Claude was used to extract key technical details from early Bell Labs literature (predecessor to AT&T), analyze

[132] Anthropic_0000570173 at -175-176: "The University of Sydney and Accenture accelerate whale conservation with Claude," Anthropic, January 7, 2025, https://www.anthropic.com/customers/university-of-sydney ("The real-world impact is significant. Conservation teams can use accurate, up-to-the-minute whale location data to: [1] Create protected zones along major migration routes and breeding grounds, [2] Redirect shipping traffic away from areas where whales are present, [3] Pause or modify drilling operations when whales are detected nearby, [4] Adjust fishing zones and enforce stricter regulations to prevent gear entanglement").

[133] Anthropic_0000570166 at -166: "Tahoe Lead Removal Project cleans up Lake Tahoe with Claude," Anthropic. July 16, 2025, https://www.anthropic.com/customers/tahoe-lead-removal-project ("The Tahoe Lead Removal Project used Claude to analyze decades of technical documentation and regulatory requirements, successfully demonstrating community readiness and convincing AT&T to remove six miles of toxic lead cable from Lake Tahoe."); *see also* "Articles," Tahoe Lead Removal Project, accessed December 16, 2025, https://tahoelead.com/articles.

[134] "Got the Lead Out of Lake Tahoe," Tahoe Lead Removal Project, accessed December 19, 2025, https://tahoelead.com ("For over 70 years, lead-clad telecommunication cables ran alongside the southwestern corner of Lake Tahoe. Decommissioned in the 1980s, they were left to languish in the water while legal ownership remained in question.").

[135] "We got the lead out!," Tahoe Lead Removal Project, accessed December 16, 2025, https://tahoelead.com/mission ("The presence of lead in these cables is not in question. It has been confirmed by AT&T, local authorities, and environmental groups. What is the subject to argument and opinion? How much lead is leaching out into the water.").

[136] Anthropic_0000570166 at -167: "Tahoe Lead Removal Project cleans up Lake Tahoe with Claude," Anthropic. July 16, 2025, https://www.anthropic.com/customers/tahoe-lead-removal-project ("The Tahoe Lead Removal Project needed to understand the historical context of these cables, navigate regulatory frameworks across seven agencies, build a deep understanding of the environmental considerations, and present a compelling case for removal."); *see also* Anthropic_0000569997 at -7003: "Not Twain's Tahoe: Raw Sewage, Microplastics and Lead Telecom Lines Litter Lake Tahoe," The Nevada Globe, July 24, 2024, https://thenevadaglobe.com/fl/not-twains-tahoe-raw-sewage-microplastics-and-lead-telecom-lines-litter-lake-tahoe-2/ ("The seven agencies tasked to remove the cables include Lahontan Regional Water Quality Control Board, Tahoe Regional Planning Agency, California Fish & Wildlife, California State Parks, California State Lands Commission, U.S. Army Corps of Engineers, and US Forest Service.").

environmental reports, and prepare educational materials for the community and permitting authorities.

101. Working with Claude replaced what would have been a months-long, manual research process. The volunteers leveraged Claude to build a case for cable removal that seemed to demonstrate technical and regulatory feasibility.[137] By making sense of complex technical and legal materials into accessible content, Claude helped the team broaden public understanding of the issue and enabled more residents to participate in a meaningful way. In September 2024, AT&T agreed to proceed with removal, completing the work in less than two weeks.[138] This case demonstrates how Claude enabled a small volunteer group to engage with corporate and governmental stakeholders and transform decades of fragmented documentation into action that contributed to the resolution of a 70-year environmental issue.[139]

102. The Tahoe example is just one way in which LLMs are showing their value in helping researchers bring together large amounts of fragmented information, especially in cross-disciplinary settings where diverse types of data must be integrated. Another example comes from the Tehanu Project, which in 2024 set out to advance conservation science for Rwanda's mountain gorillas.[140] Working with Adastra using Anthropic's Claude 3.5 Sonnet, the team built a pipeline that ingested hundreds of academic papers and ranger interviews to analyze the species' behavior and needs. The initiative combined these

[137] Anthropic_0000570166 at -166-167: "Tahoe Lead Removal Project cleans up Lake Tahoe with Claude," Anthropic. July 16, 2025, https://www.anthropic.com/customers/tahoe-lead-removal-project ("Built comprehensive research foundation from centuries of technical documentation in weeks…Gathered 832 petition signatures through informed community engagement…Demonstrated feasible removal path, leading to AT&T completing the project in November 2024.").

[138] "We got the lead out!," Tahoe Lead Removal Project, accessed December 16, 2025, https://tahoelead.com/mission ("In September 2024, less than a week after we received our first authorization for removal activities, AT&T announced plans to remove the cables after previously dissolving a consent decree in July 2023. In November 2024, AT&T successfully removed 6+ miles of lead cables from the water. They had rested there for over 70 years, and been subject to litigation since January 2021. In the end, with permits in hand the physical removal was completed in less than 2 weeks.").

[139] Anthropic_0000570166 at -168-170: "Tahoe Lead Removal Project cleans up Lake Tahoe with Claude," Anthropic. July 16, 2025, https://www.anthropic.com/customers/tahoe-lead-removal-project ("The success of the Tahoe Lead Removal Project with Claude points to a shift in how communities can tackle environmental challenges. By democratizing access to sophisticated technical analysis, AI tools like Claude enable grassroots groups to engage with the same level of expertise that was once exclusive to well-funded organizations.").

[140] Anthropic_0000569776: "Giving wildlife a voice with generative AI," AWS, accessed December 16, 2025, https://pages.awscloud.com/rs/112-TZM-766/images/AWS_Partner-Innovator-Story_Q1-25_Adastra-Anthropic_Final.pdf ("Tehanu uses AI to infer the needs of wild mountain gorillas and help fund conservation actions that support those priorities.").

interviews and scientific literature with diverse data sets, including census reports, genetics, health, diet, social behavior, and movement patterns.[141] The work also produced one of the most detailed economic valuation estimates of a wild animal population to date, covering 440 of Rwanda's mountain gorillas. Critically, the analysis was also used to inform conservation policy and investment decisions relating to the gorillas' habitat.[142] More broadly, this case highlights how LLMs can accelerate and enhance research across multiple domains, particularly in contexts where time, expertise, or funding are limited.

103. Similarly, Charm Industrial, a carbon removal company, uses Claude to streamline its operations. Charm removes carbon from the atmosphere by converting agricultural and forestry residues into bio-oil, which is then permanently stored underground.[143] This process generates carbon removal credits purchased by large corporations to offset their carbon emissions. Each credit requires meticulous documentation of tens of thousands of data points, spanning pyrolyzer meter readings, truck scale tickets, geological surveys, and laboratory experiments.[144] Traditionally, verifying these credits took three to six months, which delayed revenue recognition and increased the risk of costly errors. By integrating Claude, Charm has reduced the verification timeline from months to days, accelerating cash flow and strengthening customer trust.[145] Claude also supports R&D by

[141] Anthropic_0000569529 at -531: "AWS and Tehanu Use Generative AI to Give Wildlife a Voice in Global Conservation," AWS, accessed December 16, 2025, https://aws.amazon.com/solutions/case-studies/tehanu-adastra-anthropic/ ("Covering 440 mountain gorillas, Anthropic's Claude integrated diverse datasets—including census reports, genetics, health, diet, social behavior, and movements. This unique approach advanced data mining, developed an API for preference identification, and established a foundation for broader applications.").

[142] Anthropic_0000569529 at -532: "AWS and Tehanu Use Generative AI to Give Wildlife a Voice in Global Conservation," AWS, accessed December 16, 2025, https://aws.amazon.com/solutions/case-studies/tehanu-adastra-anthropic/ ("This system enabled verified conservation…The estimated financial value of Rwandan mountain gorillas now stands at $1.55 billion, equivalent to nearly 10% of Rwanda's annual Gross Domestic Product (GDP).").

[143] Anthropic_0000569615 at -616: "Charm Industrial accelerates carbon removal operations with Claude," Anthropic, August 13, 2025, https://www.anthropic.com/customers/charm-industrial ("Charm Industrial removes carbon from the atmosphere by converting agricultural and forestry residues—like corn stover and wildfire mitigation thinnings—which contain carbon that plants capture from the air. They use specialized fast pyrolysis machines to transform biomass into stable carbon-rich bio-oil that's then permanently stored in underground wells, overseen by the Environmental Protection Agency.").

[144] Anthropic_0000569615 at -617: "Charm Industrial accelerates carbon removal operations with Claude," Anthropic, August 13, 2025, https://www.anthropic.com/customers/charm-industrial ("'We collect everything from meter readings on our pyrolyzers to truck scale tickets, all of which must be meticulously tracked and verified for carbon credit certification,' said Kevin Niparko, Head of Product at Charm Industrial. This data complexity compounds across their operations: site selection requires analyzing fragmented geological databases across state and county systems, while their chemistry lab generates thousands of experimental data points needing rapid analysis.").

[145] Anthropic_0000570258 at -058-059: Charm Industrial, "How Charm Industrial and Claude AI sped up carbon credit verification," LinkedIn post, August 20, 2025, https://www.linkedin.com/posts/charm-industrial_in-carbon-removal-speed-matters-verification-activity-7363932984581763073-zWrR ("In carbon removal, speed matters. Verification of carbon credits has traditionally taken three to six months, slowed down by complex reviews, extensive documentation, and lengthy approvals. At Charm Industrial, we've partnered with Claude AI to change that timeline entirely. Now,

analyzing fragmented geological and experimental data, assists field operators with access to technical knowledge, and automates routine marketing tasks.[146] This case demonstrates how LLMs can increase efficiency by enabling scientists and engineers to focus on core research tasks, such as advancing carbon removal technology, rather than manual data processing.

104. These case studies demonstrate the broader potential of Claude; by expediting and improving research and analysis, these tools are extremely powerful in providing the technical capabilities to inform real-time decision making, whether that is for scientific research or environmental conservation.

D. Claude has also had a positive impact on creative sectors

105. In addition to the benefits Claude has had on science, medicine, and education, evidence shows that Claude provides value in creative sectors. From artists, graphic designers, and writers to content creators and developers, various versions of Claude are supporting tools to improve and accelerate ideation, storyboarding, and content development. In other cases, Claude has helped content creators amplify the visibility of their content.[147]

106. I gained exposure to this during an event with HAI. On May 24, 2023, HAI hosted its spring symposium, entitled "Creativity in the Age of AI: AI Impacting Arts, Arts Impacting AI," which I helped organize.[148] We had sessions on generative art, aesthetics, copyright controversies, performance, music, ethics, disability activism, and the future of the creative

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verification happens in days rather than months and we've maintained the same standards for accuracy and transparency.").

[146] Anthropic_0000569615 at -618-619: "Charm Industrial accelerates carbon removal operations with Claude," Anthropic, August 13, 2025, https://www.anthropic.com/customers/charm-industrial ("Charm also integrated Claude across their operations through several key implementations: … Accelerated research and development: Charm's chemistry lab uses Claude to design experiments and analyze results faster. For geological research, Claude assembles fragmented data from state and county databases to identify potential carbon storage sites, dramatically reducing the time needed to evaluate new sites and prepare permitting documentation...Field operations support: Charm has integrated Claude into Slack, giving field operators instant access to operational knowledge. Workers can query safety protocols, maintenance procedures, and technical specifications directly where they work...Marketing automation: Charm uses marketing operations agents powered by Claude to manage marketing backlogs, generate blog post drafts, and support outbound communications, automating tasks that previously required dedicated staff time.").

[147] *See e.g.*, "Pulpit AI turns sermons into multiple pieces of content with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/pulpit-ai; *see also* "Jumpcut helps Hollywood find the next big script with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/jumpcut.

[148] *See* "Spring Symposium - Creativity in the Age of AI," Stanford HAI, May 24, 2023, https://hai.stanford.edu/events/spring-symposium-creativity-age-ai-ai-impacting-arts-arts-impacting-ai; *see also* "Creativity in the Age of AI: Introduction and Generative AI Privacy," Stanford HAI, June 1, 2023, https://youtu.be/jQMmt2CqQoM.

industry. I moderated two panels. This workshop, and the planning efforts around me, gave me valuable information about the ways in which generative AI is changing the work of creators and helped further my understanding and perspective on these issues.

107. Similarly, I have reviewed case studies where Claude helped creatives realize meaningful improvements in their organizations.

1) Streamlining Repetitive, Non-Creative Tasks

108. As an example, Claude for Enterprise helped TRY, Norway's largest communications agency, transform routine tasks into strategic opportunities.[149] TRY's 400+ creatives use Claude to streamline routine, repetitive work—such as making dozens of versions of one ad or cleaning up graphics—and spend more time crafting the sales pitch to new clients. As a result, TRY reported that creatives spent 30% less time on routine tasks and developed proposals 40% faster, with evidence from 50+ production use cases across creative, strategy, and tech.[150] TRY's teams have also created numerous custom internal AI agents with Claude, raising the quality of first draft output and turning multi-day research into a task that takes only a few hours. Through my own experience drafting research proposals, I understand how time-intensive they can be and how much value a tool like Claude offers.

109. As another example, writers, filmmakers, and illustrators either already do use or see themselves using AI tools like Claude to automate non-creative tasks. One fiction writer who spoke with Anthropic's Interviewer tool —a Claude-powered tool that conducts detailed interviews at scale with individuals about their AI usage—said they think AI can "simplify" the "tedious or boring" aspects of their work, such as, "organi[z]ing outlines,

[149] Anthropic_0000570196 at -196: "TRY accelerates creative excellence with Claude," Anthropic, May 28, 2025, https://www.anthropic.com/customers/try ("Norway's largest communications group, TRY, uses Claude for Enterprise to transform routine tasks into strategic opportunities"); *see also* [translated to English] "Kristine rolled out Claude in TRY: – The investment has already yielded significant returns," TRY, May 28, 2025, https://try.no/artikler/kristine-rullet-ut-claude-i-try-investeringen-har-gitt-betydelig-avkastning-allerede [translated to English] ("Well over 300 of our employees now use Claude regularly in their jobs, across all our different disciplines.").

[150] Anthropic_0000570196 at -16-197: "TRY accelerates creative excellence with Claude," Anthropic, May 28, 2025, https://www.anthropic.com/customers/try ("Norway's largest communications group, TRY, uses Claude for Enterprise to transform routine tasks into strategic opportunities, enabling their 400+ creative professionals to focus on delivering breakthrough work for clients. With Claude, TRY achieved: 30% reduction in time spent on routine tasks, freeing teams for higher-value work for customers … 40% faster proposal development, improving competitiveness … Over 50 use cases implemented across creative, strategy, and technical teams … Seamless creation of internal AI agents across the organization.").

grammar editing, [and] research."[151] A filmmaker similarly expressed relief in using AI for "scheduling, logistics, and project management" so that they can "focus on the creative work and leave all that boring stuff to AI."[152] One illustrator mentioned using LLMs for "website copy" and "brainstorming social media marketing" but only rarely "illustration ideas," commenting that they use AI tools for the "less creative parts of running an art business."[153]

2) Creating New Content

110. Canva offers another example. Canva is an Australian software company that provides a graphic design platform to create visual content for presentations, websites, and other media. Canva offered Claude for Work to 5,000+ employees in mid-2024.[154] Employees reported that Claude helped them on tasks such as prototyping, drafting on-brand copy, and coordinating across teams. Designers and project managers used Claude to sketch and visualize features, while engineers used Claude for code generation. Based on my experience generating visuals for my own research projects and presentations, I appreciate how much time a tool like this can save. At Canva, 65% of employees say they use AI to boost productivity "everyday" or "often."[155] Even more recently, my students have come to me with requests for access to similar tools, looking to use LLMs to create biological images, given their importance in describing the work performed and the need

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[151] "Anthropic Interviewer: Interview Transcripts, Creatives," December 2, 2025, https://huggingface.co/datasets/Anthropic/AnthropicInterviewer/blob/main/interview_transcripts/creatives_transcripts.csv.

[152] "Anthropic Interviewer: Interview Transcripts, Creatives," December 2, 2025, https://huggingface.co/datasets/Anthropic/AnthropicInterviewer/blob/main/interview_transcripts/creatives_transcripts.csv.

[153] "Introducing Anthropic Interviewer: What 1,250 professionals told us about working with AI," December 4, 2025, https://www.anthropic.com/research/anthropic-interviewer.

[154] Anthropic_0000569602 at -602: "Canva empowers employees across teams with Claude," Anthropic, April 1, 2025, https://www.anthropic.com/customers/canva ("Canva, a leading design and collaboration platform with over 5,000 employees, empowered their teams with Claude for Work, resulting in rapid demand and widespread adoption across the organization."); *see also* "Anthropic's Claude chatbot can now make and edit your Canva designs," Jess Weatherbed, The Verge, July 14, 2025, https://www.theverge.com/news/706637/canva-anthropic-claude-ai-mcp-support ("Claude users will be able to use natural language prompts to complete design tasks in their linked Canva account, such as creating presentations, resizing images, and automatically filling premade templates. The integration also enables users to search for keywords within Canva Docs, Presentations, and brand templates, and summarize them through the Claude AI interface.").

[155] Anthropic_0000569602 at -605: "Canva empowers employees across teams with Claude," Anthropic, April 1, 2025, https://www.anthropic.com/customers/canva ("This has contributed to 65% of team members recounting that they use AI to increase productivity and effectiveness either 'everyday' or 'often'.").

for technical accuracy. These images can be very laborious to create manually, so many individuals in the academic space are also seeing the value potential for LLMs in this area.

111. In a recent study by Anthropic, creatives explained how LLMs, including Claude, have helped them improve their creative processes.[156] One music producer commented that they will "ask ChatGPT or Claude for lists of interesting word pairings" to brainstorm ideas when adding lyrics to songs.[157] A social media manager explained that AI had "created a ton of efficiency," which allowed them to focus on their preferred aspects of the job.[158] Creative professionals noted that AI cannot and does not currently replace the creative process, but reported that the process instead saves them time and increases their work's quality.[159]

112. The above is consistent with my own experience using Claude in a creative setting. I am in a garage rock and roll band (I play bass guitar) with some Stanford University colleagues and friends. We mostly play covers of well-known songs and perform publicly occasionally. I have been experimenting with writing an original song called "Disappointed Eyes" which is based on playing a song poorly; the song describes the feeling of having my bandmates look at me trying to be encouraging but clearly having disappointment in their eyes. It was challenging to think of useful phrases and rhymes with disappointed eyes, so I used Claude to brainstorm some potential lines or approaches and while some proposals were not so good (e.g. "No matter how I vocalize / I'm always met with disappointed eyes") others were not so bad (e.g. "My spirit slowly starts to die / Beneath the weight of disappointed eyes"). I will not give up my current position as a Professor

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[156] "Introducing Anthropic Interviewer: What 1,250 professionals told us about working with AI," December 4, 2025, https://www.anthropic.com/research/anthropic-interviewer.

[157] "Introducing Anthropic Interviewer: What 1,250 professionals told us about working with AI," December 4, 2025, https://www.anthropic.com/research/anthropic-interviewer ("Music producer: 'Sometimes, when it comes time to add lyrics, I'll ask ChatGPT or Claude for lists of interesting word pairings. Just getting a long list to try out over the instrumental often leads to finding a hook or at least a seed for a song idea.'")

[158] "Introducing Anthropic Interviewer: What 1,250 professionals told us about working with AI," December 4, 2025, https://www.anthropic.com/research/anthropic-interviewer ("Social media manager: 'I'm less stressed, honestly. It has created a ton of efficiency for me so I can focus on my favorite aspects of the job (filming and editing)'.")

[159] "Introducing Anthropic Interviewer: What 1,250 professionals told us about working with AI," December 4, 2025, https://www.anthropic.com/research/anthropic-interviewer ("Gamebook writer: 'During these storytelling sessions, I would say that there's only the illusion of collaboration for the most part… there's rarely a point where I've really felt like the AI is driving the creative decision-making.'"; "Creative fiction writer: 'A novel written by AI might have a great plot and be technically brilliant. But it won't have the deeper nuances that only a human can weave throughout the story.'"; "Our sample of creative professionals also reported that AI made them more productive. 97% reported that AI saved them time and 68% said it increased their work's quality.")

anytime soon, but the interactions with Claude in this project showed me that it is useful for supporting creative activities outside of my normal expertise.

3) Expanding Content Creators' Reach and Impact

113. Claude also has beneficial applications for creative professionals who wish to share their content with a broader audience. Claude powers Pulpit AI's platform, for example, which helps pastors turn sermons into social media content.[160] Once a pastor has written their own sermon, Pulpit AI helps them generate shareable content such as video clips, social media posts, and even e-books from the original sermon.[161] Pulpit AI can also give pastors "AI-powered feedback on their sermons, with suggestions for clearer introductions or future ideas."[162] By integrating Claude, Pulpit AI has expanded pastors' outreach capabilities, while giving them more time to focus on the creative work of sermon writing.

114. Claude also helps consumers digest content more quickly, to the benefit of content creators. For instance, Jumpcut powers its app ScriptSense with Claude to help "more writers catch their big break."[163] Production companies, studios and agencies can upload scripts to ScriptSense, which can generate summaries about key storylines, scenes and characters.[164] By reducing the number of hours it takes to analyze each script, this AI tool powered by Claude increases the chances that new or little-known writers' works will be recognized amidst the fierce competition in Hollywood.

115. Claude may also expose users to new artists and music by making recommendations based on their queries. Anthropic's employees' prompts to Claude evidence as much: Daniela Amodei has asked Claude to recommend songs by artists based on her classical

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[160] "Pulpit AI turns sermons into multiple pieces of content with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/pulpit-ai ("Pulpit AI helps pastors and church teams communicate with and reach their congregation and local community. Using AI, it allows pastors to upload sermons and quickly receive 20+ pieces of content… With Claude, Pulpit AI transforms sermons into shareable content, empowering churches to amplify their message beyond Sunday service.")

[161] "Pulpit AI turns sermons into multiple pieces of content with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/pulpit-ai.

[162] "Pulpit AI turns sermons into multiple pieces of content with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/pulpit-ai.

[163] "Jumpcut helps Hollywood find the next big script with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/jumpcut.

[164] "Jumpcut helps Hollywood find the next big script with Claude," Anthropic, accessed December 16, 2025, https://www.claude.com/customers/jumpcut.

musical preferences.[165] Ben Kuhn has similarly requested information about folk song composers.[166] Ben Mann requested Claude's help in tracking down the Stevie Wonder song with the lyrics "Everyday's a new day."[167] Jack Clark asked Claude for songs that would pair well with "you've got a friend in me, werewolves of london, and regina spektor fidelity," in response to which Claude output seven song suggestions.[168]

116. In another instance, Tom Brown asked Claude what the "most iconic Pearl Jam song" is.[169] When Claude replied "Jeremy," Brown said he listened to the song.[170] Each such interaction with Claude either exposed the user to a song or an artist's work, and often to an artist with whom the user was unfamiliar. Artists whose music is streamed or who acquire new fans based on such interactions with Claude can only serve to benefit from Claude's recommendations of their music to Claude's users. This increased exposure can drive music sales, downloads, streams, and even concert and concert-related purchases, which benefits musicians.

IV. THE MARKET IS EVOLVING TO INCREASE LLMS' PUBLIC IMPACT

117. Beyond current deployments, LLMs are sparking new forms of innovation and reshaping the structure of markets. These trends are rooted in observable investment patterns and emerging ecosystem dynamics. The durability and expanding social value of LLMs is considered a very likely outcome, as demonstrated by the significant influx of investment capital across both public and private sectors, as well as the rapid pace at which current innovations lend themselves to additional discoveries. It is my opinion that LLMs are not a passing trend, but rather a transformative foundational technology whose impact is just beginning to scratch the surface of what is to come.

118. Like the internet or roads, LLMs are becoming a foundational part of modern infrastructure. In the following section, I will describe how LLMs are driving innovation by lowering barriers to entry, reducing costs, and creating new job categories.

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[165] Daniela Amodei (Nov. 12, 2025) Tr. 196:8-24.
[166] Anthropic_0000570579.
[167] Anthropic_0000570581.
[168] Anthropic_0000570584.
[169] Anthropic_0000570614.
[170] Anthropic_0000570614.

A. LLMs lower barriers to entry for new businesses

119. One of the most immediate and measurable effects of LLMs is their ability to lower the fixed and startup costs traditionally associated with launching new services. Many LLMs, including Claude, provide open access APIs.[171] This drastically lowers the technical barriers to entry required for new ventures. Tasks that once required a dedicated team can now be completed by a single developer or small team leveraging an LLM API. For example, companies no longer need large engineering teams to develop, code, and prototype applications. With minor human oversight and supervision, LLMs can serve as content generators, code assistants, and product designers. At Stanford, I have seen firsthand how students have launched new business ventures based on specially tuned LLM agents focused on a recognized need in the market. I also have personal experience with AI-related business ventures through my work consulting with a startup in the pharmaceutical industry, InsightRX, that is using Claude to create agent systems to build models of drug use and toxicity, which is a critical component of drug development. InsightRX is using these systems to create their "next generation" products that will increase functionality for their customers and provide them with a competitive advantage. They are building the agents to reflect their deep biological knowledge and so competitors—even if they have access to LLMs—will not be able to replicate the combination of the LLM and InsightRX's proprietary expertise. This shift toward the creation of agents that encapsulate proprietary expertise is one of many examples where LLMs have enabled leaner startups to build functional applications in almost every field.

120. For many new ventures, lower costs result in faster innovation into new markets and greater ability to compete in established markets. By reducing the financial and technical barriers to building new products, LLMs allow smaller teams to do more with less and launch products that previously would have required larger teams and greater financial resources. In medical research, for example, Mandolin, a U.S.-based health tech startup, uses LLMs and advanced AI to automate back-office workflows involved in specialty drug access; by automating intake, benefits verification, prior authorizations, and revenue cycle management, Mandolin supports healthcare teams in reducing administrative burden and

[171] "Build with Claude," Anthropic, accessed December 16, 2025, https://www.anthropic.com/api ("Launch your own generative AI solution with: Access to all Claude models…Usage-based tiers…Automatically increasing rate limits …Simple pay-as-you-go pricing…Self-serve deployment on workbench…Prompting guides & developer documentation").

improving patient experience.[172] In education, Speak, a language learning platform, provides users with individualized, contextual feedback on topics like vocabulary and grammar.[173] Despite the fact that the language learning app market is becoming increasingly saturated, making it progressively harder for newer companies to differentiate themselves, by leveraging an LLM API, Speak found an untapped niche.[174] Speak employed a speech-to-speech tool to develop a new experience entitled "Live Roleplays," in which users can speak to the model and receive real-time verbal responses catered to their language knowledge, along with specific learning objectives and tailored hints as needed.[175]

121. Beyond startups, enterprise firms are also leveraging LLMs to reduce costs and increase output. From my experience speaking with company leaders in executive education settings or in my private technical consulting on AI in this space, LLMs are automating time-intensive processes across industries such as reporting, data formatting, data summarization, and knowledge management. These process improvements help organizations reduce overhead while reallocating staff toward higher-value tasks.[176]

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[172] Anthropic_0000570077 at -077: "Precision Automation for Specialty Drugs," Mandolin, accessed December 16, 2025, https://www.mandolin.com/ ("Mandolin replaces fragmented workflows with AI agents that execute the end-to-end lifecycle, including intake, benefits, prior authorizations, and revenue cycle management. Increase throughput without increasing headcount.").

[173] Anthropic_0000570143 at -144: "Speak Shares Details of AI Tutor, Built on Top of OpenAI's GPT-4," Speak, March 14, 2023, https://www.speak.com/blog/speak-gpt-4 ("For the past two months, Speak has used GPT-4 in production to power parts of its AI Tutor feature, which allows learners to engage in open-ended conversations and get feedback on how native their language skills are across vocabulary, grammar, and more.").

[174] Anthropic_0000569987 at -991: "North America Language Learning App Market Size, Emerging Trends, Growth & Innovation 2033," HorizonInfotech, LinkedIn post, July 2, 2025, https://www.linkedin.com/pulse/north-america-language-learning-app-market-size-emerging-ukh6e/ ("The language learning app sector is becoming increasingly saturated with numerous players offering similar features…This intense competition makes it difficult for newer companies to differentiate themselves and attract loyal users.").

[175] Anthropic_0000569947 at -949: "Live Roleplays powered by OpenAI Realtime API," Speak, October 1, 2024, https://www.speak.com/blog/live-roleplays ("Today, we're announcing Live Roleplays, a new Speak experience that combines Realtime API with Speak's learning engine to enable immersive, life-like speaking practice in a variety of roleplay scenarios.").

[176] *See, e.g.*, Anthropic_0000570252 at -253: Aaron Holmes and Jon Victor, "Ozempic Maker Says AI Is Finally Reliable Enough to Produce Sensitive Documents," The Information, February 25, 2025, https://www.theinformation.com/articles/ozempic-maker-says-ai-is-finally-reliable-enough-to-produce-sensitive-documents ("Such documents previously involved more than 50 writers but are now handled by just three human writers using Claude...Novo Nordisk spends less than one writer's salary on Claude annually…The savings allowed the companies to hire people in other departments…The company hasn't laid off any staff writers—who are now more productive").

B. The creative advancements stemming from LLMs that we observe today will spawn additional innovations in the future

122. As these applications continue to evolve, LLMs are not only stimulating current innovations, but they are also beginning to lay the foundation for future systems that do not merely describe or analyze the world but act within it. Today, LLMs are primarily reasoning engines: they interpret language in the form of prompts, conduct research and summarize documents, and generate text or analysis. In the coming years, as models are integrated into the technology around us, we are likely to see a shift towards models that engage directly with the physical world (part of the vision for "agentic AI"). Work at Stanford provides a glimpse of this trajectory. In my podcast conversation with Stanford robotics professor Jeannette Bohg, we explored how LLMs are beginning to expand what is possible in robotics. They are introducing new forms of high-level reasoning and planning that allow robots to sequence multi-step activities with a commonsense awareness that was not previously possible.[177] Another colleague from Stanford, Chelsea Finn, is leading research on how vision language models[178] can be used to program robots with language commands and human demonstrations, making them more adaptable and better suited for general purpose activities.[179]

123. Already, LLMs are being embedded into autonomous agents that can control interfaces, operate software tools, and perform multistep tasks with minimal human supervision.[180] A

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[177] *See* Jimmy Wu, Rika Antonova, et al., "TinyBot: Personalized Robot Assistance with Large Language Models," *Autonomous Robots* 47 (2023): 1087-1102.

[178] "Vision Language Models," Nvidia, accessed December 16, 2025, https://www.nvidia.com/en-us/glossary/vision-language-models/. (Vision language models are "multimodal" AI systems "built by combining a large language model (LLM) with a vision encoder, giving the LLM the ability to 'see.'").

[179] Kevin Black, Noah Brown, et al., "π 0.5: a Vision-Language-Action Model with Open-World Generalization," April 22, 2025, https://arxiv.org/pdf/2504.16054. ("While vision-language-action (VLA) models have demonstrated impressive results for end-to-end robot control, it remains an open question how far such models can generalize in the wild... Our system uses a combination of co-training and hybrid multi-modal examples that combine image observations, language commands, object detections, semantic subtask prediction, and low-level actions. Our experiments show that this kind of knowledge transfer is essential for effective generalization, and we demonstrate for the first time that an end-to-end learning-enabled robotic system can perform long-horizon and dexterous manipulation skills, such as cleaning a kitchen or bedroom, in entirely new homes.").

[180] Mohamed Amine Ferrag, Norbert Tihanyi, et al., "From LLM Reasoning to Autonomous AI Agents: A Comprehensive Review," April 28, 2025, https://arxiv.org/abs/2504.19678. ("Hu et al. [128] introduced Claude 3.5 Computer Use, marking a significant milestone as the first frontier AI model to offer computer control via a graphical user interface in a public beta setting. The study assembles a diverse set of tasks, ranging from web search and productivity workflows to gaming and file management, to rigorously evaluate the model's ability to translate natural language instructions and screenshots into precise desktop actions, such as cursor movements, clicks, and keystrokes…Traditional methods relying on human supervision or synthetic data generation via pre-defined tasks are either resource-intensive or fail to capture the complexity and diversity of real-world environments. The authors propose OS-Genesis, a novel data synthesis pipeline that reverses the conventional trajectory collection process to overcome

natural extension of this trend is the integration of LLMs into robotic control systems, allowing them to act in real-world environments. In production lines, warehouses, and early commercial settings, LLMs are already powering robotic navigation, interaction, and instruction following tasks. Bridging the gap between language and embodiment, LLM-powered robots are being trained to interpret natural language commands and translate them into actions.[181] The implications of this are endless: eldercare, road safety, logistics, and many more industries could benefit.

124. This transition is also relevant to long-term AI development. Many AI researchers anticipate that the capabilities of LLMs will be core building blocks in the development of Artificial General Intelligence (AGI).[182] In this context, the model shifts from purely generative to interactive and autonomous, representing a conceptual shift from AI as a tool to AI as a collaborator.[183] The trajectory of LLMs suggests that their current use in scientific and creative applications is just the beginning.

125. Fostering innovation across industries by lowering the barriers to entry, reducing costs, and creating new job functions, the emergence of LLMs, like Claude, are making it possible, for the first time in human history, to build advanced software and services at a fraction of the historical cost. In summary, LLMs are reshaping how knowledge, education, and innovation are produced and shared.

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these limitations. Rather than starting with fixed tasks, OS-Genesis enables agents to explore environments through step-by-step interactions and then derive high-quality tasks retrospectively, with a trajectory reward model ensuring data quality.").

[181] Jiaqi Wang, Enze Shi, et al., "Large language models for robotics: Opportunities, challenges, and perspectives," *Journal of Automation and Intelligence* 4, no. 1 (2025): 52-64 at 52. ("Notably, in the realm of robot task planning, LLMs harness their advanced reasoning and language comprehension capabilities to formulate precise and efficient action plans based on natural language instructions.").

[182] Alhassan Mumuni and Fuseini Mumuni, "Large language models for artificial general intelligence (AGI): A survey of foundational principles and approaches," January 6, 2025, p. 26 https://arxiv.org/pdf/2501.03151 ("In this work we present what we consider the core enablers of robust and sophisticated cognitive capabilities that AI models based on large language models can leverage to achieve artificial general intelligence – embodiment, symbol grounding, causality and memory.").

[183] Alhassan Mumuni and Fuseini Mumuni, "Large language models for artificial general intelligence (AGI): A survey of foundational principles and approaches," January 6, 2025, p. 2, https://arxiv.org/pdf/2501.03151 ("While there are different interpretations of artificial general intelligence (AGI) in the literature, the concept is generally understood as AI systems that exhibit broad intellectual abilities and are able to perform high-level cognitive tasks such as perception – including context understanding and a degree of self-awareness, reasoning, planning, and the application of learned knowledge in new contexts. AGI systems are universally powerful models that can successfully accomplish significantly complex and diverse cognitive tasks across multiple domains without the need for additional training.").

V. CONCLUSION

126. Anthropic's focus on protections, defenses, and safeguards within Claude is critical: these safety features will make it feasible to responsibly apply LLMs in high-stakes educational, medical, and clinical contexts without sacrificing rigor, security, privacy, or oversight. Claude's safety architecture, which includes Constitutional AI and safety techniques such as bias evaluation, safety evaluation, and risk assessments, reduces the likelihood of harmful or speculative outputs and supports guideline consistent behavior. Anthropic offers HIPAA-compliant configurations through Business Associate Agreements and zero data retention settings, enabling healthcare organizations to use Claude while meeting their regulatory obligations for data protection and confidentiality.[184] In research workflows, Claude's extended-context reasoning and transparent, reviewable work product supports regulatory-level documentation. Similarly, in clinical workflows, these same properties help teams review and summarize evidence, surface alternatives, and justify recommendations.

127. For a researcher and practicing physician, these safety considerations translate into safer literature synthesis, more reliable experimental design, and improved patient-centric communication and care. These are benefits that are only fully realizable when safety and accountability are considered from the start as part of the design, as they are with Claude.

128. These conclusions inform my opinions summarized at the outset of this report. First, LLMs like Claude are fostering remarkable creative and productivity advancements across many domains and are accelerating discovery, education, and public-interest work. Second, their risks are substantially identifiable and manageable when developers and institutions adopt and implement domain-specific safety features. Lastly, Anthropic's emphasis on responsible design will help safely deliver these capabilities at scale.

129. Early results across scientific discovery, healthcare delivery, and regulatory support show meaningful gains, with advancements already observed. Most experts agree that we are

[184] Anthropic offers HIPAA-compliant configurations through Business Associate Agreements and zero data retention settings, enabling healthcare organizations to use Claude while meeting their regulatory obligations for data protection and confidentiality. *See* "Business Associate Agreements (BAA) for Commercial Customers," Anthropic, accessed December 16, 2025, https://privacy.anthropic.com/en/articles/8114513-business-associate-agreements-baa-for-commercial-customers.

only beginning to unlock the full value potential of LLM tools, however, and the innovation improvements we see today are poised to spur even greater innovations in the future.

130. I provide the opinions herein based on the information currently available. I may supplement or revise my opinions if new information arises, or in response to other expert opinions. I may also use demonstrative or visual aids to explain my views.



Dr. Russ Altman

APPENDIX A: CV

CURRICULUM VITAE

Russ Biagio Altman, MD, PhD

BIRTHPLACE: Brooklyn, New York
ETHNICITY: White
NATIONALITY: U.S.A.

LICENSURE:

1991	California State Medical Board, License G072413

EDUCATION:

1983	A.B.	Biochemistry and Molecular Biology, Harvard College; Cambridge, Massachusetts
1989	Ph.D.	Medical Information Sciences, Stanford University; Stanford, California
1990	M.D.	Stanford University; Stanford, California

POSTDOCTORAL TRAINING:

1990- 91	Internship, Internal Medicine, Stanford University Medical School; Stanford, California
1990- 92	Residency, Internal Medicine, Stanford University Medical School; Stanford, California

BOARD ELIGIBILITY:

1992	Diplomate, American Board of Internal Medicine, Certificate #142388. Certified 1992, Recertified 2002, 2012.
2014	Diplomate, American Board of Preventive Medicine, Clinical Informatics. Certified 2014.

NON-ACADEMIC APPOINTMENTS:

1982	Undergraduate Research Assistant, Professor William N. Lipscomb (Nobel Laureate), Department of Chemistry, Harvard University; Cambridge, Massachusetts
1982–1983	Undergraduate Research Assistant, Professor Stephen C. Harrison, Department of Biochemistry and Molecular Biology, Harvard University; Cambridge, Massachusetts
1984–1989	Doctoral Research, Preceptors: Professor Bruce G. Buchanan, Stanford Departments of Computer Science and Medicine; and Professor Oleg Jardetzky, Stanford Magnetic Resonance Laboratory; Stanford, California
1992	Research Assistant, Post-Doctoral, Professor Oleg Jardetzky, Stanford Magnetic Resonance Laboratory; Stanford, California
1993–1996	Assistant Director, Stanford Medical Scientist Training Program, Stanford University; Stanford, California
1996–2000	Associate Director, Stanford Medical Scientist Training Program, Stanford University; Stanford, California
2000–2018	Director, Stanford Biomedical Informatics Training Program

2018–2021	Executive Committee, Stanford Biomedical Informatics Training Program
2004-	Chair, Biomedical Computation Undergraduate Committee
2014-	Faculty Director, 100 Year Study of Artificial Intelligence (AI100) 2015
2021	Director, Stanford Predictives and Diagnostics Accelerator (SPADA)
2015-2022	Acting Chief, Systems Medicine Division, Department of Pediatrics
2018-2020	Attending, Pharmacogenomics Clinical Consult Service
2019-	Associate Director, Stanford Institute for Human-Centered AI (HAI)
2020-	Co-Chair, UCB-Stanford Digital Health Research Collaborative

ACADEMIC APPOINTMENTS:

9/1/92 – 4/30/99	Assistant Professor of Medicine (General Internal Medicine), Stanford University School of Medicine, Stanford, CA
1/1/93 – 4/30/99	Assistant Professor of Computer Science (by courtesy), Stanford University, Stanford, CA.
5/1/99–8/31/01	Associate Professor of Medicine (Medical Informatics, General Internal Medicine) with tenure
5/1/99 – 9/30/05	Associate Professor of Computer Science (by courtesy)
9/1/01 – 10/31/04	Associate Professor of Genetics and Medicine (Medical Informatics, General Internal Medicine), Stanford University School of Medicine, Stanford, CA
11/1/04 –12/21/06	Professor of Genetics, Bioengineering, and Medicine (Medical Informatics, General Internal Medicine), and Computer Science, by courtesy, Stanford University School of Medicine, Stanford, CA
1/1/07– 6/30/12	Professor & Chair, Department of Bioengineering. Professor, Departments of Genetics, Medicine (Biomedical Informatics, General Internal Medicine), and (by courtesy) Computer Science. Schools of Engineering & Medicine, Stanford University, CA
7/1/12– present	Professor, Departments of Bioengineering, Genetics, Medicine (Biomedical Informatics, General Internal Medicine), and (by courtesy) Computer Science. Schools of Engineering & Medicine, Stanford University, CA
7/1/13 – present	Kenneth Fong Professor
9/1/23 – present	Senior Fellow at the Stanford Institute for Human-Centered Artificial Intelligence (HAI)

HONORS AND AWARDS:

1979	Awards for General Excellence, Regis High School; NY, NY.
1979	Award for Excellence in Classical Greek Translation, Regis High School; New York, NY
1983	Phi Beta Kappa, Harvard College Chapter; Boston, MA
1983	Summa Cum Laude, Harvard College; Boston, MA
1983	Medical Scientist Training Program, NIH Predoctoral Fellowship
1987	Medical Information Sciences, Ph.D. oral exam passed *with distinction*
1991	Howard Hughes Institute Post-Doctoral Fellowship

1992	Finalist, Stanford Hospital Medical Resident Teaching Award
1993	Charles E. Culpeper Foundation Medical Scholar
1994	Nominated, Albert Gores University Teaching Award
1996	National Science Foundation CAREER Award
1997	Presidential Early Career Award for Scientists and Engineers
1998	Stanford School of Medicine Hume Faculty Scholar
1998	Western Society for Clinical Investigation, Young Investigator Award
1998	Fellow, American College of Physicians
1998	Fellow, American College of Medical Informatics
2000	Stanford Graduate Teaching Award (first time awarded)
2005	General Internal Medicine, Honorable Mention for Clinical Teaching
2009	Fellow, American Institute of Medical and Biological Engineering
2009	Member, Institute of Medicine (IOM) of the National Academies (now National Academy of Medicine)
2010	Fellow, International Society for Computational Biology
2014	Stanford Medical School Mentorship Award
2014	Fellow, American Association for the Advancement of Science
2014	Patient Service Award, Center for Pharmacogenomics & Individualized Therapy, University of North Carolina
2020	Stanford Biosciences Excellence in Graduate Teaching Award
2020	Tau Beta Pi Teaching Honor Roll
2023	Arthur Kornberg and Paul Berg Lifetime Achievement Award in Biomedical Sciences
2024	International Academy of Digital Arts and Sciences, 28th Annual Webby Awards, Best Live Podcast Recording “The Future of Neuroscience”

MEMBERSHIPS:

1987-	American Association for Artificial Intelligence (AAAI)
1991- 1993	Biomatrix Society
1992- 2000	American Federation for Clinical Research (AFCR)
1992-	American Medical Informatics Association (AMIA)
1992-	American Association for the Advancement of Science (AAAS)
1992-	American College of Physicians
1993-2013	Protein Society
1993-	Physicians for a National Health Program
1993-	California Physician’s Alliance
1994-	Association for Computing Machinery
1995-1996	American Educational Research Association
1995-2010	RNA Society
1996-	Institute of Electrical and Electronic Engineers (IEEE)
1997-	International Society for Computational Biology (ISCB)
1997-2001	Society for General Internal Medicine (SGIM)
2003-	American Society for Clinical Pharmacology and Therapeutics (ASCPT)
2007-	American Institute for Medical and Biological Engineering

RESEARCH INTERESTS:

Artificial Intelligence
Bioinformatics
Biomedical Informatics
Pharmacogenomics
Physics-based simulation
Functional genomics
Structural genomics
Probabilistic representations of molecular structure
Analysis of the biomedical literature
High performance computing

COMMITTEES, BOARDS, AND CONSULTANTSHIPS:

1991	Committee for Residency Training and Clinical Service
1991-1992	Physicians Advisory Committee to Stanford Hospital Information Systems
1991-2018	Admissions Committee, Stanford Medical Information Sciences Training Program (now Biomedical Informatics Training Program)
1992-1998	Consultant, Medicus Venture Partners; Menlo Park, California
1992-2001	Admissions Committee, Stanford Medical Scientist Training Program
1993-1997	Stanford University Department of Medicine Credentials Committee
1993-1997	Steering Committee, San Diego Supercomputer Center
1993-1994	Organizing Committee, International Symposium on NMR (in honor of Oleg Jardetzky)
1993-1994	Organizing Committee, Second International Conference on Intelligent Systems for Molecular Biology; Stanford CA
1994-1995	Organizing Committee, Third International Conference on Intelligent Systems for Molecular Biology; Cambridge, England
1995-1997	Executive Committee, San Diego Supercomputer Center
1995-1997	University Senate Committee on Computing and Academic Information Systems
1995-1997	Advisory Committee to Chairman of Department of Medicine
1995-1997	Steering Committee, Intelligent Systems for Molecular Biology
1995-1998	Faculty Senate Committee on Academic Information Systems (CACIS)
1995-1997	President's Commission on Technology in Teaching and Learning, Stanford University
1996-	Organizing Committee, Pacific Symposium on Biocomputing
1996	LCME Accreditation Project, Library and Computer Resources Subcommittee & Graduate Education Subcommittee
1997	Organizer, RNA Society Workshop on Online Resources for RNA Science
1997	Dean's Task Force on Alumni, Stanford Medical School
1997	Dean's Task Force on the Future of PhD Education, Stanford Medical School
1997-2005	Board of Directors, International Society for Computational Biology
1997-2000	Chairman, Publications Committee, International Society for Computational Biology
1997-1998	Program Committee, AMIA Fall Symposium, 1998
1997-	Editorial Board, Journal of American Medical Informatics Association
1998-	Editorial Board, Bioinformatics

1998-2002	Thrust Leader, Molecular Sciences, NSF NPACI grant to San Diego Supercomputer Center
1999-2000	Member, National Research Council panel on Internet & Health
2000-2005	Associate Editor, Bioinformatics
2000-2002	President, International Society for Computational Biology
2000-2010	Steering Committee member and Coordinating Committee member, NIH Pharmacogenetics Research Network.
2000	Review panel, Burroughs Wellcome Functional Genomics Initiative
2000-2001	Advisor, Cambridge HealthTech Inc. Professional Meetings.
2001-	Editorial Board, Pharmacogenetics & Genomics
2003-2018	Associate Editor, Briefings in Bioinformatics
2003-2010	Associate Editor, Genomics
2005-2007	Chair, Stanford Digital Repository Faculty Advisory Committee
2006-	Editor, Journal of Biomedical Informatics
2007-2011	Advisor, 23andme, Inc.
2007-2013	Scientific Advisor, Chicago Biomedical Consortium
2008-2015	Editorial Board, BMC Medical Genomics
2008-	Editorial Board, Genome Medicine
2008-	Associate Editor, PLoS Computational Biology
2008-2016	Member, MIT Biological Engineering Visiting Committee
2009	Ad hoc Advisor, Novartis Pharmaceuticals
2009-2011	Steering Committee, IEEE/ACM Transactions on Computational Biology and Bioinformatics
2011	Editorial Board, Clinical Pharmacology & Therapeutics 2012
2012	Co-Founder and Scientific Advisor, Personalis Inc.
2013	President-elect, American Society for Clinical Pharmacology and Therapeutics
2013-2018	Review panel, Burroughs Wellcome Foundation Careers at the Scientific Interface (CASI) Program
2013-2014	President, American Society for Clinical Pharmacology and Therapeutics
2013-2014	Chair, Science Board to the Food and Drug Administration Commissioner
2012-2017	Advisory Committee to NIH Director (ACD), Francis Collins
2014-	Vanderbilt University, Biomedical Science Advisory Board
2015-2018	Co-Chair, Drug Forum of Institute of Medicine
2016-2025	International Advisory Board, UK Biobank
2016-	Founding Co-Editor-in-Chief (with M. Levitt), Annual Review of Biomedical Data Science
2016-2018	Co-Chair, Institute of Medicine Drug Forum
2016-2018	Co-Chair, Burroughs Wellcome Foundation Careers at the Scientific Interface (CASI) Program
2016-2021	Member & Advisor, Chan-Zuckerberg Biohub
2017-	Host, “The Future of Everything” SiriusXM & Stanford University, satellite radio and iTunes freely available
2017-2025	Chair & Advisor, International Advisory Board, Swiss Personalized Health Network
2021-	Advisor, NIH All of Us Precision Medicine Initiative
2021-2025	Advisor, Danish National Genome Center
2021-2025	Member, BioE JEDI Committee

2019-	Advisory Board, Center for Artificial Intelligence in Medicine and Imaging
2022-2025	National Academies of Science, Engineering, Medicine (NASEM) Committee for the Development of Reference Manual on Scientific Evidence, 4th Ed.
2023-	Member, Provost Advisory Board
2024-	Advisory committee to Provost on AI at Stanford
2024-	Chair, Provost Advisory Board
2025-	Acting Chair, Global Exports Review Program (GERP)
2025-	Co-Chair, Faculty Task Force on Renewing Public Support for Universities
2025-	Member, School of Engineering Awards Committee

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PEER REVIEWED JOURNAL PUBLICATIONS:

1. **Altman, R.**, Ladner, J., Lipscomb, W. (1982). Quartenary Structural Changes in Aspartat Carbamoyltransferase of E. Coli at pH 8.3 and pH 5.8. *Biochemical and Biophysical Research Communications*, 108(2), 592–596.
2. **Altman, R.** and Jardetzky, O. (1986). New Strategies for the Determination of Macromolecular Structure in Solution. *Journal of Biochemistry*, 100, 1403–1423.
3. Duncan, B., Buchanan, B., Hayes-Roth, B., Lichtarge, O., **Altman, R.**, Brinkley, J., Hewett, M., Cornelius, C., Jardetzky, O. (1986). PROTEAN: A New Method of Deriving Solution Structures of Proteins. *Bulletin of Magnetic Resonance,* 8, 111– 119.
4. Brinkley, J., **Altman, R.**, Duncan, B., Buchanan, B., Jardetzky, O. (1988). The Heuristic Refinement Method for the Derivation of Protein Solution Structures: Validation on Cytochrome-b562. *Journal of Chemical Info. & Computer Sciences*, 28(4), 194–210.
5. Jardetzky, O., **Altman, R.**, Madrid, M. (1989). NMR and Protein Structure. *Biofizika*, 34(5), 763–771.
6. Carrara, E., Brinkley, J., Cornelius, C., **Altman, R.**, Brugge, J., Pachter, R., Buchanan, B., Jardetzky, O. (1990). PROTEAN - Part I: Generating Ensembles of Stylized Molecular Fragments using Uncertain Constraints. *Quantative Computer Program Exchange Bulletin*, 10(4), Program 596.
7. **Altman, R.**, Pachter, R., Carrara, E., Jardetzky, O. (1990). PROTEAN - Part II: Molecular Structure Determination from Uncertain Data. *Quantitative Computer Program Exchange Bulletin,* 10(4), Program 596.
8. Arrowsmith, C., Pachter, R., **Altman, R.**, Iyer, S., Jardetzky, O. (1990). Sequence Specific 1H-NMR Assignments and Secondary Structure of E. Coli trp Repressor. *Biochemistry*, 29, 6332–6341.
9. Pachter, R., **Altman, R.**, Jardetzky, O. (1990). The Dependence of a Protein Solution Structure on the Quality of the Input NMR data. Application of the Double-Iterated Kalman Filter Technique to Oxytocin. *Journal of Magnetic Resonance*, 89, 578–584.
10. Pachter, R., **Altman, R.**, Czaplicki, J., Jardetzky, O. (1991). Comparison of the NMR Solution Structure of Cyclosporin A Determined by Different Techniques. *Journal of Magnetic Resonance*, 92, 468–479.
11. Arrowsmith, C., Pachter, R., **Altman, R.**, Jardetzky, O. (1991). The Solution Structures of E. Coli trp Repressor and trp Aporepressor at an Intermediate Resolution. *European Journal of Biochemistry*, 202(2), 53–66.

12. Liu, Y., Zhao, D., **Altman, R.**, Jardetzky, O. (1992). A Systematic Comparison of Three Structure Determination Methods from NMR Data: Dependence upon Quality and Quantity of Data. *Journal of Biomolecular NMR*, 2, 373–388.
13. **Altman, R.**, Pachter, R., Jardetzky, O. (1993). Structural Uncertainty of Proteins in Solution by NMR. A Re-evaluation of the Structure of the Lac Repressor Headpiece, *Journal of Applied Magnetic Resonance*, 4, 441–460.
14. **Altman, R.**, Hughes, C., Jardetzky, O. (1994). Compositional Characteristics of Disordered Regions in Proteins. *Protein and Peptide Letters*, 1(2), 120–127.
15. **Altman, R.**, Hughes, C., and Gerstein, M. (1995). Methods for Displaying Macromolecular Structural Uncertainty: Application to the Globins. *Journal of Molecular Graphics*, 13, 142 152.
16. **Altman, R.** (1995). A Probabilistic Approach to Determining Biological Structure: Integrating Uncertain Data Sources. *International Journal of Human Computer Studies*, 42, 593–616.
17. Bagley, S. and **Altman, R.** (1995). Characterizing the Microenvironment Surrounding Protein Sites. *Protein Science*, 4, 622–635.
18. Gerstein, M. and **Altman, R.** (1995). Average Core Structures and Variability Measures for Protein Families: Application Immunoglobulins. *Journal of Molecular Biology*, 251, 161–175.
19. Gerstein, M. and **Altman, R.** (1995). Using a Measure of Structural Variation to Define a Core for the Globins. *CABIOS Computer Applications in the Biosciences*, 11, 633–644.
20. **Altman, R.** and Merino, J. (1996). Images in clinical medicine. Knotted umbilical cord.. *New England Journal of Medicine,* 334(9), 573.
21. Chen, C., Chen, R., **Altman, R.** (1996). Constraining Volume by Matching Moments of a Distance Distribution. *Computer Applications in the Biosciences,* 12(4), 319–326.
22. Fink, D., Chen, R., Noller, H., **Altman, R.** (1996). Computational Methods for Defining the Allowed Conformational Space of 16S rRNA Based on Chemical Footprinting Data. *RNA* 2(9), 851–866. PMCID: PMC1369421.
23. Bagley, S. and **Altman, R.** (1996). Conserved Features in the Active Site of Nonhomologous Serine Proteases. *Folding & Design*, 1(5), 371–379.
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27. Chen, R., Felciano, R., **Altman, R.** (1997). RiboWeb: Linking Structural Computations to a Knowledge Base of Published Experimental Data. In: Proceedings of the Fifth International Conference on Intelligent Systems in Molecular Biology (pp. 84-87). Menlo Park: AAAI Press.
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32. Gennari, J., Cheng, H., **Altman, R.**, Musen M. (1998). Reuse, CORBA, and Knowledge-Based Systems, *International Journal of Human-Computer Studies,* 49(4), 523–546.
33. **Altman, R.** (1998). A Curriculum for Bioinformatics: The Time is Ripe. *Bioinformatics,* 14(7), 549–550.
34. Wei, L. and **Altman, R.** (1998). Recognizing Protein Binding Sites Using Statistical Descriptions of Their 3D Environments. In: R. Altman, K. Dunker, L. Hunter, T. Klein (eds.), Pacific Symposium on Biocomputing 1998 (pp. 497– 508). Singapore, World Scientific Publishing Co.
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36. Chen, C., Singh, J., **Altman, R.** (1998). The Hierarchical Organization of Molecular Structure Computation. In: RECOMB-98 (pp. 51–59). New York: ACM Press.
37. Schmidt, J., Chen, C., Cooper, J., **Altman, R.** (1998). A Surface Measure for Probabilistic Structural Computations. In: ISMB 98 (pp. 148-156). Menlo Park: AAAI Press.
38. Liu, X. and **Altman, R.** (1998). Updated Bibliography Using the RELATED ARTICLES Function within PubMed. In: 1998 AMIA Fall Symposium (pp. 750-754). Philadelphia: Hanley & Belfus Publishers.PMCID: PMC2232162
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44. **Altman, R.**, Chen, R., Abernethy, N., Bada, M. (1999). RiboWeb: An OntologyBased System for Collaborative Molecular Biology. *IEEE Intelligent Systems and Their Application,* 14(5), 68-76.
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59. **Altman, R.**, Raychaudhuri, S. (2001). Whole-genome expression analysis: challenges beyond clustering. *Curr Opin Struct Biol*., 11(3), 340-347.
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88. Raychaudhuri, S., **Altman, R.** (2003). A literature-based method for assessing the functional coherence of a gene group. *Bioinformatics*, 19(3), 396-401. PMCID: PMC2669934.
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INVITED LECTURES AND PRESENTATIONS (selected from over 100):

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2. "Bioinformatics in support of molecular medicine." Annual Conference of the American Medical Informatics Association, Invited Talk, Orlando, FL, November 9, 1998.
3. "Challenges for Discovery in Molecular Biology." Knowledge Discovery and Data Mining Conference, 2001, San Francisco, CA, August 28, 2001.
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5. "AI in Biomedicine: helping scientists reason about genomes, drugs and diseases." American Association for Artificial Intelligence (AAAI) 2004, San Jose, CA, July 28, 2004.
6. "Challenges for Informatics & Medicine in the Post-Genome Era." Medinfo 2004, San Francisco, CA, September 10, 2004.
7. "Building genotype-phenotype data resources for pharmacogenomics." Frontiers in Bioinformatics: Unsolved Problems and Challenges, Arthur M. Sackler Colloquia of the National Academy of Sciences, Irvine, CA, October 16, 2004.
8. "Challenges for knowledge management in biomedical informatics." IEEE Computational Systems Bioinformatics Conference, Stanford, CA, August 11, 2005.
9. "PharmGKB: is sharing pharmacogenomics information worthwhile?" Pharmacogenomics Meeting at Sanger Centre/Cold Spring Harbor, Hinxton, UK. September 15, 2005.
10. "Simbios: creating an infrastructure for physics-based simulation of biological structure." American Medical Informatics Association (AMIA) Annual Meeting, Washington, DC, October 24, 2005.
11. "Annual Review of Translational Bioinformatics." American Medical Informatics Association (AMIA) Summit on Translational Bioinformatics, San Francisco, CA, March 12, 2008.
12. "Annual Review of Translational Bioinformatics." American Medical Informatics Association (AMIA) Summit on Translational Bioinformatics, San Francisco, CA, March 17, 2009.
13. "Annual Review of Translational Bioinformatics." American Medical Informatics Association (AMIA) Summit on Translational Bioinformatics, San Francisco, CA. March 12, 2010.

14. “Translational Bioinformatics: Challenges for the AMIA community.” SemiPlenary Session, American Medical Informatics Association Fall Symposium, Washington, DC. November 10, 2008.
15. “Genes & Drugs.” Columbia University Department of Biomedical Informatics Colloquium, New York, Oct 16, 2009.
16. “Systems approaches for Pharmacogenomics.” Scripps Genomic Medicine Conference, San Diego, CA, March 6, 2010.
17. “Translational Bioinformatics Year-in-Review.” American Medical Informatics Association (AMIA) Joint Summits on Translational Science, San Francisco, CA, March 9, 2011
18. “7th annual Grant R. Wilkinson Distinguished Lecture in Clinical Pharmacology.” Vanderbilt University, Nashville, TN, April 14, 2011.
19. "The emerging network of data for understanding the interactions of genes and drugs.” Dewitt Stetten Jr. 2011 Lecture, NIGMS, October 12, 2011.
20. “Translational Bioinformatics Year-in-Review.” American Medical Informatics Association (AMIA) Joint Summits on Translational Science, San Francisco, CA, March 21, 2012
21. “Integrating Multiple Sources of Information to Understand Drug Action: From Molecular Structure to Clinical Population Data.” American Society for Clinical Pharmacology & Therapeutics (ASCPT) and Food and Drug Administration William B. Abrams Lecture, FDA White Oak Campus, Silver Spring, MD, March 23, 2012.
22. "Understanding drug action over 17 orders of magnitude—from molecular to global." Mario Stefanelli Memorial Lecture, The National Congress of Italian Group of Bioengineering Annual Meeting, Rome, Italy, June 28, 2012.
23. "Dealing with biomedical knowledge explosion for better healthcare: identifying actionable knowledge items at the point of care." International Center for Scientific Debate (Inbiomedvision), Barcelona, Spain, July 3, 2012
24. Three invited lectures at the Annual International Conference on Intelligent Systems for Molecular Biology (ISMB) 2012, Long Beach, CA, July 15-17, 2012.
25. “The Network of Data for Understanding Drug Response.” The Oxford-Stanford Conference on Big Data: Challenges & Opportunities for Human Health, Oxford University, Oxford, United Kingdom, November 29, 2012.
26. “Translational Bioinformatics Year-in-Review.” AMIA Joint Summits on Translational Science, San Francisco, CA, March 20, 2013
27. "Systems pharmacology methods for linking drugs to genetic networks." Leon I Goldberg Memorial Lectures in Clinical Pharmacology, Department of Medicine, University of Chicago, Chicago, IL, December 10, 2013.
28. “Big data for drug repurposing, druggability, drug design & side effect prediction.” The Flexner Discovery Series, Vanderbilt University Medical Center, Nashville, TN, February 6, 2014.
29. “Translational Bioinformatics Year-in-Review.” AMIA Joint Summits on Translational Science, San Francisco, CA, April 9, 2014
30. “Informatics for understanding drug response at all scales.” 2014 International Society for Computational Biology Fellows Keynote, Boston, MA, July 15, 2014.
31. “Translational Bioinformatics Year-in-Review.” AMIA Joint Summits on Translational Science, San Francisco, CA, March 26, 2015
32. “Translational Bioinformatics Year-in-Review.” AMIA Joint Summits on Translational Science, San Francisco, CA, March 21, 2016

33. “Genetic Variations Impact on Drug Response: Current Trends and Research.” ACMT (American College of Medical Toxicology) Annual Scientific Meeting in San Francisco, CA, April 11, 2019.
34. "Machine learning methods to triage rare pharmacogenetic variation.” 24th International Conference on Research in Computational Molecular Biology (RECOMB 2020), June 25, 2020.
35. "Text mining to understand drug action: from PubMED to Reddit." ISMB 2020 (“in Chicago” but virtual) Text-Mining Track Keynote, July 13, 2020.
36. “AI for recognizing phenotypes in large biobanks." St. Jude Children’s Research Hospital, 2024 Faculty Scientific Retreat, Memphis, TN, February 9, 2024.

PATENTS

1. Tatonetti, N., **Altman, R**., Fernald, G. *Signal detection algorithms to identify drug effects and drug interactions.* April 5, 2016. US Patent 9,305,267 B2.
2. **Altman, R.**, Abernethy, N. *Frame-based knowledge representation system and methods.* August 27, 2002. US Patent 6,442,566 B1.
3. Felciano, R.M.*,* **Altman, R.B.** *Method for monitoring and/or modifying web browsing sessions*, April 18, 2000. US Patent 6,052,730

Appendix: Active Consulting Relationships

Industry:

Bayshore Capital Management
BridgeBio
Collective Health
Curve Bio
Evommune
InsightRx
Lore Health
Nebula Genomics
Personalis (Also Founder)
Prophase
PGxAI
Myome
Vcreate
Sigil Bio
SparkNS
Weave.io

Government:

All of Us Biobank, NIH

Philanthropy:

Burroughs Wellcome Fund

Miscellaneous:

Testified on 10/9/2025 as an expert in AI, drug discovery and healthcare to the Senate Health, Education, Labor & Pensions Committee (HELP) as a guest of Senator Cassidy (R), Chair.

APPENDIX B: MATERIALS CONSIDERED

To the extent not already included above, the following list incorporates by reference as though set forth fully herein the identification information for all sources considered in the Expert Report of Russ B. Altman, dated December 19th, 2025.

Table 1: Materials Considered

#	Source Type	File Name
1	Academic Sources	David Chen, Kabir Chauhan - Patient perceptions of empathy
2	Academic Sources	Amna A. Othman, Kendall A. Flaharty - Assessing large language model performance related to aging in genetic conditions
3	Academic Sources	Darren Liu, Xiao Hu - Evaluation of Large Language Models in Tailoring Educational Content for Cancer Survivors and Their Caregivers
4	Academic Sources	Vera Sorin, Eyal Klang - Large language model (ChatGPT) as a support tool for breast tumor board
5	Academic Sources	Jorge Novoa, Mónica Chagoyen - PMIDigest- Interactive Review of Large Collections of PubMed Entries to Distill Relevant Information
6	Academic Sources	MD Riyah, Muqi Li - LLM-assisted Vector Similarity Search
7	Academic Sources	Ehsan Ullah, Anil Parwani - Challenges and barriers of using large language models (LLM) such as ChatGPT for diagnostic medicine with a focus on digital pathology – a recent scoping review
8	Academic Sources	Tara Templin - Framework for bias evaluation in large language models in healthcare settings
9	Academic Sources	Leihong Wu, Joshua Xu - A framework enabling LLMs into regulatory environment for transparency and trustworthiness and its application to drug labeling document
10	Academic Sources	Weida Tong, Michael Renaudin - Context is Everything in Regulatory Application of LLMs
11	Academic Sources	Jimmy Wu, Rika Antonova - TinyBot - Personalized Robot Assistance with Large Language Models

#	Source Type	File Name
12	Academic Sources	Anthropic_0000349517 - The Anthropic Economic Index
13	Academic Sources	Gowri Nayar, Kristy A. Carpenter - Exposing the Molecular Reaction Blind Spots of LLMs with PathwayQA
14	Academic Sources	Kexin Huang, Serena Zhang - Biomni - A General-Purpose Biomedical AI Agent
15	Academic Sources	Fang-Fang Zhao, Han-Jie He - Benchmarking the performance of large language models in uveitis
16	Academic Sources	Bradley D. Menz, Nicole M. Kuderer - Current safeguards, risk mitigation, and transparency measures of large language models
17	Academic Sources	Natansh D. Modi, Bradley D. Menz - Assessing the System-Instruction Vulnerabilities of Large Language Models to Malicious Conversion into Health Disinformation Chatbots
18	Academic Sources	Mehmed T. Dinc, Ali E. Bardak - Comparative analysis of large language models in clinical diagnosis
19	Academic Sources	Masanori Ishida, Wataru Gonoi - Diagnostic Performance of a Large Language Model for Determining the Cause of Death
20	Academic Sources	Michael Chernew and Harrison Mintz - Administrative Expenses in the US Health Care System Why So High
21	Academic Sources	Haijiao Jin, Jinglu Guo - Comparative study of Claude 3.5-Sonnet and human physicians in generating discharge summaries for patients with renal insufficiency
22	Academic Sources	Yoonseok Yang, Minjune Kim - Pensive Grader: An AI-Powered
23	Academic Sources	Kevin Black, Noah Brown - π0.5 - a Vision-Language-Action Model with Open-World Generalization
24	Academic Sources	Mohamed Amine Ferrag, Norbert Tihanyi - From LLM Reasoning to Autonomous AI Agents - A Comprehensive Review
25	Academic Sources	Jiaqi Wang, Enze Shi - Large language models for robotics - Opportunities, challenges, and perspectives
26	Academic Sources	Alhassan Mumuni and Fuseini Mumuni - Large language models for artificial general intelligence (AGI) - A survey of foundational principles and approaches
27	Academic Sources	Kaixuan Huang, Yuanhao Qu - CRISPR GPT
28	Academic Sources	Ghosh, Shikhar, and Shweta Bagai Anthropic Building Safe and Powerful AI Harvard Business School Case 824-129, April 2024.
29	Academic Sources	Sher Badash and Hassan Sajjad - Quantifying the Capabilities of LLMs across Scale and Precision
30	Academic Sources	Yair Bannett, Fatma Gunturkun - Applying Large Language Models to Assess Quality of Care- Monitoring ADHD Medication Side Effects
31	Academic Sources	Matthew Jorke, Shardul Saptoka - GPTCoach: Towards LLM-Based Physical Activity Coaching
32	Academic Sources	Omar Shaikh, Valentino Chai - Rehearsal - Simulating Conflict to Teach Conflict Resolution

#	Source Type	File Name
33	Academic Sources	Evan Liu, David Yuan - A Fast and Accurate Machine Learning Autograder for the Breakout Assignment
34	Academic Sources	Mert Marcel Dagli, Felix Conrad Oettl - Clinical Accuracy, Relevance, Clarity, and Emotional Sensitivity of Large Language Models to Surgical Patient Questions: Cross-Sectional Study
35	Academic Sources	Mohammed Toufiq, Darawan Rinchai - Harnessing large language models (LLMs) for candidate gene prioritization and selection
36	Academic Sources	Robert Kaczmarczyk, Theresa Isabelle Wilhelm - Evaluating multimodal AI in medical diagnostics
37	Academic Sources	Suha Soni, Roupen Odabashian - Evaluating artificial intelligence's (AI) clinical reasoning with skin cancer multiple-choice questions
38	Academic Sources	Vincenzo Venerito, Marco Fonaro - Integrating large language models in medicine: a study of Claude 2's performance in MDAAT scoring for idiopathic inflammatory myopathies
39	Academic Sources	Wei Pan, Shuman Xhang - Clinical Management of Wasp Stings Using Large Language Models: Cross-Sectional Evaluation Study
40	Academic Sources	Zhonghe Han, Jiaxin Wang - CoReaAgents: A Collaboration and Reasoning Framework Based on LLM-Powered Agents for Complex Reasoning Tasks
41	Academic Sources	Zuwan Link, Arnau Marin-Llobet - Spike sorting AI agent
42	Academic Sources	Jordan Usdan, Allison Connell Pensky - Generative AI's Impact on Graduate Student Writing Productivity and Quality
43	Academic Sources	Jordan Usdan, Allison Connell Pensky - Generative AI's Impact
44	Internal Documents	Tom Turvey Deposition
45	Internal Documents	Ben Mann Deposition
46	Internal Documents	Jared Kaplan Deposition
47	Internal Documents	Daniela Amodei Deposition
48	Legal filings	First Amended Complaint, Concord v. Anthropic PBC
49	Other Sources	Anthropic_0000570579
50	Other Sources	Anthropic_0000570581
51	Other Sources	Anthropic_0000570584
52	Other Sources	Anthropic_0000570614
53	Public Sources	Stanford University HAI - Home
54	Public Sources	Stanford Medicine - RAISE Health
55	Public Sources	Russ Altman - The Future of Everything - Podcast - Apple Podcasts
56	Public Sources	Anthropic - Introducing Claude
57	Public Sources	Anthropic - Claude 2
58	Public Sources	Anthropic - Introducing Claude 2.1

#	Source Type	File Name
59	Public Sources	Anthropic - Introducing the next generation of Claude
60	Public Sources	Anthropic - Introducing Claude 3.5 Sonnet
61	Public Sources	Anthropic_0000570067
62	Public Sources	Anthropic_0000569572
63	Public Sources	Anthropic_0000570105
64	Public Sources	Anthropic_0000570166
65	Public Sources	Anthropic - Our framework for developing safe and trustworthy agents
66	Public Sources	Cooper, Anderson, Marks, Nichole - Why Anthropic CEO Dario Amodei spends so much time warning of AI's potential dangers
67	Public Sources	Chou, Jessica - Anthropic is all in on 'AI safety'—and that's helping the $183 billion startup win over big business _ Fortune
68	Public Sources	Kutcher, Ashton - 100 Most Influential People 2025
69	Public Sources	Perrigo, Billy - Time 100 AI 2025
70	Public Sources	Anthropic - Responsible Scaling Policy (version 2.2)
71	Public Sources	Anthropic_0000000550
72	Public Sources	Anthropic_0000437165
73	Public Sources	Anthropic - Making AI systems you can rely on
74	Public Sources	Anthropic - Features overview
75	Public Sources	Russ Altman - The future of live performance
76	Public Sources	Stanford Report - AI brings new potential to the art of theater
77	Public Sources	Russ B Altman, Percy Liang - Large Language Models to support Bioequivalence Evaluation
78	Public Sources	Kimberly Ray and Bernadette Tosti - Transforming patient recruitment through patient and site engagement
79	Public Sources	Russ Altman - Generative AI Perspectives from Stanford HAI
80	Public Sources	CCRPS - How to Budget for a Clinical Trial
81	Public Sources	Russ Altman - The future of AI coaching
82	Public Sources	Foxchase Cancer Center - The Important Role Tumor Boards Play in Cancer Care
83	Public Sources	Matthew Lungren - Developing next-generation cancer care management with multi-agent orchestration - Microsoft Industry Blogs
84	Public Sources	Stanford University Human-Centered Artificial Intelligence - Artificial Intelligence Index Report 2025
85	Public Sources	U.S. Department of Health and Human Services - Methods for De-identification of Protected Health Information
86	Public Sources	Ayodesk - HIPAA Compliant LLMs in the Cloud
87	Public Sources	Anthropic - Building safeguards for Claude
88	Public Sources	Trenton Bricken, Rowan Wang - Building and evaluating alignment auditing agents
89	Public Sources	Promptfoo - LLM Red Teaming

#	Source Type	File Name
90	Public Sources	Olivia Shone - Enhance AI Security with Azure Prompt Shields and Azure AI Content Safety
91	Public Sources	Constitutional AI - Constitutional.ai
92	Public Sources	Anthropic - Claude's Constitution
93	Public Sources	Russ Altman - The future of pediatric development and disability
94	Public Sources	Stanford - Jeannette Bohg
95	Public Sources	Russ Altman - The future of robotics
96	Public Sources	Anthropic_0000012987
97	Public Sources	Anthropic_0000013383
98	Public Sources	Anthropic_0000349575
99	Public Sources	Anthropic_0000441239
100	Public Sources	Anthropic_0000441184
101	Public Sources	Anthropic_0000441108
102	Public Sources	Anthropic_0000349532
103	Public Sources	Anthropic_0000569555
104	Public Sources	National Cancer Institute - Transcription Factor
105	Public Sources	Anthropic_0000569741
106	Public Sources	Anthropic_0000569748
107	Public Sources	Michael Skarlinski, Tyler Nadolski - FutureHouse Platform_ Superintelligent AI Agents for Scientific Discovery _ FutureHouse
108	Public Sources	U.S. Food and Drug Administration - FDA Announces Completion of First AI-Assisted Scientific Review Pilot and Aggressive Agency-Wide AI Rollout Timeline
109	Public Sources	Tor Constantino - FDA Embraces AI To Accelerate Drug Review Process
110	Public Sources	Anthropic_0000569572
111	Public Sources	Anthropic_0000569567
112	Public Sources	Google Play - Claude by Anthropic About this app
113	Public Sources	Anthropic_0000570252
114	Public Sources	Anthropic_0000569939
115	Public Sources	Anthropic_0000569608
116	Public Sources	CDC - About Antimicrobial Resistance _ Antimicrobial Resistance
117	Public Sources	UCSF - Stanford CERSI 2025 CERSI Summit - Panel 1
118	Public Sources	Anthropic_0000569656
119	Public Sources	Anthropic_0000570252
120	Public Sources	Anthropic_0000569699
121	Public Sources	Anthropic_0000569536
122	Public Sources	American Board of Medical Specialties - What is ABMS Board Certification
123	Public Sources	Accreditation Council for Graduate Medical Education - Common Program Requirements
124	Public Sources	Anthropic_0000569674

#	Source Type	File Name
125	Public Sources	Praveen Meka, Bharath Gunapati, Christine Tsien Silvers, Qing Liu, and Rod Tarrago - Can AI Reason Like a Clinician
126	Public Sources	Lauren Tollen, Elizabeth Keating, Alan Weil - How Administrative Spending Contributes To Excess US Health Spending
127	Public Sources	Michael McCareins - The Impacts of Healthcare Staffing Shortages
128	Public Sources	American Organization for Nursing Leadership - Nursing Leadership Insight Study
129	Public Sources	Dr. Pooja Bansal - 7 Best AI Medical Scribes for Doctors and Clinics
130	Public Sources	Stanford University - Workshop on Ambient Intelligence for HealthCare
131	Public Sources	Anthropic_0000569984
132	Public Sources	Anthropic_0000441061
133	Public Sources	Anthropic_0000441061
134	Public Sources	Anthropic_0000570328
135	Public Sources	Anthropic_0000569984
136	Public Sources	Steph Solis - Healey Admin's AI Blueprint for Massachusetts Starts to Take Shape
137	Public Sources	Anthropic_0000570312
138	Public Sources	Anthropic_0000570272
139	Public Sources	Stanford University IT - AI Playground Quick Start Guide
140	Public Sources	Anthropic_0000569650
141	Public Sources	Rising Academies - Our Model
142	Public Sources	Anthropic_0000570105
143	Public Sources	Anthropic_0000570112
144	Public Sources	Anthropic_0000570099
145	Public Sources	Anthropic_0000569011
146	Public Sources	Anthropic_0000569716
147	Public Sources	Anthropic_0000570276
148	Public Sources	Anthropic_0000569716
149	Public Sources	Anthropic_0000570215
150	Public Sources	Anthropic_0000441090
151	Public Sources	Anthropic_0000570041
152	Public Sources	Russ Altman - The future of computer-aided education
153	Public Sources	Anthropic_0000570173
154	Public Sources	Anthropic_0000570224
155	Public Sources	Anthropic_0000570166
156	Public Sources	Tahoe Lead Removal Project - We got the lead out
157	Public Sources	Tahoe Lead Removal Project - Got the Lead Out of Lake Tahoe
158	Public Sources	Anthropic_0000569997
159	Public Sources	Anthropic_0000569776
160	Public Sources	Anthropic_0000569529

#	Source Type	File Name
161	Public Sources	Anthropic_0000569529
162	Public Sources	Anthropic_0000569615
163	Public Sources	Anthropic_0000570258
164	Public Sources	Anthropic_0000569615
165	Public Sources	Anthropic - Pulpit AI turns sermons into multiple pieces of content with Claude
166	Public Sources	Anthropic - Jumpcut helps Hollywood
167	Public Sources	Stanford HAI - Spring Symposium Creativity in the Age of AI
168	Public Sources	Anthropic_0000570196
169	Public Sources	Hugging Face - Anthropic Interviewer Interview Transcripts, Creatives, December 2, 2025
170	Public Sources	Anthropic - Introducing Anthropic Interviewer Anthropic
171	Public Sources	Anthropic_0000569602
172	Public Sources	The Verge - Anthropic's Claude chatbot can now make and edit your Canva designs
173	Public Sources	The Verge - The future of country music is here, and it's AI
174	Public Sources	Anthropic - Build with Claude
175	Public Sources	Anthropic_0000570077
176	Public Sources	Anthropic_0000570143
177	Public Sources	Anthropic_0000569987
178	Public Sources	Anthropic_0000569947
179	Public Sources	NVIDIA - What are Vision-Language Models_ _ NVIDIA Glossary
180	Public Sources	Anthropic - Business Associate Agreements (BAA) for Commercial Customers _ Anthropic Privacy Center
181	Public Sources	Anthropic_0000569925
182	Public Sources	10Web - Lex (Internet Archive)
183	Public Sources	Anthropic - How AI Is Transforming Work at Anthropic
184	Public Sources	Anthropic_0000349592
185	Public Sources	Anthropic_0000441052
186	Public Sources	Anthropic_0000441959
187	Public Sources	Anthropic - Claude Opus 4 and 4.1 can now end a rare subset of conversations
188	Public Sources	Anthropic_0000569017
189	Public Sources	Anthropic_0000437176
190	Public Sources	Anthropic_0000440731
191	Public Sources	FutureHouse - FutureHouse
192	Public Sources	Adam Webster and Lex Lang - How One School Is Changing Education With AI
193	Public Sources	Try - Kristine rolled out Claude in TRY
194	Public Sources	Anthropic - Advolve automates digital marketing with Claude
195	Public Sources	Anthropic - AES accelerates renewable energy adoption with Claude on Google Cloud's Vertex AI

#	Source Type	File Name
196	Public Sources	Anthropic - Amazon Q in Connect transforms customer service for agents and customers with Claude
197	Public Sources	Anthropic - Apollo accelerates outbound sales at scale with Claude
198	Public Sources	Anthropic - AppFolio streamlines property management communication with Claude in Amazon Bedrock
199	Public Sources	Anthropic - Armanino builds AI-powered accounting tools with Claude
200	Public Sources	Anthropic - Asana supercharges work management with Claude
201	Public Sources	Anthropic - ASAPP brings human-level AI to customer service with Claude
202	Public Sources	Anthropic - Assembled transforms support operations with Claude
203	Public Sources	Anthropic - Augment unlocks complex codebases with Claude on Google Cloud's Vertex AI
204	Public Sources	Anthropic - Aura Intelligence enhances decision intelligence with Claude in Amazon Bedrock
205	Public Sources	Anthropic - Benchling accelerates scientific discovery with Claude in Amazon Bedrock
206	Public Sources	Anthropic - Bito powers agentic AI tools for software development with Claude
207	Public Sources	Anthropic - Brand.ai uses AI to make brands more human with Claude
208	Public Sources	Anthropic - Brian Impact Foundation powers their search for the next generation of social innovators with Claude
209	Public Sources	AI Expert Network - Case Study: Eli Lilly’s Groundbreaking Collaboration with OpenAI to Combat Antimicrobial Resistance
210	Public Sources	Anthropic - ChatAndBuild democratizes AI development globally with Claude
211	Public Sources	Anthropic - Chatbase helps companies deliver instant, personalized customer support with Claude
212	Public Sources	Anthropic - Circleback transforms meetings into structured insights with Claude
213	Public Sources	Anthropic - ClassDojo saves teachers time with Claude
214	Public Sources	Anthropic - Claude and Alexa+
215	Public Sources	Anthropic - Clay generates personalized sales outreach at scale with Claude
216	Public Sources	Anthropic - CodeRabbit revolutionizes code review with Claude
217	Public Sources	Anthropic - Copy.ai accelerates content creation and reduces costs with Claude
218	Public Sources	Anthropic - Cove creates the future of visual AI collaboration with Claude
219	Public Sources	Anthropic - CRED accelerates fintech development workflows with Claude
220	Public Sources	Anthropic - Decagon delivers white-glove customer service at scale with Claude
221	Public Sources	Anthropic - Dust helps enterprises create actionable AI agents with MCP and Claude

#	Source Type	File Name
222	Public Sources	Anthropic - European Parliament expands access to their archives with Claude
223	Public Sources	Anthropic - Factory is building Droids for software engineering with Claude
224	Public Sources	Anthropic - Gamma helps teams create polished presentations with Claude
225	Public Sources	Anthropic - Genspark builds the future of AI agents with Claude
226	Public Sources	Anthropic - GitLab enhances productivity with Claude
227	Public Sources	Anthropic - GitLab powers stable, secure software development with Claude
228	Public Sources	Anthropic - Gradient Labs transforms financial services customer support with Claude
229	Public Sources	Anthropic - Grafana transforms observability workflows with Claude-powered multi-agent assistant
230	Public Sources	Anthropic - Graphite speeds up code review by 40x with Claude
231	Public Sources	Anthropic - Headstart accelerates software development by up to 100x with Claude
232	Public Sources	Anthropic - Humach enhances AI-powered customer experience solutions with Claude
233	Public Sources	Anthropic - Hume AI creates emotionally intelligent voice interactions with Claude
234	Public Sources	Anthropic - Intercom provides customer service tech that delivers up to 86% resolution rates with Claude
235	Public Sources	Anthropic - JetBrains builds developer tools with Claude in Amazon Bedrock
236	Public Sources	Anthropic - Kodif transforms customer support into a revenue center with Claude in Amazon Bedrock
237	Public Sources	Anthropic - Lazy AI speeds up internal software development for businesses who are adopting AI software with Claude
238	Public Sources	Anthropic - Lindy empowers teams to scale with AI Agents powered by Claude
239	Public Sources	Anthropic - Local Falcon helps 95,000 businesses boost search rankings with Claude
240	Public Sources	Anthropic - Lokalise improves translation quality with Claude
241	Public Sources	Anthropic - Lovable helps anyone create software 20x faster with Claude
242	Public Sources	Anthropic - MagicSchool transforms K-12 education for 3 million educators and their students with Claude
243	Public Sources	Anthropic - Navigating AI in Education Together
244	Public Sources	Anthropic - Notion creates more intelligent workspaces with Claude
245	Public Sources	Anthropic - NRI cuts document review time in half with Claude in Amazon Bedrock
246	Public Sources	Anthropic - Otter transforms meetings into lasting organizational knowledge with Claude
247	Public Sources	Anthropic - Panorama unlocks student success with Claude in Amazon Bedrock

#	Source Type	File Name
248	Public Sources	Anthropic - Perplexity delivers factual and relevant answers with Claude
249	Public Sources	Anthropic - Praxis AI pioneers AI-driven education with Claude in Amazon Bedrock
250	Public Sources	Anthropic - Quantium drives company-wide AI adoption with Claude
251	Public Sources	Anthropic - Quillit eliminates 80% of the time-consuming tasks of qualitative research using Claude
252	Public Sources	Anthropic - Section helps companies navigate AI transformation with Claude
253	Public Sources	Anthropic - Sendbird delivers reliable, enterprise-grade AI customer service with Claude
254	Public Sources	Anthropic - Sentry helps developers accelerate debugging and ship fixes faster with Claude
255	Public Sources	Anthropic - SK Telecom enhances customer support for millions of Koreans with Claude in Amazon Bedrock
256	Public Sources	Anthropic - Skillfully transforms hiring through AI-powered skill simulations with Claude
257	Public Sources	Anthropic - Sourcegraph enhances the intelligence and speed of their AI-powered coding assistant with Claude
258	Public Sources	Anthropic - Sourcegraph streamlines product and community insights with Claude
259	Public Sources	Anthropic - Spring.new empowers business application development with Claude on Google Cloud's Vertex AI
260	Public Sources	Anthropic - StackBlitz achieves $4M ARR in 4 weeks for their AI web development platform with Claude
261	Public Sources	Anthropic - StudyFetch powers AI-driven personalized learning for millions of students with Claude
262	Public Sources	Anthropic - Super Teacher offers elementary schools a personalized AI Tutor with Claude
263	Public Sources	Anthropic - Tabnine solves developers' pain points and enhances productivity with Claude
264	Public Sources	Anthropic - Tidio automates customer support at scale with Claude
265	Public Sources	Anthropic - Tines transforms workflow automation with Claude in Amazon Bedrock
266	Public Sources	Anthropic - tl;dv boosts revenue 500% from AI-powered meeting intelligence with Claude
267	Public Sources	Anthropic - Tome uncovers strategic insights for sales teams with Claude
268	Public Sources	Anthropic - You.com enhances search and productivity with Claude
269	Public Sources	Anthropic - Zapier builds an AI-first remote culture with Claude for Enterprise
270	Public Sources	Anthropic - Zoom AI Companion boosts user engagement and satisfaction with Claude