# Case

#### We affirm

### C1: Preventing Miscalc

#### Chinese cyber attacks are getting stronger

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Hundreds of private cybersecurity firms, technology services providers, and universities are helping China's state apparatus develop offensive cyber capabilities to support the country's strategic military, economic, and geopolitical goals, according to research released this week. "The existence of state-sponsored threat groups operating under the Chinese state's direction has long been well documented," researchers at France's Orange Cyberdefense wrote in [their report,](https://research.cert.orangecyberdefense.com/hidden-network/report.html) based on eight months of analysis of China's cyber-offense capabilities. But any notions that these entities are strictly in government hands, especially given the authoritarian nature of China's government, are off base, the authors warned. "China's offensive cyber capabilities are, in fact, supported by a complex and multilayered ecosystem involving a broad array of state and non-state actors," they wrote. Their findings provide deeper context on the troubling success that Chinese cyber actors have had infiltrating US critical infrastructure, breaching government, military, and business networks, not to mention theft of defense data, trade secrets, and intellectual property from American entities and others around the world. **An Extensive Ecosystem** The synergies have enabled quicker government access to cutting-edge technology and talent, especially in critical areas such as artificial intelligence (AI), big data analytics, 5G wireless, and cloud computing, says Dan Ortega, security strategist at Anomali. "China's collaboration between its tech companies and state entities has dramatically accelerated the development of its cyber-offensive capabilities," Ortega says. Importantly, it has also allowed the nation to scale state-sponsored cyber missions effectively. And that collaboration enables government access to vast data sets collected by companies, facilitating enhanced targeting and more-effective cyberattacks, he notes. "China fosters formal and informal partnerships with tech firms through initiatives like the Military-Civil Fusion strategy, mandating companies to share their technological advancements and insights with the state," he says. A feedback loop exists in which innovations made in the private sector directly enhance state capabilities. **Poised to Strike?** The Orange report arrives as domestic concerns grow over Chinese cyberattacks on US entities, such as operations like Volt Typhoon's targeting of [critical infrastructure organizations](https://www.darkreading.com/threat-intelligence/china-cyberattackers-disrupt-us-critical-infrastructure). Many in government and industry are convinced that Chinese groups have attained the presence they need on US networks to [cause widespread disruption](https://www.darkreading.com/ics-ot-security/fbi-director-wray-issues-dire-warning-on-chinas-cybersecurity-threat) to domestic energy, telecommunications utilities, and technology services. Such concerns prompted the Office of the Director of National Intelligence (ODNI) to describe China as the "[most active and persistent cyber threat](https://www.dni.gov/files/ODNI/documents/assessments/ATA-2024-Unclassified-Report.pdf) to US government, private sector, and critical infrastructure networks," in its 2024 annual report. Orange's research showed the four main government stakeholders responsible for building and executing China's cyber-offense capabilities are the People's Liberation Army (PLA), the Ministry of State Security (MSS), the Ministry of Public Security (MPS), and the Ministry of Industry and Information Technology (MIIT). Their multipronged efforts include actively recruiting or otherwise supporting private hackers and hacktivists in activities such as data theft, website defacement, and distributed denial-of-service attacks. **Hundreds of Private Firms** Under the current model, the government stakeholders are working with hundreds of private companies, both big and small, to carry out cyberattacks against foreign and domestic entities that are of strategic interest to Beijing, the Orange report noted. One example of big-player involvement in the report is Shanghai stock exchange-listed Integrity Technology Group (ITG), which the [FBI](https://www.justice.gov/usao-wdpa/pr/court-authorized-operation-disrupts-worldwide-botnet-used-peoples-republic-china-state) has linked to the [Flax Typhoon APT](https://www.darkreading.com/threat-intelligence/china-unleashes-flax-typhoon-apt-live-off-land-microsoft-warns). Like ITG, many of China's top technology companies are also the state's biggest cyber contractors, according to Orange's report. "Enterprises such as ThreatBook, Qihoo360, and Qi An Xin not only provide defensive security solutions to public agencies but are also believed to indirectly contribute to offensive cyber operations." At the other end of the spectrum are dozens of smaller and medium-size private entities that often act as subcontractors for the bigger companies and deliver a range of highly specialized services. One example is i-Soon, a 72-person Shanghai firm whose [ties to the Chinese governmen](https://www.darkreading.com/threat-intelligence/-isoon-contractor-helps-the-prc-hack-foreign-governments-companies)t emerged after a leak earlier this year. "These entities often act as subcontractors to the industry giants, [filling the gap](https://margin.re/2024/02/same-same-but-different/) in their cyber offensive competencies and further fragmenting the hack-for-hire supply chain," Orange's researchers wrote. The company found that while in many instances, China's PLA, MSS, and others worked with legitimate private entities, others created shell companies that acted as fronts for procuring cyberattack infrastructure. **Tapping Top Universities** The Chinese government's efforts to rope in academic institutions began in earnest in 2017. Today many universities — including eight of the C9 League of China's top nine public universities — are engaged in state-sponsored cyber-offense research, according to Orange. Their contributions range from advanced research on the use of AI in cybersecurity to helping state operatives translate stolen documents and gathering open source intelligence. Trey Ford, chief information security officer at Bugcrowd, says the willingness among Chinese companies to work for the government point up very different business norms in China. While organizations in countries like the US are beholden to fiduciary, legal, ethical, and privacy norms, those in China have a different set of obligations. "Communist government-backed organizations, aligned to formal Five-Year economic and military objectives, will have very different outcomes in mind, and can make different investments and sacrifices than capitalist businesses," he says. Customer trust and user privacy are different context in China than in the US and other western nations, Ford says. "Companies doing business in China must run their services in-country today. This includes the expectation of access to their systems, data, intellectual property — as well as their customers' data." The continued expansion of China's cyber ecosystem will lead to more sophisticated attacks and better targeting of intellectual property and critical infrastructure through trusted business relationships, cautions Stephen Kowski, field chief technology officer at SlashNext Email Security+. "This model could enable more advanced supply chain compromises and social engineering attacks that bypass traditional security controls," Kowski says. "China's civil-military fusion model

#### Cyber security is part of higher education

**Eneken Tikk-Ringas, Mika Kerttunen, and Christopher Spirito ET AL**, 9-30-20**14**, Eneken Tikk-Ringas, senior fellow for cyber security at the International Institute for Strategic Studies, talks about the development of international law in the context of cyber security. These developments include proposals for a new treaty, different interpretations of existing norms and the evolution of new norms. Tikk-Ringas is introduced by Tom Dukes, deputy coordinator for cyber issues at the U.S. Department of State and UVA Law lecturer who co-teaches Cyber Law and Policy. "Cyber Security as a Field of Military Education and Study", <https://ndupress.ndu.edu/Media/News/Article/577562/cyber-security-as-a-field-of-military-education-and-study/> doa: 3/6/2025 as

Elements and aspects of cyber security and defense form an important part of higher level education. “Cyber capabilities and their use in war and peacekeeping” and “planning the use of cyber capabilities” should constitute the core themes of any joint and senior level officer course.

#### Military education includes also includes war games.

John Burnham 24, I currently work at the University of Alberta, having recently graduated with an MPP from the Max Bell School of Public Policy at McGill University. My professional background is in security and defence studies; in my current role, I produce war-gaming documents and non-classified briefings on military matters in the Indo-Pacific region for government clients. I have previously written for the NATO Association of Canada and I have been published by IRPP, CIDP, and SOAS., 4-22-2024, “The Use of AI in War Games Could Change Military Strategy,” Military, https://www.military.com/daily-news/2024/04/22/use-of-ai-war-games-could-change-military-strategy.html, Accessed 2-13-2025, GX recut ARC

[The rise of commercially viable **generative artificial intelligence**](https://www.forbes.com/sites/tiriasresearch/2023/04/12/the-dawn-of-creation-2023-rise-of-generative-ai/?sh=21cfc1c01a7f) **(AI)** has the potential to transform a vast range of sectors. This transformation will be particularly profound in **contemporary military education**.

Generative AI will fundamentally reshape [war gaming](https://doi.org/10.1093/isq/sqac021) — analytical games that simulate aspects of warfare at tactical, operational or strategic levels — [by allowing senior military and political leaders to pursue better tactical solutions to unexpected crises](https://apnews.com/article/russia-ukraine-china-japan-moscow-baecc4c1a068a5f96bcff66ed873b7f0), solve more complex logistical and operational challenges and deepen their strategic thinking.

**The art of war gaming**

From its inception, war gaming has been intended to offer realistic training to commanders that could otherwise only be gained through real-world experience.

**Initially instituted by**[**Prussian staff officers**](https://apps.dtic.mil/sti/pdfs/ADA521381.pdf)**in the early 1800s** and involving highly detailed scale models and complex charts to calculate casualties, **war** **games often** **serve** [**as** **educational** **exercises** intended to allow commanders to **gain experience** against a live adversary.](https://apnews.com/article/china-taiwan-united-states-war-game-deterrence-a0a31285a16afedd04c2a5d9c0fc934b)

By forcing commanders to adapt to an opponent’s tactics and rely on their own intuition to confront unexpected situations, war games are an attempt to mirror the [human experience](https://warontherocks.com/2019/11/getting-the-story-right-about-wargaming/) of combat.

War gaming also offers a way to test operational plans, allowing leaders to gain experience planning large-scale operations and work through complex logistical challenges.

By allowing vast distances to be visualized on a single board, operational war games allow for doctrines to be tested at scales impossible to replicate for most professional military forces.

**From**[**Japan’s strikes**](https://www.nationalww2museum.org/war/topics/battle-of-midway#:%7E:text=had%20sustained%20damage.-,The%20Battle,facilities%20only%20suffered%20minor%20damage.) on **Midway**, which were [practised and planned primarily using war games](https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=2109&context=nwc-review), to **NATO’s long-running**[**naval war-game series**](https://news.usni.org/2013/09/24/brief-history-naval-wargames), such exercises are often a **critical** **part of operational planning**.

Lastly, war games provide the foundation for a common strategic culture within a country’s military and national security institutions. Because these exercises are often reflections of the most likely crises faced by senior military and political leaders, war games offer the opportunity for officers to share their perspectives.

#### GenAI decreases risk of miscalc and de-escalates cyber attacks

**Sentient Digital**, Inc., 3-xx-20**24**, Sentient Digital, Inc. is a technology solutions provider for government and commercial clients, "The Most Useful Military Applications of AI", <https://sdi.ai/blog/the-most-useful-military-applications-of-ai/> doa:3/6/2025 as

**A BREAKDOWN OF MILITARY APPLICATIONS OF AI and The Benefits of Artificial Intelligence In The Military** Every aspect of military work, from planning operations to transporting troops, from training personnel to providing them with medical care, can benefit from the assistance of AI. However, in order to be useful, the systems must be implemented according to best practices and in a manner suited to the task at hand. WARFARE SYSTEMSWarfare systems such as weapons, sensors, navigation, aviation support, and surveillance can employ AI in order to make operations more efficient and less reliant on human input. This additional efficiency means that these systems may require less maintenance. Taking away the need for full human control of warfare systems reduces the impact of human error and frees up humans’ bandwidth for other essential tasks. Specifically regarding weapons, the Pentagon recently updated its [autonomous weapons policy](https://www.defensenews.com/artificial-intelligence/2023/01/25/pentagon-updates-autonomous-weapons-policy-to-account-for-ai-advances/) to take into account recent advances in AI. Since the policy’s original creation in 2012, a number of technological leaps forward have been made that necessitated this update. The update provides guidance for the safe and ethical development and use of autonomous weapons, one of the most useful military applications of AI. In addition to review and testing requirements, the policy creates a working group focused on autonomous weapons systems to advise the DoD. DRONE SWARMSOne of the most exciting developing military applications of AI involve leveraging [swarm intelligence for drone operations](https://sdi.ai/blog/military-drone-swarm-intelligence-explained/). These [swarms of drones](https://www.nextgov.com/ideas/2021/09/swarms-may-offer-next-level-artificial-intelligence/185177/) are inherently much more effective than a singular drone for several reasons. When a drone receives vital information, it can act upon it or communicate it to other drones in the swarm. These swarms can be used in simulations, as well as actual training operations and have the ability to make decisions in a variety of situations, with the swarm having an overarching objective but the individual drones having the ability to act independently and creatively towards it. AI-controlled swarms of drones are actually programmed to act in the same manner that swarms of insects act in nature. For example, when a bee finds something that could benefit the rest of the hive, it will report that information in detail to other bees. The drones can do the same. They are able to communicate the distance, direction, and elevation of a target, as well as any potential dangers, just as a bee does. The ability to use AI-powered drone swarms to put this powerful collective intelligence to work towards military objectives represents a critical frontier in the military applications of AI. STRATEGIC DECISION MAKINGOne of the best benefits of artificial intelligence in the military is in an area that military commanders might feel hesitant to let AI contribute. That is helping with strategic decision making. AI’s algorithms are able to collect and process data from numerous different sources to aid in decision making, especially in high-stress situations. In many circumstances AI systems can quickly and efficiently analyze a situation and make the best decision in a critical situation. It is also able to neutralize prejudices that may come with human input, with the caveat that AI may not yet have a fully developed understanding of human ethical concerns and there is a danger of AI learning from the biases that may exist in materials in its database. However, decision making under pressure is a critical part of being a service member, and AI and humans can work together to make this process easier. The combination of humans’ ethical understanding and AI’s quick analytical abilities can speed up the decision making process. Generative AI can contribute to the decision-making process in military settings. Rapidly sorting through large amounts of data, generative models can show connections, patterns, and potential implications that humans alone would take a longer time to find. This information can be presented to human decision makers not only as reports but also in a conversational format, facilitating human-AI collaboration. AI can also create simulations to test out possible scenarios, allowing for more informed decision making. Upon receiving this information from AI, humans must fill in the gaps, using their understanding of ethical principles, national security interests, and situational nuances to create optimal outcomes. With close human supervision, generative AI has a lot of potential to enhance military leaders’ strategic thinking. Among the considerations in implementing AI to assist decision making include counteracting harmful biases, accounting for real-world conditions that may be beyond models’ understanding, safeguarding classified data, not using AI as a replacement for human judgment, and ensuring alignment with regulations, ethics, and more. The key takeaway here is that the capabilities of AI for decision making are those of assisting humans, rather than taking this function out of their hands. DATA PROCESSING AND RESEARCHIn many cases, [processing large volumes of data](https://sdi.ai/blog/how-do-data-fusion-technologies-work/) can be extremely time consuming, but AI’s capabilities can really add value in this area. AI can be helpful for quickly filtering through data and selecting the most valuable information. It can also aid in grouping information from various datasets. This can allow military personnel to identify patterns more efficiently, draw more accurate conclusions, and create plans of action based on a more complete picture of the situation. Generative AI’s analysis capabilities mean that it can find connections in large volumes of information that might escape humans’ notice, or can find them faster than a human would. Thanks to their NLP abilities, generative AI models can also communicate this information to humans in a conversational manner and engage in a dialogue to explain it. AI can also be used in order to filter through large amounts of content from news and social media outlets in order to aid in identifying new information. This allows analysts to save time when tasked with large quantities of content. AI systems can also eliminate repetitive information, as well as inaccurate information. This can optimize the research process, helping analysts finish a job faster, and more accurately, as well as, again, reducing human error. Generative AI can speed up the analysis process when it’s critical to understand information as quickly as possible. Models can bring order to chaos when handling massive datasets, uncovering connections between seemingly unrelated data points. This allows military leaders to formulate strategy based on a deeper understanding of conditions. AI can also rapidly generate and compare thousands of scenarios by making small changes to variables; by understanding a wide range of permutations of a problem or situation, military commanders can prepare for many contingencies. Furthermore, generative models can quickly compare intelligence with existing knowledge and research, and make useful suggestions, enabling better predictions. Humans, rather than AI, will still need to make final strategic decisions, due to their ability to take into account context that may elude AI. However, by collaborating with AI, military leaders can have a more detailed understanding of what is happening around them and what may happen in the future. COMBAT SIMULATION and Training[Military training simulation software](https://sdi.ai/blog/military-training-simulation-software-ai/) has been used in the U.S. Army for quite some time. It combines systems engineering, software engineering, and computer science in order to build digitized models that prepare soldiers with combat systems deployed during operations. In simpler terms, military training simulation software is essentially a virtual “wargame” that is used in order to train soldiers. This software can be used for just about anything from mathematical models to simulating strategies used in non-combative environments. In turn, this will better prepare soldiers for real-life situations. These simulations are able to provide realistic missions and tasks to soldiers, to ensure they gain the most experience possible before applying their skills to real-life situations. Generative AI can improve military training and educational programs. AI-powered language models can read training manuals and other sources and use them to create new training materials, including notes, quizzes, and study guides. AI can also help evaluate students’ current abilities and tailor training to their specific needs. With NLP, generative AI can answer students’ questions and explain concepts similar to the way that a human instructor would. By analyzing large amounts of intelligence data, records of previous combat experiences, and more, AI can craft more comprehensive training, including detailed [military simulations](https://sdi.ai/rd/ultron-emergent/). Conversational AI can also provide customized feedback to help students build their skills and help commanding officers know where a particular student may be struggling. While AI holds a lot of potential for military training applications, it should never entirely replace human instructors. To avoid issues like bias or misinformation, leadership should always review AI-generated materials and be in charge of the ultimate analysis of students’ skills. Human instructors should determine the overall syllabus, while AI can craft individualized lessons that human instructors can then review for accuracy and other issues. However, with AI assistance, instructors can create and administer more effective training programs, because of individualized attention to students that humans may not be able to always provide, and do so more quickly due to AI’s processing speed. How Sentient Digital is Leveraging LLM in Military SimulationsSentient Digital works to apply cutting edge AI-based technology in the service of the military’s objectives. Our recently developed [naval wargaming simulation](https://sdi.ai/blog/naval-wargaming-fleet-emergence/), Fleet Emergence, leverages state-of-the-art LLM together with ACI architecture. The sophistication of this simulation lies in the intricate scenarios the LLM can create, as well as its ability to generate realistic communications and to respond in a manner similar to the way real-life adversaries would. One of the most important details about combat simulation is that it is far safer than reality. Many casualties can occur from training with real weapons and situations.This allows soldiers to experience the best simulation of the realities of warfare, without being endangered. These virtual realities can aid soldiers in understanding how to handle clones of weapons just like their real-life counterparts, make decisions in stressful situations, as well as work with their teammates. The training softwares can prepare soldiers for just about anything, and can save them in the long run. Not only can AI-based simulation train soldiers, but it can personalize training programs, as well as make fair assessments in order to make future adjustments to the programs. Combat simulation can also save time and money due to being more efficient at certain tasks than humans are. Check out our innovative AI model, [Strat Agent](https://sdi.ai/rd/strat-agent/), which acts as a modern-day battlefield commander that can be used in combat simulation. TARGET RECOGNITIONArtificial intelligence can aid in making target recognition more accurate in combat environments. AI can improve the ability for systems like this to identify the position of their targets. It can also allow defense forces to acquire a detailed understanding of an operation area by examining reports, documents, news, and other forms of information, aggregating and analyzing these sources much more quickly than humans would be able to do so. With generative AI’s conversational abilities, there can be a two-way discussion about this information, so military decision makers can ask questions to make sure the most relevant information comes to the surface. AI systems have the ability to predict enemy behavior, anticipate vulnerabilities, weather and environmental conditions, assess mission strategies, and suggest alleviation plans. This can save time and human resources, putting soldiers a step ahead of their targets, but as always requires humans to make the ultimate decision. THREAT MONITORINGThreat monitoring, as well as situation awareness uses operations that gain and analyze information to aid in many different military activities. There are unmanned systems that can be remotely controlled or sent on a pre-calculated route. These systems use AI in order to aid defense personnel in monitoring threats, and thus leveraging their situational awareness. Drones with AI can also be used in these situations. They can monitor border areas, recognize threats, and alert response teams. Additionally, they can strengthen the security of military bases, as well as increase the safety of soldiers in combat. CYBERSECURITYEven highly secure military systems can be vulnerable to cyber attacks, which is where AI can be of great help. Attacks can put classified information at risk, as well as damage a system altogether, which can endanger military personnel and jeopardize the mission. AI has the ability to protect programs, data, networks, and computers from persons not authorized to access them. AI also has the skills to study patterns of cyber attacks and form protective strategies in order to fight against them. These systems can recognize the smallest behaviors of malware attacks far before they enter a network. Generative AI’s analysis, scenario generation, and communication capabilities can also improve cybersecurity in military settings. With the ability to analyze large quantities of data and find patterns, generative AI can detect potential threats and use [predictive analytics](https://www.investopedia.com/terms/p/predictive-analytics.asp) to help predict future attacks. At the same time, generative AI also poses its own threats in the wrong hands, such as the concern that attackers can leverage the power of generative models for social engineering. The military will also have to take care to counteract this possibility as well, with consistently updated training and mitigation plans. When applied with care and close supervision, generative AI can enhance cyber defense, even for critically important military applications. As it does in many other areas, [advanced AI has a mixed impact on cybersecurity](https://www.crn.com/news/security/5-big-pros-and-cons-of-chatgpt-for-cybersecurity/). Functions such as the ability to write malware may make AI dangerous in the hands of bad actors, but AI can also help to detect and mitigate these threats. In essence, the military applies AI to counter adversaries who may also have access to AI. This means that it is critical for the military to have access to the most advanced and tailored AI cybersecurity solutions in order to stay safe amid a constantly evolving landscape of AI-driven cybersecurity risks. TRANSPORTATIONAI is able to play a role in the transportation of ammunition, goods, armaments, and troops. The logistics and transportation of these things is obviously vital to the success of military operations. AI can lower transportation costs and reduce the need for human input by, for example, plotting the most efficient route to travel under current conditions. It can also pre-identify problems for military fleets in order to increase efficiency of their performance. As the combination of innovation in computer vision and autonomous decision making over time also continues to bring self-driving vehicles closer to common use in the commercial space, this technology may also prove useful in the military context. CASUALTY CARE AND EVACUATIONBecause soldiers and medics have to make decisions in high-stress situations, AI is able to aid them when a fellow service member may need help. The dangerous environment of the battlefield presents a lot of obstacles to providing medical treatment to the wounded. The assistance of AI in a highly emotional environment can help with analyzing the situation and suggesting the best course of action. This advice can help humans to base their sometimes split-second decisions on information provided by an analytical rather than emotional mind. However, obviously, AI cannot make these decisions for humans, precisely because AI does not have an understanding of the emotional and contextual factors involved in a life or death situation. This type of AI uses an algorithm and large medical database that is able to access data containing medical trauma cases, which include diagnoses, vital sign sets, medications given, treatments, and outcomes. It then takes this data, combined with manually entered information in order to provide indications, warnings, and suggestions for treatment. This is another situation in which AI needs human guidance in order to operate effectively; while the AI will make recommendations without emotional considerations as a hindrance, humans must use their emotional abilities to make appropriate decisions that take into account these recommendations. AI is not qualified to make medical decisions but it can provide rapid analysis to give humans more information on which to base their decisions. **CONTACT SDi TODAY TO LEARN MORE ABOUT OUR MILITARY AI SERVICES** Meticulously implemented, state-of-the-art AI can improve the functioning of many aspects of military operations. Enhancing productivity, reducing the need for human input, and increasing efficiency are just a few of the areas where AI can support our armed forces. Extensive expertise is required to optimize the use of these systems, so DoD needs contractors who have a deep understanding of and experience with military AI. At Sentient Digital, Inc., we provide global technology solutions and services for military, government, and private sector clients. We innovate in areas ranging from artificial intelligence and machine learning, to rapid software development, to efficient prototyping and manufacturing. Each client is different, and that’s why we tailor each solution to our clients’ needs, from concept to completion. Enabling technology allows our clients to fully optimize their projects, and we want to help you do the same. Learn more about [how we work](https://sdi.ai/about/how-we-work/) to provide custom solutions for our clients, or [contact us](https://sdi.ai/contact-us/) for more information.

#### Wargames simulates the fog of war so even during a successful cyber attack we can prevent escalation

John Burnham 24, Senior Policy Research Analyst of Defence at the University of Alberta, 4-22-2024, “The Use of AI in War Games Could Change Military Strategy,” Military, https://www.military.com/daily-news/2024/04/22/use-of-ai-war-games-could-change-military-strategy.html, Accessed 2-13-2025, GX recut ARC’

Along with training commanders to confront the battlefields of the future, AI-enhanced war games may also spur **significant improvements** in operational planning. Borrowing from commercial industries, AI may be capable of [directing equipment and personnel](https://breakingdefense.com/2024/04/ai-can-make-logistics-data-as-valuable-as-intelligence-or-operational-data-for-mission-success/) to support specific campaign objectives while optimizing for flexibility to respond to unexpected threats.

Given its vast computing power, AI war games will also allow professional military planners to **test their assumptions** against a near endless range of possible contingencies, [strengthening internal decision-making processes](https://hbr.org/2023/09/using-technology-to-improve-supply-chain-resilience) and fine-tuning pre-existing models.

Lastly, generative AI will allow war games to **incorporate more strategy**, providing **invaluable insights** and **experience** to both military and political leaders.

Preparing for uncertainty

In generating a broader range of [underlying scenarios](https://www.csis.org/analysis/it-time-democratize-wargaming-using-generative-ai) to guide game play, AI will also allow participants to consider a multitude of possible developments, each branching out into near-limitless possibilities.

This will allow participants to adapt to changes in each player’s strategic calculations, including **alliance structure, economic considerations, political developments** and **societal trends**, all of which exert pressures on real-world military strategy.

AI’s capacity to introduce new developments into game play, including through its [faulty assumptions](https://www.wired.com/story/plaintext-in-defense-of-ai-hallucinations-chatgpt/), will force commanders to prepare for **uncertainty and the “**[**fog of war**](https://mwi.westpoint.edu/genius-mastery-military-innovation/),” an increasingly necessary skill in the complex **environment of contemporary combat**.

AI-enhanced strategic war games will also increase the likelihood of senior leaders being forced to contend with doubts regarding their own strategic doctrines, contributing to deeper discussions within their respective organizations.

Military science revolution

The use of war gaming as a tactical, operational and strategic exercise has been a hallmark of advanced militaries since the First World War and has allowed political and military leaders to carry out wars that possess complexities that were unimaginable only a generation ago.

The rise of generative AI and its contribution to war gaming will likely prompt [yet another revolution](https://www.csis.org/analysis/real-revolution-military-affairs) in the field of [military science](https://doi.org/10.1038/515489a). These games will improve the realism of training exercises and prepare leaders for the future of conflict, solve complex logistical challenges and spark new innovations in overarching military strategy.

**As contemporary combat grows ever more chaotic and complex, properly teaching the art of war has become even more crucial.**

**Otherwise cyberattacks go nuclear.**

Michael T. **Klare** **19**. Professor emeritus of peace and world security studies at Hampshire College and senior visiting fellow at the Arms Control Association. “Cyber Battles, Nuclear Outcomes? Dangerous New Pathways to Escalation.” <https://www.armscontrol.org/act/2019-11/features/cyber-battles-nuclear-outcomes-dangerous-new-pathways-escalation> doa:3/6/2025 as

Another initiative incorporated in the strategy document also aroused concern: the claim that an enemy cyberattack on U.S. nuclear command, control, and communications (NC3) facilities would constitute a “non-nuclear strategic attack” of sufficient magnitude to **justify the use of nuclear weapons** in response. Under the Obama administration’s NPR report, released in April 2010, the circumstances under which the United States would consider responding to non-nuclear attacks with nuclear weapons were said to be few. “The United States will continue to…reduce the role of nuclear weapons in deterring non-nuclear attacks,” the report stated. Although little was said about what sort of non-nuclear attacks might be deemed severe enough to justify a nuclear response, cyberstrikes were not identified as one of these. The 2018 NPR report, however, portrayed a very different environment, one in which nuclear combat is seen as increasingly possible and in which non-nuclear strategic threats, especially in cyberspace, were viewed as sufficiently menacing to justify a nuclear response. Speaking of Russian technological progress, for example, the draft version of the Trump administration’s NPR report stated, “To…correct any Russian misperceptions of advantage, the president will have an expanding range of limited and graduated [nuclear] options to credibly deter Russian nuclear or non-nuclear strategic attacks, which could now include attacks against U.S. NC3, in space and cyberspace.”1 The notion that a cyberattack on U.S. digital systems, even those used for nuclear weapons, would constitute sufficient grounds to launch a nuclear attack was seen by many observers as a dangerous shift in policy, greatly increasing the risk of accidental or inadvertent nuclear escalation in a crisis. “The entire broadening of the landscape for nuclear deterrence is a very fundamental step in the wrong direction,” said former Secretary of Energy Ernest Moniz. “I think the idea of nuclear deterrence of cyberattacks, broadly, certainly does not make any sense.”2 Despite such admonitions, the Pentagon reaffirmed its views on the links between cyberattacks and nuclear weapons use when it released the final version of the NPR report in February 2018. The official text now states that the president must possess a spectrum of nuclear weapons with which to respond to “attacks against U.S. NC3,” and it identifies cyberattacks as one form of non-nuclear strategic warfare that could trigger a nuclear response. That cyberwarfare had risen to this level of threat, the 2018 NPR report indicated, was a product of the enhanced cybercapabilities of potential adversaries and of the creeping obsolescence of many existing U.S. NC3 systems. To overcome these vulnerabilities, it called for substantial investment in an upgraded NC3 infrastructure. Not mentioned, however, were extensive U.S. efforts to employ cybertools to infiltrate and potentially incapacitate the NC3 systems of likely adversaries, including Russia, China, and North Korea. For the past several years, the U.S. Department of Defense has been exploring how it could employ its own very robust cyberattack capabilities to compromise or destroy enemy missiles from such states as North Korea before they can be fired, a strategy sometimes called “left of launch.”3 Russia and China can assume, on this basis, that their own launch facilities are being probed for such vulnerabilities, presumably leading them to adopt escalatory policies such as those espoused in the 2018 NPR report. Wherever one looks, therefore, the links between cyberwar and nuclear war are growing. The Nuclear-Cyber Connection These links exist because the NC3 systems of the United States and other nuclear-armed states are **heavily dependent on computers and other digital processors** for virtually every aspect of their operation and because those systems are **highly vulnerable** **to cyberattack**. Every nuclear force is composed, most basically, of weapons, early-warning radars, launch facilities, and the top officials, usually presidents or prime ministers, empowered to initiate a nuclear exchange. Connecting them all, however, is an extended network of communications and data-processing systems, all reliant on **cyberspace**. Warning systems, ground- and space-based, must constantly watch for and analyze possible enemy missile launches. Data on actual threats must rapidly be communicated to decision-makers, who must then weigh possible responses and communicate chosen outcomes to launch facilities, which in turn must provide attack vectors to delivery systems. All of this involves operations in **cyberspace**, and it is in **this domain that** **great power rivals seek vulnerabilities** to exploit in a constant struggle for advantage. The use of cyberspace to gain an advantage over adversaries takes many forms and is not always aimed at nuclear systems. China has been accused of engaging in widespread cyberespionage to steal technical secrets from U.S. firms for economic and military advantages. Russia has been accused, most extensively in the Robert Mueller report, of exploiting cyberspace to interfere in the 2016 U.S. presidential election. Nonstate actors, including terrorist groups such as al Qaeda and the Islamic State group, have used the internet for recruiting combatants and spreading fear. Criminal groups, including some thought to be allied with state actors, such as North Korea, have used cyberspace to extort money from banks, municipalities, and individuals.4 Attacks such as these occupy most of the time and attention of civilian and military cybersecurity organizations that attempt to thwart such attacks. Yet for those who worry about **strategic stability** **and the** **risks of nuclear escalation**, it is the threat of **cyberattacks** on **NC3** **systems** that provokes the greatest concern. This concern stems from the fact that, despite the immense effort devoted to protecting NC3 systems from cyberattack, no enterprise that relies so extensively on computers and cyberspace can be made 100 percent invulnerable to attack. This is so because such systems employ many devices and operating systems of various origins and vintages, most incorporating numerous software updates and “patches” over time, offering multiple vectors for attack. Electronic components can also be modified by hostile actors during production, transit, or insertion; and the whole system itself is dependent to a considerable degree on the electrical grid, which itself is vulnerable to cyberattack and is far less protected. Experienced “cyberwarriors” of every major power have been working for years to probe for weaknesses in these systems and in many cases have devised cyberweapons, typically, malicious software (malware) and computer viruses, to exploit those weaknesses for military advantage.5 Although activity in cyberspace is much more difficult to detect and track than conventional military operations, enough information has become public to indicate that the major nuclear powers, notably China, Russia, and the United States, along with such secondary powers as Iran and North Korea, have established extensive cyberwarfare capabilities and engage in offensive cyberoperations on a regular basis, often aimed at critical military infrastructure. “Cyberspace is a contested environment where we are in constant contact with adversaries,” General Paul M. Nakasone, commander of the U.S. Cyber Command (Cybercom), told the Senate Armed Services Committee in February 2019. “We see near-peer competitors [China and Russia] conducting sustained campaigns below the level of armed conflict to erode American strength and gain strategic advantage.” Although eager to speak of adversary threats to U.S. interests, Nakasone was noticeably but not surprisingly reluctant to say much about U.S. offensive operations in cyberspace. He acknowledged, however, that Cybercom took such action to disrupt possible Russian interference in the 2018 midterm elections. “We created a persistent presence in cyberspace to monitor adversary actions and crafted tools and tactics to frustrate their efforts,” he testified in February. According to press accounts, this included a cyberattack aimed at paralyzing the Internet Research Agency, a “troll farm” in St. Petersburg said to have been deeply involved in generating disruptive propaganda during the 2016 presidential elections.6 Other press investigations have disclosed two other offensive operations undertaken by the United States. One called “Olympic Games” was intended to disrupt Iran’s drive to increase its uranium-enrichment capacity by sabotaging the centrifuges used in the process by infecting them with the so-called Stuxnet virus. Another left of launch effort was intended to cause malfunctions in North Korean missile tests.7 Although not aimed at either of the U.S. principal nuclear adversaries, those two attacks demonstrated a willingness and capacity to conduct cyberattacks on the nuclear infrastructure of other states. Efforts by strategic rivals of the United States to infiltrate and eventually degrade U.S. nuclear infrastructure are far less documented but thought to be no less prevalent. Russia, for example, is believed to have planted malware in the U.S. electrical utility grid, possibly with the intent of cutting off the flow of electricity to critical NC3 facilities in the event of a major crisis.8 Indeed, every major power, including the United States, is believed to have crafted cyberweapons aimed at critical NC3 components and to have implanted malware in enemy systems for potential use in some future confrontation. Pathways to Escalation Knowing that the NC3 systems of the major powers are constantly being probed for weaknesses and probably infested with malware designed to be activated in a crisis, what does this say about the risks of escalation from a nonkinetic battle, that is, one fought without traditional weaponry, to a kinetic one, at first using conventional weapons and then, potentially, nuclear ones? None of this can be predicted in advance, but those analysts who have studied the subject worry about the emergence of dangerous new pathways for escalation. Indeed, several such scenarios have been identified.9 The first and possibly most dangerous path to escalation would arise from the early use of cyberweapons in a great power crisis to paralyze the vital command, control, and communications capabilities of an adversary, many of which serve nuclear and conventional forces. In the “fog of war” that would naturally ensue from such an encounter, the recipient of such an attack might fear more punishing follow-up kinetic attacks, possibly including the use of nuclear weapons, and, fearing the loss of its own arsenal, **launch** **its** **weapons immediately**. This might occur, for example, in a confrontation between NATO and Russian forces in east and central Europe or between U.S. and Chinese forces in the Asia-Pacific region. Speaking of a possible confrontation in Europe, for example, James N. Miller Jr. and Richard Fontaine wrote that “both sides would have overwhelming incentives to go early with offensive cyber and counter-space capabilities to negate the other side’s military capabilities or advantages.” If these early attacks succeeded, “it could result in huge military and coercive advantage for the attacker.” This might induce the recipient of such attacks to back down, affording its rival a major victory at very low cost. Alternatively, however, the recipient might view the attacks on its critical command, control, and communications infrastructure as the prelude to a full-scale attack aimed at neutralizing its nuclear capabilities and choose to strike first. “It is worth considering,” Miller and Fontaine concluded, “how even a very limited attack or incident could set both sides on a slippery slope to rapid escalation.”10 What makes the insertion of latent malware in an adversary’s NC3 systems so dangerous is that it may not even need to be activated to increase the risk of nuclear escalation. If a nuclear-armed state comes to believe that its critical systems are infested with enemy malware, its leaders might not trust the information provided by its early-warning systems in a crisis and might misconstrue the nature of an enemy attack, leading them to overreact and possibly **launch their nuclear weapons out of fear** they are at risk of a preemptive strike. “The **uncertainty** **caused by** the unique character of **a** **cyber threat** **could jeopardize** **the credibility of the** **nuclear deterrent** **and undermine strategic stability** in ways that advances in nuclear and conventional weapons do not,” Page O. Stoutland and Samantha Pitts-Kiefer wrote in 2018 paper for the Nuclear Threat Initiative. “[T]he introduction of a flaw or malicious code into nuclear weapons through the supply chain that compromises the effectiveness of those weapons could lead to a **lack of confidence in the nuclear deterrent,” undermining strategic stability**.11 Without confidence in the reliability of its nuclear weapons infrastructure, a nuclear-armed state may **misinterpret confusing signals** from its early-warning systems and, fearing the worst, **launch its** **own** **nuclear weapons** rather than lose them to an enemy’s first strike. This makes the scenario proffered in the 2018 NPR report, of a nuclear response to an enemy cyberattack, that much more alarming.

#### Nuclear war causes extinction.

**Solomon 22** [Norman Solomon, national director of RootsAction and the executive director of the Institute for Public Accuracy, 7-3-2022, Nuclear War Could Mean Human Extinction. Biden and Congress Should Stop Messing Around, Truthout, https://truthout.org/articles/nuclear-war-could-mean-annihilation-but-biden-and-congress-are-messing-around/] BZ

**Nuclear War Could Mean Annihilation**, But Biden and Congress Are Messing Around Biden and the bipartisan leadership in Congress are pretending that the surging danger of nuclear war doesn’t exist. By Norman Solomon , Truthout PublishedJuly 3, 2022 Nuclear missiles against fiery sky The Biden administration hasn't just remained mum about current nuclear war dangers — it’s actively exacerbating them. Anton Petrus / Getty Images Did you know that Truthout is a nonprofit and independently funded by readers like you? If you value what we do, please support our work with a donation. President Joe Biden and top subordinates have refused to publicly acknowledge the danger of nuclear war — even though it is now higher than at any other time in at least 60 years. Their silence is insidious and powerful, and their policy of denial makes grassroots activism all the more vital for human survival. In the aftermath of the 1962 Cuban missile crisis, President John F. Kennedy was more candid. Speaking at American University, he said: “A single nuclear weapon contains almost 10 times the explosive force **delivered by** **all the allied air forces in the Second World War**.” Kennedy also noted, “The deadly poisons produced by a nuclear exchange would be carried by wind and water and soil and seed to the far corners of the globe and to generations yet unborn.” Finally, he added, “**All we have built, all we have worked for,** **would be destroyed in** **the first 24** **hours.”** Kennedy was no dove. He affirmed willingness to use nuclear weapons. But his speech offered some essential honesty about nuclear war — and the need to seriously negotiate with the Kremlin in the interests of averting planetary incineration — an approach sorely lacking from the United States government today. At the time of Kennedy’s presidency, nuclear war would have been indescribably catastrophic. Now — with large arsenals of hydrogen bombs and what scientists know about “nuclear winter” — experts have concluded that a nuclear war would virtually end agriculture and amount to **omnicide** (the destruction of human life on earth).

### C2: Innovation

#### Productivity is high now because of GenAi

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Imagine this: You wake up tomorrow, reach for your phone, and **ChatGPT is gone**. No more instant answers. No more help with writing or debugging code. *It’s like the world has hit the brakes.* At the WCIT 2024 panel, senior analyst Berge Ayvazian raised a chilling question: *What if AI like ChatGPT just stopped working?* This got me thinking — how deeply do we depend on generative AI? And what would life look like without it? **Generative AI: The Invisible Engine of Our World** From coders to marketers, ChatGPT has become more than just a tool — it’s the lifeblood of modern productivity. It powers creativity and innovation in ways we hardly notice. But take it away, and we’d be left *scrambling like an engine suddenly cut off mid-flight.* **Developers in Crisis Mode** For developers, ChatGPT is the co-pilot they never knew they needed. According to a GitHub Copilot survey, it makes code-writing **55% faster**. Now imagine reverting to the endless rabbit holes of StackOverflow, wasting hours on what was once a quick fix. Deadlines would crumble. Projects would stall. And quality? *It would plummet — dragging companies down with it.* **Content Creation Slows to a Crawl** Writers and marketers are in for a rude awakening. AI boosts writing productivity by **40%** according to a study by MIT researchers. Without it? Content pipelines would grind to a halt. Burnout would soar. Marketing teams would lose their edge, turning out bland, uninspired material that customers would scroll right past. In a world where *attention is everything*, **mediocrity is a death sentence**. **Customer Support Overload** Businesses rely on AI-powered chatbots to handle the flood of customer inquiries. AI can automate up to **70% of routine customer queries**, improving efficiency and reducing response times, as reported by sources like Zendesk and Kore.ai. Without it, call centers would be buried under mountains of requests. Long wait times. Angry customers. It wouldn’t just be frustrating — it would be chaos. **Education Takes a Step Back** In classrooms, AI is reshaping the way students learn. According to multiple studies, it increases engagement by 30–45% and saves teachers up to 40% of their time. Take it away, and students lose the personalized learning that’s shaping the next generation. Teachers, drowning in paperwork, would be forced back into outdated methods. The future of education? **Stuck in reverse**. **Personal Insight: AI as a Lifeline** Before ChatGPT, I was drowning in repetitive tasks — writing reports and fixing small bugs. It drained my energy, leaving me burned out. When ChatGPT entered my workflow, it felt like having an assistant who never sleeps, always there to handle the tedious work. *It freed me from the grind and reignited my spark.* If it vanished tomorrow? Burnout would be waiting for me, ready to pull me back under. **Innovation Slows Without AI** Generative AI has ignited a revolution in creativity. Without it, the pace of innovation would screech to a halt. Industries like music, art, and tech would lose their edge. We’d still move forward, but cautiously — too afraid to take risks. What once took months to build could now take years. **Are We Too Dependent?** Berge Ayvazian’s question still lingers: *Could we survive without generative AI?* Perhaps. But the world would be slower, less efficient, and far less creative. **AI isn’t just a convenience** — it’s the force driving us into the future. Without it, we’d be lost in a slower, less inspired world.

#### GenAi improves learning

[Lixiang **Yan**](https://www.nature.com/articles/s41562-024-02004-5#auth-Lixiang-Yan-Aff1), [Samuel Greiff](https://www.nature.com/articles/s41562-024-02004-5#auth-Samuel-Greiff-Aff2-Aff3-Aff4), [Ziwen Teuber](https://www.nature.com/articles/s41562-024-02004-5#auth-Ziwen-Teuber-Aff2), [Dragan Gašević](https://www.nature.com/articles/s41562-024-02004-5#auth-Dragan-Ga_evi_-Aff1) **ET AL**, 10-21-20**24**, Lixiang Yan is a research fellow at the Centre for Learning Analytics at Monash University, "Promises and challenges of generative artificial intelligence for human learning", Nature, <https://www.nature.com/articles/s41562-024-02004-5> doa:3/6/2025

Abstract Generative artificial intelligence (GenAI) holds the potential to transform the delivery, cultivation, and evaluation of human learning. This Perspective examines the integration of GenAI as a tool for human learning, addressing its promises and challenges from a holistic viewpoint that integrates insights from learning sciences, educational technology, and human-computer interaction. GenAI promises to enhance learning experiences by scaling personalised support, diversifying learning materials, enabling timely feedback, and innovating assessment methods. However, it also presents critical issues such as model imperfections, ethical dilemmas, and the disruption of traditional assessments. Cultivating AI literacy and adaptive skills is imperative for facilitating informed engagement with GenAI technologies. Rigorous research across learning contexts is essential to evaluate GenAI’s impact on human cognition, metacognition, and creativity. Humanity must learn with and about GenAI, ensuring it becomes a powerful ally in the pursuit of knowledge and innovation, rather than a crutch that undermines our intellectual abilities. Keywords: Generative Artificial Intelligence, Human Learning, AI Agent, Large Language Models, Diffusion Models 1 Main Human learning is a journey that shapes minds, fosters innovation, and builds the foundations of society. Beyond merely acquiring knowledge and skills, learning is a path towards fostering critical thinking, creativity, collaboration, and social cohesion. By nurturing the ability to question, analyse, and innovate, learning empowers individuals to navigate complex challenges and contribute to societal progress. While education encompasses formalised systems that structure learning processes, learning represents the dynamic and personal process that occurs within this framework (Table 1). The history of human learning presents a narrative of continuous evolution and adaptation to technological breakthroughs. For example, the printing press democratised access to knowledge and opened the opportunity of learning to many, while the Internet and digital technologies transformed information dissemination and collaborative learning across time and space. In this continuum of innovation, recent advancements in artificial intelligence (AI) present another transformative opportunity to rethink learning processes and educational methodologies [1]. Generative AI (GenAI) technologies, such as large language models (LLMs) and diffusion models (Table 2), have shown promise in automating various learning tasks [2], delivering feedback on human efficacy [3], outperforming average students in reflective writing [4], innovating conversational assessments [5], creating dynamic learning resources [6], and supporting multimedia learning [7]. However, these technologies also present challenges and ethical considerations that could outweigh their benefits [2, 8]. One major concern is the digital divide, where unequal access to these powerful technologies can exacerbate existing inequalities in learning opportunities [9]. Additionally, overreliance on GenAI may negatively impact learners’ agency, critical thinking, and creativity, warranting caution [10]. Consequently, it is essential to balance technological advancement and humancentred values in learning. This perspective paper aims to delve into the promises and challenges of advancing human learning in the age of GenAI. By integrating human-centred theories of learning and instruction, we emphasise the importance of designing AI-driven educational tools that prioritise the needs of learners in contemporary societies. We elaborate on how this technology can transform learning and teaching practices while remaining critical of the ethical and practical challenges it poses, contributing to a future research agenda for investigating human-AI interaction and the adoption of GenAI as a tool for learning (Fig. 1). 2 Promises GenAI promises to transform human learning by scaling personalised support, diversifying learning resources, enabling timely feedback, and innovating assessment methods. The realisation of these promises depends on the roles and interactions GenAI has with learners and educators (Fig. 2). Specifically, GenAI technologies can act as cognitive facilitators within learners’ Zone of Proximal Development, providing adaptive support at scale. GenAI can also enrich learning experiences by assisting in the creation of diverse multimedia resources. In feedback, GenAI systems offer timely and multimodal insights, surpassing traditional methods in depth and efficiency. For Fig. 1 Overview of the impacts of generative artificial intelligence on human learning. The left side of the figure lists various learning impacts, which are categorised into promises (green), challenges (red), and needs (blue). The middle column presents key components associated with each learning impact. These components detail specific aspects that need to be addressed or leveraged to use generative AI as a tool for learning. The matrix on the right shows the five main groups involved in implementing these key components: learners, educators, researchers, policymakers, and technologists. The dots in each column indicate that the relevant group needs to make a substantive contribution to achieving the goals of the key component in the corresponding row. assessment, GenAI enables adaptive and authentic evaluations using generative agents and multimodal models. The following sections explore each of these promises, illustrating their potential to transform the delivery, cultivation, and evaluation of human learning. 2.1 Learning Support The unique contribution of GenAI, particularly LLMs, to learning support lies in its scalability and adaptability. GenAI can function as a master teacher at scale, providing personalised and adaptive support to a wide range of learners across various subjects and languages. Unlike conventional intelligent tutoring systems that require extensive knowledge engineering to design rule-based responses [11], GenAI can achieve superior and more naturalistic interactions, such as personalised feedback, adaptive questioning, and conversational engagement, with minimal prior training. These enhanced interactions facilitate more effective and intuitive tutoring experiences, making the learning process more engaging and tailored to individual student needs [8]. This capability holds the potential to democratise access to high-quality learning support, making it accessible to learners globally. GenAI’s role aligns with Vygotsky’s sociocultural theory of learning, where more knowledgeable others guide learners within their Zone of Proximal Development [12]. By integrating novel technologies like ChatGPT into intelligent tutoring systems, GenAI can offer personalised and adaptive support based on each learner’s unique knowledge [13]. These language models have demonstrated remarkable proficiency in processing semantic and contextual information [14], a key aspect of their effectiveness as a tool for learning. By accurately interpreting and responding to the linguistic and contextual nuances in learners’ queries, LLMs ensure that the learning experience is interactive and thought-provoking. Rather than merely dispensing solutions, they can be used to encourage learners to engage cognitively with the material. This engagement is achieved by prompting students to think critically, unpack problems, and understand underlying concepts. A representative case of how GenAI can support learning comes from Khan Academy’s ”Khanmigo” chatbot, powered by GPT-4 and designed to assist with mathematical queries [15]. Khanmigo exemplifies the shift from providing direct answers to a more nuanced, guided learning approach that offers constructive feedback and step-by-step instruction. For example, when students present Khanmigo with a problem on fractions, it guides them through the underlying concepts of denominators and numerators, encouraging them to apply these concepts to solve the problem through a series of guiding questions. Khanmigo functions as a facilitator, aligning with the principles of inquiry-based learning [16], a human-centred learning theory that emphasises the importance of active learning through inquiry. This theory encourages students to ask questions, explore, and engage deeply with the learning material to develop deep knowledge. This iterative methodology reflects Vygotsky’s emphasis on the importance of the learning journey over the destination by fostering deep conceptual comprehension and retention [12, 16]. By engaging learners in a dialogic process, GenAI-driven systems such as Khanmigo aim to enhance learners’ critical thinking and problem-solving skills. Despite the promising design of systems like Khanmigo and students’ positive attitudes towards using such technologies for personalised learning support [17], it is important to acknowledge the current limitations in empirical evidence regarding their short- and long-term impacts on learning outcomes [18]. Emerging evidence indicates that the impact on learning engagement, agency, and performance can paint a complicated and mixed picture (e.g., lack of learning gains after removing GenAI supports) [19, 20]. Therefore, further research is needed to substantiate GenAI’s long-term benefits to human learning. This includes conducting longitudinal and randomised controlled studies that compare the effectiveness of GenAI tutoring with conventional rule-based tutoring systems over several academic terms and across different subjects to contextualise its impacts within various educational settings. 2.2 Learning Resource Effective learning relies on the quality and diversity of resources, yet developing highquality materials is often time-consuming and resource-intensive. GenAI promises to ease this burden by creating diverse and engaging content, fostering curriculum innovation and enhancing learning experiences. Studies on human-AI collaboration indicate Fig. 2 Examples of human-AI interactions in human learning. a, Learners receive personalised and adaptive support from generative AI tutors, which are co-designed with educators and have access to prior learner data and domain knowledge. b, Educators use generative AI to create multimodal learning resources, incorporating text, audio, and video content. c, Educators collaborate with generative AI to deliver multimodal feedback to learners. d, Generative AI agents use input requirements from educators, prior learner data, and domain knowledge to create assessment activities that evaluate learners. that co-creating content with GenAI can meet diverse learning needs, providing students with relevant and accessible materials to support their individual paths efficiently and creatively [21–23]. For instance, early explorations have shown that GPT-4 can automatically generate instructional materials, such as explanations of programming concepts, examples, and quiz questions, thereby boosting learner engagement and satisfaction [24]. Additionally, GPT-4 has demonstrated proficiency in generating college-level biology questions for lower levels of Bloom’s Taxonomy (e.g., remember and understand) but struggles with higher levels (e.g., apply and create) [25]. These findings suggest that while GenAI can produce learning resources, educators’ expertise remains crucial for ensuring the accuracy, relevance, and pedagogical soundness of the material. This highlights the need for a human-AI collaborative approach to create meaningful resources that meet diverse learning objectives and learner needs. GenAI can also enrich learning resources by generating interactive activities, multimedia content, and real-world problem-solving scenarios. Text-to-image models like Stable Diffusion, Midjourney, and DALL-E [26, 27] enable educators to create visual learning materials from textual content. These tools can foster students’ creative thinking by engaging them in activities such as using AI to generate images. For instance, students can create imaginative visuals with AI and write inspired diaries based on these images, a practice found to reduce gender disparities in interest in art during Science, Technology, Engineering, the Arts and Mathematics (STEAM) classes [28]. This innovative approach has also been shown to enhance primary school students’ extrinsic motivation, problem-solving awareness, critical thinking, and learning performance in ancient Chinese poetry [29]. Similarly, text-to-video generation tools like Runway’s Gen-3 Aphla and OpenAI’s Sora can support educators in creating video narratives from textual content, further diversifying learning modalities. This capability is particularly valuable for teaching students with specific disabilities, such as providing multisensory instruction to students with dyslexia [30]. A preliminary study found no significant differences in learning gains and perceived experiences between GenAI-generated videos with synthetic instructors and traditional recorded instructor videos, suggesting that GenAI could make high-quality learning resources more accessible globally [31]. By offering a range of pedagogical possibilities through efficient and diversified resource development, GenAI can help educators create more dynamic and engaging learning environments. This enables learners to interact with content in more informed, creative, and personalised ways. Such an approach aligns with constructivist learning principles, which emphasise the importance of learners actively constructing knowledge through exploration and interaction [32]. However, more research is needed to balance this integration of GenAI in developing resources for human learning [21, 33], such as determining the optimal level of automation versus human control, the extent of expert validation required, and the degree of alignment with learning objectives. 2.3 Learning Feedback Another promise of GenAI in supporting human learning is its potential to provide timely, specific, and constructive feedback, a key element of high-quality instruction and essential for effective learning [34–36]. Providing detailed feedback regularly is laborious and time-consuming, adding to educators’ workloads, especially since students perceive timely feedback as the most effective [37]. GenAI can assist by analysing student work and delivering instant, personalised feedback with minimal prior training. For example, a recent study found that ChatGPT generates more in-depth and fluent feedback, coherently summarising students’ performances compared to human educators [3]. This AI-generated feedback also includes process-focused elements, which are more effective in shaping learning strategies [36]. Emerging studies show similar benefits in various learning contexts, such as formative feedback in secondary school essay writing [38, 39], programming assignments in introductory computer science courses [40, 41], and collaborative second language writing [42]. GenAI-generated feedback has led to enhanced task performance and positive experiences [39, 40, 42]. Additionally, chatbots powered by GenAI models with natural and visual language understanding capabilities (e.g., GPT-4 with Vision and Gemini 1.0 Pro) can help students navigate and comprehend insights from learning analytics dashboards [43], which combine data, analytics, and visualisations to provide feedback on learning processes and outcomes [44]. These chatbots could facilitate dialogic feedback, which is associated with improved learner productivity and engagement [45]. GenAI could also expand feedback delivery beyond text and graphics to include narrated audio and video, addressing the scalability challenges of these formats and leveraging their benefits for enhanced feedback efficiency and student engagement [46]. For example, by combining 3D diffusion models [47] and text-to-speech models [48], educators can create digital avatars to convey feedback through a narrated voice rather than text alone. This diversity in feedback modalities can increase engagement and effectiveness [46]. Prior research indicates that audio and video feedback is often perceived as more personal and dynamic, enhancing understanding and engagement compared with traditional written feedback [49–51]. The integration of GenAI technologies promises to facilitate timely and multimodal feedback, providing more informative feedback and fostering improved effectiveness and engagement in the learning process. However, it is essential to evaluate the cost and benefits, as these models, especially video generation models, require high computational power, potentially widening the inequality in learning opportunities. 2.4 Learning Assessment GenAI is transforming the assessment of learning, shifting from traditional, often onerous methods to more adaptive and authentic processes [52]. Central to this shift is GenAI’s potential to create personalised and adaptive assessments, enhancing the understanding of each student’s needs and progression. This is enabled by advancements in generative agents – autonomous and adaptive AI entities that operate independently, pursuing objectives without continuous user interaction, as exemplified by tools like AutoGen (preprint) [53]. These agents exhibit human-like cognitive and metacognitive abilities, including task planning, situational assessment, progress monitoring, and collaborative efforts among agents. For instance, a group of 25 generative agents in a dynamic sandbox environment successfully organised and conducted a Valentine’s Day celebration based on a single user input [54]. By leveraging a similar agent architecture, encompassing observation, planning, and reflection, and integrating these with process-centred methodologies (e.g., modelling self-regulated learning from learners’ digital traces [55]) from the field of learning analytics [56, 57], learning scientists and researchers can develop generative agents capable of autonomously evaluating human learning. These agents can identify areas of knowledge deficiency and provide tailored learning resources and adaptive assessments. Recent educational technology studies highlight the potential of automated assessments through multi-agent frameworks that leverage multiple LLM agents. These GenAI systems are being used to grade coding assignments in online learning [58], conduct cognitive assessments to identify students’ strengths and weaknesses according to Bloom’s taxonomy in e-learning environments [59], and assess educators’ mathematical content knowledge for professional development programs [60]. These applications demonstrate strong potential for generalisability, precision, and dependability. GenAI also holds promise for advancing authentic assessments [52]. It can enhance learning tasks in both virtual and physical simulations to more accurately mirror realworld situations, making assessments more meaningful and contextualised. Previous studies have shown the effectiveness of combining LLMs with knowledge graphs to create virtual standard patients, aiding the training and evaluation of medical students’ diagnostic skills [61]. Knowledge graphs are structured representations that integrate diverse data sources, providing a comprehensive understanding of a domain [62]. When used with LLMs, they can simulate complex learning and assessment scenarios requiring critical thinking and problem-solving skills, such as in driving education [63], programming education [64], and laboratory safety courses [65]. Integrating multimodal generative models, such as GPT-4 Vision for text and image generation, Meta’s Voicebox for audio creation from text, and generative adversarial networks for digital avatar production, can further enhance the authenticity of simulated assessment environments [66]. These enhancements allow students to interact naturally and perform procedural actions as if they were in real professional settings, a concept proven effective in virtual internships [67] and healthcare simulations [68]. However, much effort is required to develop valid and reliable behavioural and psychological indicators in these novel assessment settings to accurately capture genuine human learning.

#### Independently, GenAi data trading is good for models’ improvement

Kaif **Shaikh**, 12-12-20**24**, Kaif Shaikh is a journalist and writer passionate about turning complex information into clear, impactful stories. His writing covers technology, sustainability, geopolitics, and occasionally fiction. Kaif's bylines can be found in Times of India, Techopedia, and Kitaab. Apart from the long list of things he does outside work, he likes to read, breathe, and practice gratitude. "Publishers sell data for millions as AI faces imminent data shortage", Interesting Engineering, <https://interestingengineering.com/culture/publishers-sell-data-ai-earn-millions> doa:2/16/25 as

I systems, particularly large language models (LLMs), require extensive and diverse information to train, function, and naturally grow. However, these ever-hungry systems also require a constant influx of data to satisfy their insatiable appetite, leading to data shortage, with [predictions indicating](https://epoch.ai/trends#:~:text=Training%20data&text=The%20median%20projected%20year%20in,confidence%20interval%3A%202026%20to%202033.) that AI models will soon exhaust the available public online text. This reliance has positioned rich, detailed, scholarly content, which has vetted information, as an extremely valuable resource for [training these advanced AI](https://interestingengineering.com/innovation/ai-training-data-privacy) systems. Consequently, scholarly publishers, custodians of vast archives of detailed research, have entered into multimillion-dollar licensing agreements with technology companies. These deals provide tech firms with the critical data needed to [train their AIs](https://interestingengineering.com/innovation/ai-training-data-privacy) while offering publishers a lucrative revenue stream. While financially beneficial, these partnerships also pose complex questions of ethics, ownership, and the broader implications for the accessibility of knowledge. **The multi-million dollar AI agreements** In recent months, some of the most significant deals in the AI data domain have featured partnerships between leading tech companies and scholarly publishers. One of the most notable transactions involved [Microsoft and the UK academic publisher Taylor & Francis](https://www.thebookseller.com/news/academic-authors-shocked-after-taylor--francis-sells-access-to-their-research-to-microsoft-ai). Microsoft secured a $10-million agreement to utilize the publisher’s extensive repository of papers to train its AI systems. Similarly, the academic publisher Wiley has also entered lucrative agreements, having reported to its investors a $23 million earning from a deal with an unnamed technology firm, with an additional $21 million expected within the financial year. From the publishers’ perspective, these deals represent a significant revenue opportunity, a crucial factor in an industry often grappling with financial constraints. However, alongside the profit potential, these agreements raise ethical considerations. Publishers must address the complex intellectual property rights considerations and ensure responsible use of academic content. The primary concern is that commercial deals should not jeopardize the integrity or accessibility of scholarly work. **The looming data drought in AI development** As AI systems, particularly large language models (LLMs), continue to grow, their insatiable hunger for data has led to an unprecedented consumption of available online text. This trend is pushing the limits of the internet’s text resources, with a striking projection suggesting that by 2028, AI models may exhaust the stock of public online text available for training purposes. Data scarcity is real for a system that [constantly needs data](https://www.nature.com/articles/d41586-024-03990-2) to fuel growth and intelligence, a pivotal challenge facing the AI research community. Content providers, wary of unauthorized use, are tightening restrictions on how their data can be accessed and used. Major news outlets like The New York Times have initiated [legal actions against AI](https://interestingengineering.com/culture/openai-hits-back-at-new-york-times-lawsuit) companies, advocating for compensation and tighter control over their intellectual property. These developments indicate a shift in the ‘data commons,’ where freely available resources are becoming more guarded and access more contested. In response to these constraints, AI developers are exploring alternative strategies. Leading AI firms, including OpenAI and Anthropic, acknowledge the issue while investing in innovative solutions to circumvent potential data shortages. These strategies include forming partnerships to access non-public data, generate synthetic data, and tap into unconventional data sources that have not been traditionally utilized for AI training. This includes scholarly articles and academic data. These adaptive measures are crucial for sustaining the pace of AI advancement and navigating complex copyright laws and ethical considerations. This scenario presents a dual challenge and opportunity for the scholarly community. On one hand, the tightening of data access could inhibit the free exchange of knowledge and complicate academic research. On the other hand, it offers a chance for academia to redefine its role in the AI ecosystem and potentially lead the way in creating and curating high-quality datasets that respect both copyright and ethical standards, thereby contributing to [responsible AI development](https://interestingengineering.com/culture/chatgpt-gets-ethical-nod-from-g7). **The Generative AI Licensing Agreement Tracker** In response to the growing trend of licensing agreements, Roger Schonfeld and his colleagues at Ithaka S+R, a consulting service focusing on higher education, initiated the Generative [AI Licensing Agreement Tracker](https://sr.ithaka.org/our-work/generative-ai-licensing-agreement-tracker/). Schonfeld observed, “We were seeing announcements of these deals, and we got to thinking that this is starting to become a pattern.” The tracker primarily aims to enhance transparency and is a crucial resource for the academic community. It sheds light on the nature and scope of these deals, catalogs individual agreements, and sketches a broader pattern within the industry by documenting both confirmed and forthcoming deals between major academic publishers and technology firms. **Publishers’ strategic decisions in AI licensing** While entities like Wiley and Taylor & Francis have rapidly adapted to and embraced the opportunities presented by AI technology, others show more caution. In contrast, the American Association for the Advancement of Science (AAAS), a non-profit academic publisher that publishes the journal *Science*, has adopted a more responsible stance. Meagan Phelan, communications director for the Science family of journals, indicated that AAAS might consider licensing its content to technology companies if they meet certain criteria, assessing the firm’s trustworthiness and the usefulness of the tools created with the content. These differing approaches highlight the strategic dilemmas facing publishers. The decision to enter into AI licensing deals involves weighing potential revenue against the risks of losing control over the use of scholarly content. The health of the scholarly ecosystem depends on [balancing intellectual property](https://interestingengineering.com/science/balancing-data-and-human-knowledge-could-fuel-scientist-like-ai) rights with open access while factoring in the possibility of replication. Publishers must balance innovation and profit with ethical responsibility. **Authorship and ownership in the age of AI** Integrating AI into scholarly publishing has provoked mixed reactions from authors whose works are central to these licensing deals. While some authors are supportive, viewing these partnerships as opportunities to amplify the reach and impact of their research, others remain skeptical or even unaware of the implications these agreements may have on their work. Concerns mainly revolve around the control over their [intellectual property](https://interestingengineering.com/innovation/new-exhibition-explores-whether-ai-robots-should-own-intellectual-property) and the potential misuse of their scholarly content. To address these concerns and ensure that authors are not left in the dark, some publishers have implemented various strategies for involving authors in the licensing process. For instance, Cambridge University Press & Assessment (CUPA) has adopted an opt-in approach, actively reaching out to around 20,000 authors for permission before licensing their content to technology companies developing LLMs.

(this gives funding for unis to innovate as well)

#### Otherwise, a slowdown in innovation makes us vulnerable to extinction

**William MacAskill, 2022.** William MacAskill is a philosopher and professor at the University of Oxford, known for his work on effective altruism and longtermism. His writing explores ethics, economics, and the moral responsibilities of future generations. *What We Owe the Future* discusses the long-term impact of present-day decisions. **"Chapter 5: Are We at the Beginning of History?"** Basic Books, https://www.basicbooks.com/titles/william-macaskill/what-we-owe-the-future/9781541618633/. **Doa:3/6/25**

What is different about the **modern growth** era is that technological progress and economic growth have been sustained to reach much greater heights. With the Industrial Revolution, the world moved to unprecedentedly rapid rates of growth and technological progress, which continue to this day. But will this continue? In Chapter 4, we saw that there was a case for thinking that, by automating the process of technological innovation, artificial intelligence could bring about even faster technological progress than we’ve seen to date. In this chapter we’ll consider the opposite possibility. Perhaps future historians will look back on our era just as a really big efflorescence that, like other efflorescences before us, was followed by stagnation. My concern here is not just with a **slowdown in innovation** but with a near halt to growth and a plateauing of technological advancement. Though indefinite stagnation seems unlikely to me, it seems entirely plausible that we could stagnate for hundreds or thousands of years—a sort of civilisational interregnum. That would be of great longtermist importance for two reasons. First, the society that emerges from the interregnum might be guided by very different values than society today. Second, and more clearly, **a period of stagnation could increase the risks of extinction and permanent collapse.** To see this second point, consider what would have happened if we had plateaued at 1920s technology. We would have been stuck relying on fossil fuels. Without innovations in green technology, we would have kept emitting an enormous amount of carbon dioxide. Not only would we have been unable to stop climate change, but we would also have simply run out of coal, oil, and gas eventually. The 1920s’ level of technological advancement was unsustainable. **It’s only with the technological progress of the last hundred years that we have the capability to transition away from fossil fuels.** Our next level of technological advancement might be unsustainable, too. **We could face easy-to-manufacture pathogens and other potent means of destruction without sufficient technology to defend against them**. There would be a **constant risk of a civilisation-ending catastrophe**. If we stayed stuck at this unsustainable level for long enough, such a catastrophe would be essentially **inevitable.** To safeguard civilisation, we therefore need to make sure we get beyond that unsustainable level and reach a point where we have **the technology to effectively defend against such catastrophic risks.** The idea of sustainability is often associated with trying to slow down economic growth. But if a given level of technological advancement is unsustainable, then that is not an option. We may be like a climber scaling a sheer cliff face with no ropes or harness, with a significant risk of falling. In such a situation, **staying still is no solution**; that would just wear us out, and we would fall eventually. Instead, we need to keep on climbing: only once we have reached the summit will we be safe.9

### C3: Antimicrobial Resistance

#### AMR is becoming a globally pervasive issue

**Guang-Yu Liu et. al 24**, Guang-Yu Liu, Dan Yu, Mei-Mei Fan, Xu Zhang, Ze-Yu Jin, Christoph Tang & Xiao-Fen Liu, Guang-Yu Liu is an assistant director of product and solution and has a degree from the National University of Singapore, 1-22-2024, "Antimicrobial resistance crisis: could artificial intelligence be the solution?", SpringerLink, <https://link.springer.com/article/10.1186/s40779-024-00510-1#Sec26> // DOA: 2/9/2025 AT

Skip to main content Advertisement Springer Nature Link Log in Find a journal Publish with us Track your research Search Cart Home Military Medical Research Article Antimicrobial resistance crisis: could artificial intelligence be the solution? Review Open access Published: 23 January 2024 Volume 11, article number 7, (2024) Cite this article Download PDF You have full access to this open access article Military Medical Research Aims and scope Submit manuscript Antimicrobial resistance crisis: could artificial intelligence be the solution? Download PDF Guang-Yu Liu, Dan Yu, Mei-Mei Fan, Xu Zhang, Ze-Yu Jin, Christoph Tang & Xiao-Fen Liu 13k Accesses 12 Citations 18 Altmetric 2 Mentions Explore all metrics Abstract Antimicrobial resistance is a global public health threat, and the World Health Organization (WHO) has announced a priority list of the most threatening pathogens against which novel antibiotics need to be developed. **The discovery and introduction of novel antibiotics are time-consuming and expensive**. According to WHO’s report of antibacterial agents in clinical development, only 18 novel antibiotics have been approved since 2014. Therefore, novel antibiotics are critically needed. Artificial intelligence (AI) has been rapidly applied to drug development since its recent technical breakthrough and has dramatically improved the efficiency of the discovery of novel antibiotics. Here, we first summarized recently marketed novel antibiotics, and antibiotic candidates in clinical development. In addition, we systematically reviewed the involvement of AI in antibacterial drug development and utilization, including small molecules, antimicrobial peptides, phage therapy, essential oils, as well as resistance mechanism prediction, and antibiotic stewardship. Similar content being viewed by others The role of artificial intelligence in the battle against antimicrobial-resistant bacteria Article 13 February 2021 Antibiotic Drug Development Methods Chapter © 2024 Harnessing Artificial Intelligence and Machine Learning in the Battle Against Antimicrobial-Resistant Infections Chapter © 2024 Explore related subjects Discover the latest articles, news and stories from top researchers in related subjects. Artificial Intelligence Background Antimicrobial resistance (AMR) is a natural phenomenon wherein microorganisms, including bacteria, viruses, fungi, and parasites, develop the ability to survive the drugs designed to kill them. The misuse and overuse of antibiotics in human medicine, animal agriculture, and the environment have accelerated the emergence and spread of AMR. This phenomenon renders once-effective treatments ineffective, leading to prolonged illnesses, increased mortality rates, and higher healthcare costs. Thus, AMR is a serious and foremost global threat to human health that requires practical actions urgently. The Global Antimicrobial Resistance and Use Surveillance System launched by the World Health Organization (WHO) revealed that AMR is on the rise and already a leading cause of death [1, 2]. Globally, it was estimated that, in 2019 alone, approximately 4.95 million deaths were linked to bacterial AMR, with 1.27 million deaths specifically attributed to bacterial AMR [1]. The highest all-age death rate due to resistance was observed in Western sub-Saharan Africa, with 27.3 deaths per 100,000 individuals (20.9–35.3) [1]. According to the data from the Centers for Disease Control and Prevention report, AMR to at least first-line antibiotics accounts for more than two million infections in the US alone each year and at least 23,000 deaths [3]. There were more than 2.8 million infections caused by antibiotic-resistant bacteria in the US in 2019 [4]. **It is estimated that AMR will cause 10 million deaths each year by 2050** [5]. The Infectious Disease Society of America has highlighted 6 pathogens including Enterococcus faecium, Staphylococcus aureus (S. aureus), Klebsiella pneumoniae (K. pneumoniae), Acinetobacter baumannii (A. baumannii), Pseudomonas aeruginosa (P. aeruginosa) and Enterobacter spp. as “ESKAPE” organisms, which pose the highest threat to human lives, owing to their fast-growing antibiotic resistance [6]. The WHO has published an antibiotic-resistant “priority pathogen” list to help drug developers target the pathogens that urgently need novel antibiotics. AMR has also become a public health concern in China. According to data from the Chinese Antimicrobial Surveillance Network, the resistance rate of carbapenem-resistant Gram-negative bacteria has shown a significant increase. Notably, carbapenem-resistant A. baumannii has risen from 39.0 to 71.9%, while carbapenem-resistant K. pneumonia has surged from 2.9 to 24.2% from 2005 to 2022 [7]. Additionally, methicillin-resistant S. aureus has been consistently detected at a high rate of approximately 30% in recent years (www.chinets.com) [7]. The number of novel antibiotics developed and approved has gradually decreased over the past decade, with only 4 novel antibiotics approved between 2010 and 2014 [8], resulting in limited treatment options for antibiotic-resistant bacterial infections in clinics. Historically, antibiotics were mostly discovered by screening secondary metabolites with antibacterial activities from soil microbes [9]. Unfortunately, the discovery of novel antibiotics is becoming increasingly difficult due to the rediscovery problem where identical compounds were isolated repeatedly [10]. **Thus, new drug development is insufficient to meet the demands of clinical treatment**, especially for those pathogens on the WHO priority list. Artificial intelligence (AI), a field of computer science, refers to the development of intelligent machines capable of executing tasks typically requiring human-like intelligence in an objective fashion [11]. AI technologies present innovative approaches and have increasingly integrated into a wide range of disciplines to accelerate scientific discoveries, especially in medicine where AI has empowered the discovery of novel drugs and expedited the overall drug development and clinical research process [12,13,14]. Without exceptions, AI has constituted a central part of concerted interdisciplinary efforts to tackle the crisis of AMR [15]. In this review, we will discuss the progress and challenges of antibacterial drugs in clinical and preclinical development, as well as novel AI-based methodologies in antibacterial drug development, with a particular focus on new drug design, structure optimization, and exploration of new mechanisms of action (MOA).

#### GAI has been used by Stanford researchers to develop drugs against AMR.

Rachel **Tompa**, 3-28-20**24**, Rachel Tompa is an award-winning science and health writer, editor, and podcaster. A molecular biologist turned writer, she's been telling science stories since 2007, "Generative AI develops potential new drugs for antibiotic-resistant bacteria", News Center, <https://med.stanford.edu/news/all-news/2024/03/ai-drug-development.html> // DOA: 2/4/24 AT

With nearly 5 million deaths linked to antibiotic resistance globally every year, new ways to combat resistant bacterial strains are urgently needed. **Researchers at Stanford Medicine and McMaster University** are tackling this problem with **generative artificial intelligence. A new model, dubbed SyntheMol** (for synthesizing molecules), **created structures and chemical recipes for six novel drugs aimed at killing resistant strains of Acinetobacter baumannii**, **one of the leading pathogens responsible for antibacterial resistance-related deaths**. The researchers described their model and experimental validation of these new compounds in a study published March 22 in the journal Nature Machine Intelligence. "There's a huge public health need to develop new antibiotics quickly," said James Zou, PhD, an associate professor of biomedical data science and co-senior author on the study. "Our hypothesis was that there are a lot of potential molecules out there that could be effective drugs, but we haven't made or tested them yet. That's why we wanted to use AI to design entirely new molecules that have never been seen in nature." Before the advent of generative AI, the same type of artificial intelligence technology that underlies large language models like ChatGPT, researchers had taken different computational approaches to antibiotic development. They used algorithms to scroll through existing drug libraries, identifying those compounds most likely to act against a given pathogen. This technique, which sifted through 100 million known compounds, yielded results but just scratched the surface in finding all the chemical compounds that could have antibacterial properties. testKyle Swanson "Chemical space is gigantic," said Kyle Swanson, a Stanford computational science doctoral student and co-lead author on the study. "People have estimated that there are close to 1060 possible drug-like molecules. So, 100 million is nowhere close to covering that entire space." Hallucinating for drug development Generative AI's tendency to "hallucinate," or make up responses out of whole cloth, could be a boon when it comes to drug discovery, but previous attempts to generate new drugs with this kind of AI resulted in compounds that would be impossible to make in the real world, Swanson said. The researchers needed to put guardrails around SyntheMol's activity - namely, to ensure that any molecules the model dreamed up could be synthesized in a lab. "We've approached this problem by trying to bridge that gap between computational work and wet lab validation," Swanson said. The model was trained to construct potential drugs using a library of more than 130,000 molecular building blocks and a set of validated chemical reactions. **It generated not only the final compound but also the steps it took with those building blocks, giving the researchers a set of recipes to produce the drugs.** The researchers also trained the model on existing data of different chemicals' antibacterial activity against A. baumannii. **With these guidelines and its building block starting set, SyntheMol generated around 25,000 possible antibiotics and the recipes to make them in less than nine hours.** **To prevent the bacteria from quickly developing resistance to the new compounds, researchers then filtered the generated compounds to only those that were dissimilar from existing compounds.** testJames Zou "Now we have not just entirely new molecules but also explicit instructions for how to make those molecules," Zou said. A new chemical space The researchers chose the 70 compounds with the highest potential to kill the bacterium and worked with the Ukrainian chemical company Enamine to synthesize them. **The company was able to efficiently generate 58 of these compounds, six of which killed a resistant strain of A. baumannii when researchers tested them in the lab**. These new compounds also showed antibacterial activity against other kinds of infectious bacteria prone to antibiotic resistance, including E. coli, Klebsiella pneumoniae and MRSA. The scientists were able to further test two of the six compounds for toxicity in mice, as the other four didn't dissolve in water. The two they tested seemed safe; the next step is to test the drugs in mice infected with A. baumannii to see if they work in a living body, Zou said. The six compounds are vastly different from each other and from existing antibiotics. The researchers don't know how their antibacterial properties work at the molecular level, **but exploring those details could yield general principles relevant to other antibiotic development.** "This AI is really designing and teaching us about this entirely new part of the chemical space that humans just haven't explored before," Zou said. **Zou and Swanson are also refining SyntheMol and broadening its reach. They're collaborating with other research groups to use the model for drug discovery for heart disease and to create new fluorescent molecules for laboratory research.** The study was funded by the Weston Family Foundation, the David Braley Centre for Antibiotic Discovery, the Canadian Institutes of Health Research, M. and M. Heersink, the Chan-Zuckerberg Biohub, and the Knight-Hennessy scholarship.

#### In medical research it can prevent resistance in the first place

[Francesco **Branda**](https://pubmed.ncbi.nlm.nih.gov/?term=%22Branda%20F%22%5BAuthor%5D) **and** [Fabio **Scarpa**](https://pubmed.ncbi.nlm.nih.gov/?term=%22Scarpa%20F%22%5BAuthor%5D), 5-29-20**24**, PhD in Information and Communication Technologies, 2023University of Calabria M.Sc. in Computer Engineering, 2019 University of Calabria B.Sc. in Computer Engineering, 2016 University of Calabria,"Implications of Artificial Intelligence in Addressing Antimicrobial Resistance: Innovations, Global Challenges, and Healthcare’s Future", PubMed Central (PMC), <https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/> doa:3/6/25 as

8. Discussion Antimicrobial resistance represents one of the greatest threats to global public health. This complex phenomenon is due to a combination of biological factors intrinsic to bacteria, such as genetic mutation, as well as external factors related to the misuse of antibiotics in medical, veterinary, and agricultural settings. The rapid and adaptive evolution of pathogens requires a multidisciplinary approach to effectively counter this crisis. The integration of AI in the fight against antimicrobial resistance presents a promising and innovative solution. AI can contribute significantly in several areas: 1. Genomic analysis: AI can accelerate the analysis of genomic data to identify resistance markers early on, thereby improving surveillance and monitoring of resistant infections. This enables timely and targeted interventions. For example, the use of machine learning algorithms to analyze genomic sequences can help to quickly identify specific mutations associated with antibiotic resistance. Such tools can be integrated into clinical microbiology laboratories to provide faster results than traditional methods, allowing clinicians to intervene earlier. 2. Optimizing antibiotic use: AI-based decision support systems can guide clinicians in choosing the most appropriate antibiotics, reducing inappropriate use and minimizing the risk of resistance development. This can significantly improve clinical management of infections. For example, the implementation of a CDSS can help to analyze real-time patient data and microbiological information in order to suggest the most effective therapies while taking into account clinical history and local patterns of resistance. In addition, such systems can be continuously updated with newly collected data to improve their recommendations over time. 3. Discovery of new antibacterial agents: AI facilitates the discovery and design of new antibacterial drugs through predictive modeling and computational simulation, accelerating the drug development process and potentially reducing associated costs. Using deep learning techniques, large libraries of chemical compounds can be analyzed to identify those with potential antibacterial activity. These approaches can also predict the likelihood of success of new drugs at later stages of development, thereby reducing the risks and costs associated with pharmaceutical research and development. 4. AI-controlled delivery and action of antibiotics: AI technologies are increasingly being used to improve the delivery and efficacy of antibiotics. These advanced systems can optimize dosing regimens, improve drug targeting, and monitor patient responses in real time. Significant examples of antibiotics for which administration and action have been successfully managed by artificial intelligence systems include: - Optimizing vancomycin dosing with AI: Vancomycin is a key antibiotic for the treatment of serious infections caused by Gram-positive bacteria, including methicillin-resistant Staphylococcus aureus (MRSA). Traditional vancomycin dosing requires careful monitoring to avoid toxicity and ensure therapeutic efficacy. Several studies have shown how AI models can optimize vancomycin dosing to improve efficacy and reduce the risk of toxicity. For example, an approach based on ensemble learning strategies has shown high accuracy and specificity in predicting initial and subsequent doses of vancomycin, making treatment safer and more effective [[63](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B63-antibiotics-13-00502),[64](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B64-antibiotics-13-00502)]. - AI-driven delivery of amikacin: Amikacin, an aminoglycoside antibiotic, is commonly used to treat severe Gram-negative infections. Its therapeutic window is narrow and requires precise dosing to avoid ototoxicity and nephrotoxicity. Artificial intelligence systems have been developed to monitor blood levels of amikacin in real time and adjust dosing accordingly. These artificial intelligence-driven delivery systems use pharmacokinetic and pharmacodynamic models to ensure that optimal drug concentrations are maintained, thereby improving treatment efficacy and safety. For example, Adbulla et al. [[65](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B65-antibiotics-13-00502)] conducted a prospective evaluation of a model-based amikacin dosing regimen in infants which showed significant improvements in achieving target drug concentrations compared with traditional methods. Similarly, advances in biosensor technology have enabled real-time monitoring and dose adjustment of antibiotics such as amikacin, leading to improved outcomes in the treatment of critically ill patients [[66](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B66-antibiotics-13-00502),[67](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B67-antibiotics-13-00502)]. - AI-driven targeted delivery of colistin: Colistin is an antibiotic of last resort for multidrug-resistant Gram-negative bacterial infections; however, its use is limited by significant nephrotoxicity. Researchers have employed artificial intelligence to develop targeted colistin delivery systems, such as nanoparticle-based delivery vehicles, that can be targeted to the site of infection. Artificial intelligence algorithms can optimize the design and release profiles of these nanoparticles to maximize therapeutic effects and minimize systemic toxicity. Early studies indicate that AI-guided targeted delivery significantly reduces adverse effects and improves treatment outcomes. For example, silver nanoparticles conjugated to colistin (Col-AgNPs) have shown enhanced antimicrobial activity and reduced toxicity compared to colistin alone, demonstrating the potential of AI-optimized nanoparticle systems for improving the colistin therapeutic index [[68](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B68-antibiotics-13-00502)]. - AI-personalized antibiotic regimens: AI can help to personalize antibiotic regimens by analyzing large amounts of patient data, including genetic information, aiding in the prediction of individual responses to different antibiotics. For example, Zagajewski et al. [[69](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B69-antibiotics-13-00502)] have demonstrated the use of AI to detect antibiotic resistance and tailor treatments accordingly. This study highlighted rapid detection capabilities and the potential for personalized antibiotic regimens, particularly with ciprofloxacin, showcasing how AI can revolutionize treatment strategies to combat antibiotic resistance. Weaver et al. [[70](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B70-antibiotics-13-00502)] focused on using reinforcement learning to develop optimal treatment strategies that limit antibiotic resistance. Personalized approaches for various antibiotics, including ciprofloxacin and azithromycin, formed part of their research. A study on personalized dosing of antibiotics at the bedside for severe sepsis and septic shock included ciprofloxacin among the tested antibiotics. Artificial intelligence systems based on pharmacokinetic models were used to optimize dosing, demonstrating potential for improved efficacy and safety in antibiotic administration [[71](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B71-antibiotics-13-00502)]. Despite significant progress, there are still critical challenges facing the effective implementation of AI in the fight against AMR. One major challenge is the availability of high-quality, properly annotated, and standardized data. In order to develop accurate and reliable machine learning models, it is critical to have large amounts of data representing a wide range of clinical and biological scenarios. However, data from different sources often vary in terms of format, annotation, and quality. This heterogeneity can compromise the performance and generalizability of AI models. Standardizing data and creating centralized repositories with high-quality data are key steps towards improving the effectiveness of AI algorithms in the medical field. Another significant obstacle is ensuring the interpretability and transparency of AI models. Many machine learning algorithms, particularly those based on deep neural networks, are often described as black boxes, as their decisions are difficult to understand and explain. This lack of transparency can create mistrust among healthcare providers and patients, hindering large-scale adoption of these technologies. It is essential that researchers and AI developers adopt explainability practices, such as using interpretable models and implementing post hoc interpretation techniques, to make their algorithms more transparent. Techniques such as LIME (Local Interpretable Model-agnostic Explanations) and SHAP (SHapley Additive exPlanations) [[72](https://pmc.ncbi.nlm.nih.gov/articles/PMC11200959/#B72-antibiotics-13-00502)] can help to explain the predictions of complex models by providing insights into which features most influenced a particular decision. In addition, transparency is critical to ensure that AI models are used ethically and responsibly. Algorithms must be designed to avoid bias and discrimination, which can occur if the training data are not representative of the population or contain bias. Ongoing evaluation and independent validation of AI models are necessary to ensure that they work properly in different populations and clinical settings. Finally, it is important to consider the regulatory and legal aspects of AI use in healthcare. Regulators need to establish clear guidelines for the approval and oversight of AI systems to ensure that they meet standards of safety, efficacy, and privacy. Collaboration among AI developers, healthcare providers, and regulators is essential in order to create an environment of trust and security that facilitates the adoption of AI technologies in the fight against AMR. Looking forward, the integration of AI with other emerging technologies, such as synthetic biology and nanomedicine, could open up new perspectives in the fight against antimicrobial resistance. For example, AI-based intelligent drug delivery systems could improve the efficacy of antibiotic treatments while reducing the risk of side effects and the development of resistance. In addition, the application of AI to computational epidemiology and predictive modeling could make it possible to anticipate the emergence of new forms of resistance, thereby promoting large-scale prevention and containment strategies. International collaboration is essential to addressing the global challenges of antimicrobial resistance. Sharing data, resources, and knowledge across institutions and countries can improve the effectiveness of AI-based interventions and accelerate progress in combating AMR. In this context, global initiatives such as establishing research consortia and promoting international standards for data collection and analysis can play a key role in overcoming both current and future challenges.

#### AMR causes extinction

**Silverman ’16** (Rachel Silverman – MPhil with Distinction in Public Health @ the University of Cambridge, Senior Policy Analyst and Assistant Director of Global Health Policy @ the Center for Global Development, focusing on global health financing and incentive structures, “Confronting Antimicrobial Resistance: Can We Get to Collective Action?” 19 April 2016, )<https://www.cgdev.org/blog/confronting-antimicrobial-resistance-can-we-get-collective-action> //doa 02/11/25 AT

Antimicrobial resistance is already causing huge harm – and the worst is yet to come. To open the panel, Dr. Chan issued a serious warning about the size and scope of the AMR threat: “everyone will be affected if we do not address this problem.” AMR is already responsible for an estimated **700,000** **global** **deaths each year**, 50,000 of which take place in the US and Europe. Extensively drug-resistant (XDR) tuberculosis—cases where the most effective first- and second-line drugs are rendered useless—infected an estimated 47,000 people worldwide in 2014, only one ‘last-line’ antimicrobial is available to reliably treat gonorrhea, and few new antimicrobial drugs are in the development pipeline. According to the latest review, **AMR could cause 10 million** **deaths** **each year by 2050**, with **knock-on effects** draining many **trillions from the** **global** **economy**. Summers suggested that AMR and potential pandemics, alongside climate change and nuclear proliferation, represent the top three **existential threats to life on earth** as we know it. And as Dr. Chan explained, the worst-case scenario implies **the end of modern medicine** as we know it. Even worse, Summers suggested that AMR seems like a “**quintessential** **non-linear** **phenomenon**, and therefore more dangerous.” Year by year the effects are small and **mostly** **invisible**. But at some point in the future they could **suddenly become catastrophic**, like a “levee that doesn’t hold and unleashes a flood.” Dr. Chan concurred that “**the tipping point is not predictable** because…microbes are invisible. We don’t even know when they’re going to make the switch” to become resistant to existing drugs. Antimicrobial efficacy is a global public good threatened by serious market failures. In response to this huge threat, why don’t pharmaceutical companies invest in new antibiotics? “It does not pay” for them to do so, explained Osborne. Pharmaceutical companies want to invest in technologies that will make a lot of money, and soon; so long **as other** antibiotic**s** **remain** effective, the market for new options will be tiny and unprofitable.

#### AMR is an existential risk multiplier

Maxine **Builder 14**, Research Associate for the Council on Foreign Relations' Global Health Program, “Antimicrobial Resistance as an Emerging Threat to National Security,” The Atlantic Council, December 2014, https://www.atlanticcouncil.org/images/files/Antimicrobial\_Resistance\_as\_an\_Emerging\_Threat\_to\_National\_Security.pdf

At this point, AMR does not pose an immediate and direct threat to national security, but without an **effective and swift response** to the growing problem of AMR, the situation will continue to **deteriorate on a global scale**. This is a **creeping national security crisis**, and underestimates of the problem now may lead to **disaster in the near future**. If current trends continue, the drugs will lose effectiveness. The gains made in fighting infectious diseases **will be reversed,** and a wide range of routine surgeries and easily treatable infections will become much more dangerous and deadly. This will cause the **health of the world’s working population** to **deteriorate** and the **economic productivity** and social cohesion of the globe **to decline**. At any time**,** **a “black swan**” event, triggered by an outbreak of drug-resistant tuberculosis, cholera, or pneumonia, for example, could **prove catastrophic**, endangering the **fabric of societies** and our **globalized economy**, **forcing a halt to international trade** and travel to prevent further spread.As demonstrated by the rapid spread of NDM-1, current trends of international trade and travel are **exacerbating the spread of resistance**, and conflict and displacement of populations only hasten the process. The current conflict in Syria has caused the displacement of millions of people, and preventable communicable diseases, such as cholera and even polio, have run rampant in these populations, crossing borders quickly and often unnoticed. These diseases are neither being treated nor prevented because of a lack of resources and access to proper drugs, in spite of the technical ability to prevent and effectively treat these diseases. If the diseases circulating in these refugee communities become drug-resistant, it could lead to even **higher mortality rates** among this **already vulnerable population**, and it is more than likely that these resistant genes and strains will appear **in the broader population**, at which point the issue becomes more than one of public health, but **also one of development** **and foreign affairs.**Concern about the threat of AMR to US national security has lead the US Department of Health and Human Services (HHS) to fund development of a new drug to address two antibiotic-resistant infections linked to **bioterrorism threats**. HHS announced in February 2014 that a publicprivate partnership will advance the development of Carbavance, a new option to treat bioterrorism threats and antibiotic-resistant infections. Carbavance will address melioidosis, also known as Whitmore’s disease, and glanders–both of which are bacterial infections and can therefore become resistant to existing antibiotics. Already, approximately **40 percent** of people who contract these bacteria **will die**, and **up to 90 percent** of those infected **will die** **if not treated.** “Antibiotic resistance **adversely impacts** our nation’s ability to **respond effectively to a bioterrorism attack** and to everyday public health threats,” said Dr. Robin Robinson, director of the Office of the Assistant for Preparedness and Response’s Biomedical Advanced Research Development Authority, which will oversee the project. “By partnering with industry to develop novel antimicrobial drugs against biothreats that also treat drug-resistant bacteria, we can address health security and public health needs efficiently.”67

# Rebuttal

## AT: LLMs

#### 1] NL -- Their ev. isnt about biz investment specifically in GAI-- the topical link to the impact is incoherent. [we read green]

**Hicks-19** [Alex Hicks, 6-19-2019, [B.B.A. @ University of Iowa, SVP @ US Bank],“Why impact investors love the education sector”, Mergers & Acquisitions, https://www.themiddlemarket.com/opinion/why-impact-investors-love-the-education-sector //DS]

Up to now, the education sector has made up a relatively small part of the impact investing pie. The Global Impact Investing Network estimates that only 4 percent of the half a trillion dollars in total impact investments is devoted to education, far behind financial services and energy. That small share, perhaps, has to do with the perceived complexities of the education sector, the traditional dominance of government in this area, and the difficulty of measuring outcomes precisely. But there are signs that **the market is changing as** some **big impact investment players warm to the education sector.** Several **recent developments and deals have highlighted this trend**, suggesting it has the potential to become a theme for mid-market funds as well as the bigger players. ● Bain Capital’s $390 million Double Impact fund last year led a group of investors that purchased online education provider Penn Foster. Penn Foster, which focuses on providing post high-school skills training, then went on to acquire online institution Ashworth College this February. ● U.S. private equity firm TPG Capital’s $2 billion Rise Fund announced last year it was investing $130 million to take a majority stake in DreamBox, a K-8 educational technology company used by nearly 3 million students in the United States, Canada, and Mexico. ● KKR announced last year it was jumping on the impact investing bandwagon. With its new fund aiming for deals around the $50-$75 million range and with investment themes tied to the United Nations’ Sustainable Development goals, the education sector can be expected to benefit. Largely the prior realm of large foundations, non-profits and governments, these **recent transactions show that big funds are starting to wake up to the unlocked potential in the education sector**, both **in the United States and globally.** They are now **willing to consider putting hundreds of millions of dollars to work** in the sector, **rather than the tens of millions** previously. Much room for growth **Several factors are driving this trend,** which should **make the education sector an attractive target for impact investors** and mid-market PE firms in the coming years. First, there is a sense that education is not working around the world, **creating a clear need for private-sector dollars to make up for a global shortfall in education** **investment.** Even as global demand for access to quality education has grown, governments have failed to keep pace with the necessary investment in schools and colleges. Education systems in many rich countries have struggled due to public spending cuts and soaring prices for higher education. Total spending on education will need to go from $1.2 trillion per year in 2016 to $3 trillion by 2030 across all low- and middle-income countries in order to meet the U.N. Sustainable Development goals for education, according to the International Commission for Financing Global Education. Second, **technological advances have revolutionized the way in which education can be designed** and delivered. Rather than building and running bricks-and-mortar schools, **modern education firms are more likely to be focused on improving students’ access to learning through software platforms, online classes, and support.** This **has reduced** some of **the old complexity and costs of education investing, making it a more attractive proposition.** One successful example of this is Bridge International Academies, which has rolled out its “academy in a box” program to cover nearly 100,000 students in several African countries. It has attracted funding from venture capital investors like LearnCapital and Rethink Education as well as impact investors Omidyar Network and CDC. Lastly, there is the supply side of the equation. U.S. private equity is sitting on about $2 trillion in dry-powder funds, according to Bain Capital and facing a diminishing range of things to do with it. With so much money chasing relatively few opportunities, **investors are taking a closer look at alternative investments and are willing to accept more modest returns.** Returns are not everything These days, an IRR of 15-20 percent is seen as acceptable, which brings many education investment opportunities into range over a seven-year time frame. For PE firms, **buying impact assets in education** and other sectors **has also become an attractive way to boost their image**, **differentiate themselves, and attract investors** who are increasingly **interested in being benevolent** as well as generate investment returns. All levels of education are set to benefit from this trend, but perhaps the most promising in the medium term is the field of corporate training and professional development. This is where a lot of U.S. ed tech investment has been focused recently in an effort to address a growing skills gap in the workforce between high school, college, and the workplace. Bain’s purchase of Penn Foster and its subsequent acquisition of Ashworth College are among those that are squarely focused on this theme.

### !

#### 1] no i/l for why terrorists rn can’t get weapons

**Egan-23** [Janet Egan, 11-6-2023, [B.A. Philosophy & German Studies @ Monash University, M.A. Public Policy @ Harvard University, Senior Fellow @ CNAS, DAAD Scholarship Winner - 2014], "Biosecurity in the Age of AI: What’s the Risk?", Belfer Center. https://www.belfercenter.org/publication/biosecurity-age-ai-whats-risk] AB

“**The** **biggest** **issue** with **AI** is **actually** **going** to **be** … **its** **use** in **biological** **conflict**,” **according** to **former** **Google** **CEO**, **Eric** **Schmidt**.[1] And **he’s** **not** **the** **only** AI **expert** **worried**. In **his** **testimony** **before** the **Senate** **Judiciary** **Committee** **Subcommittee** on **Privacy**, **Technology**, and the **Law**, the **CEO** of **Anthropic**, **Dario** **Amodei**, **warned** that in **just** **two** to **three** **years**, **AI** **has** the **potential** **to** “**greatly** **widen** the **range** of **actors** **with** the **technical** **capability** to **conduct** a **large**-**scale** **biological** **attack**.”[2] OpenAI’s Sam Altman has called for regulation on AI models “that could help create novel biological agents.”[3]President Biden’s recent Executive Order on Safe, Secure and Trustworthy Development and Use of Artificial Intelligence explicitly tasks relevant agencies with assessing the ways in which AI can increase, and potentially help mitigate, biosecurity risks.[4]But what exactly has experts and officials so worried? The deliberate use of microorganisms like viruses or bacteria to cause disease or death[5] has a long and terrible history: Japan weaponized typhus and cholera in World War II,[6] and the Soviet Union’s bioweapon program throughout the Cold War included producing and stockpiling smallpox, anthrax, and drug-resistant plague.[7] The United States also developed its own bioweapon program in this period, including anthrax and Q-fever, until it was terminated by President Nixon in 1969.[8] Today, the Centers for Disease Control warns that the bacteria that causes anthrax is one of the most likely agents to be used in a biological attack.[9] To date, the development, containment, and deployment of such weapons have required significant resourcing and expertise.[10] This does not mean such weapons have only been accessible to nation-states, but it has ensured that only a limited number of actors have had the capability to develop them. AI experts are concerned that highly capable AI models could assist non-experts in designing, synthesizing, and using these weapons, thus expanding the pool of actors that could access these dangerous capabilities. Concerns are increasingly centered around future capabilities, rather than those of the present day. **MIT** **students** **recently** **demonstrated** how **large** **language** **model** (**LLM**) **chatbots** **could** be **used** **to** **help** **non-experts** **understand** the **process** of **manufacturing** **risky** **pathogens**.[11] **Within** **one** **hour**, **students** without **science** **backgrounds** had **used** the **chatbots** to **list** **four** **viruses** **capable** of **causing** a **pandemic**, **identify** **reverse** **genetics** as a **means** to **manufacture** **them** and **suggest** **acquisition** **methods** that **could** **help** **bypass** **misuse** **screening**.[12] But in this and other experiments, such as a recent report by RAND, LLMs have not yet generated explicit, directly actionable instructions on how to create bioweapons, and it is not clear that today’s LLMs offer significant advantages over what can already be gleaned from the internet.[13] **In** **the** **future**, more **advanced** **AI** **capabilities** **may** **cause** **greater** **concern**, as **LLMs** **increasingly** **enable** the **synthesis** and **production** of **sophisticated** and **accurate** **insights** at an **expert** **level**.[14] Even less advanced models, when focused on biological data, might give rise to biological risks. In 2022, an experiment revealed how AI used in pharmaceutical design could be tweaked to design highly toxic chemicals instead.[15] **As** **AI** **models** are **increasingly** **trained** and **deployed** to **aid** **research** in **areas** like **pathogens** and **cancers**, **they** may **have** **the** **potential** to be **similarly** **co**-**opted** to **design** **new** and **more** **harmful** **pathogens**. Given the potentially catastrophic impacts of biological agents, it will be necessary for AI, biology, and broader experts to collaborate on better understanding these risks.

**No risk of bioterror**

**Blum and Neumann 20** Marc-Michael Blum and Peter Neumann, Marc-Michael Blum is a former Head of Laboratory at the Organisation for the Prohibition of Chemical Weapons. He holds a PhD in Biochemistry from the University of Frankfurt. Peter Neumann is Professor of Security Studies at King’s College London, and served as Director of its International Centre for the Study of Radicalisation from 2008-18., 6-22-2020, "Corona and Bioterrorism: How Serious Is the Threat? ," War on the Rocks, <https://warontherocks.com/2020/06/corona-and-bioterrorism-how-serious-is-the-threat/> // ella [brackets in original article] [correction of the article says the hamster survived the Islamic State’s ricin bioterror attempt]

The novel coronavirus pandemic has put the threat of bioterrorism back in the spotlight. White supremacist chat rooms are teeming with talk about “biological warfare.” ISIL even called the virus “one of Allah’s soldiers” because of its devastating effect on Western countries. According to a recent memo by the U.S. Department of Homeland Security, terrorists are “[making] bioterrorism a popular topic among themselves.” Both the United Nations and the Council of Europe have warned of bioterrorist attacks. **How serious is the threat**? There is a **long history of terrorists being fascinated by biological weapons,**but it**is also one of failures**. For the vast majority, **the tech**nical **challenges associated with weaponizing biological agents have proven insurmountable**. The only reason this could change is if terrorists were to receive support from a state. Rather than panic about terrorists engaging in biological warfare, governments should be vigilant, secure their own facilities, and focus on strengthening international diplomacy. A History of Failures Biological warfare, which uses organisms and pathogens to cause disease, is nearly as old as war itself. The first known use of biological agents as a weapon dates back to 600 B.C., when an ancient Greek leader poisoned his enemies’ water supply. Throughout the Middle Ages, especially during the time of the Black Death, it was common to hurl infected corpses into besieged cities. And during the two world wars, all major powers maintained biological weapons programs (although only Japan used them in combat). **Among terrorists, however, the use of biological weapons has been rarer**, although groups from nearly all ideological persuasions have contemplated it. Recent examples include a plot to contaminate Chicago’s water supply in the 1970s; food poisoning by a religious cult in Oregon in the 1980s; and the stockpiling of ricin by members of the Minnesota Patriot Council during the 1990s. **No one died in any of these instances.**The same is true for the biological warfare programs of al-Qaeda and the Islamic State group. Both groups have sought to buy, steal, or develop biological agents. For al-Qaeda, this seems to have been a priority in the 1990s, when its program was overseen by (then) deputy leader Ayman al-Zawahiri, a trained physician. With the Islamic State, evidence dates back to 2014, when Iraqi forces discovered thousands of files related to biological warfare on a detainee’s laptop. **Yet none of these efforts succeeded.** The **only al-Qaeda plot in which bioterrorism featured prominently** — the so-called “ricin plot” in England in 2002 — was **interrupted at such an early stage that none of the toxin had actually been produced**. The Islamic State’s most serious attempt, in 2017, involved a small amount of ricin, whose only fatality was the hamster on which it was tested. **Of the tens of thousands of people that jihadists have murdered, not a single one has died**

#### Pref actor analysis

## AT: Regulation

#### 1] investor confidence is high – Shaik 24 – microsoft, google are going to invest & want regulations, they want the best checked data to train their models

#### 2] DL – state regs

Marshall C. **Romaine**, **2-25**-2025, "Some States Step Up Early to Regulate AI Risk Management", National Law Review, <https://natlawreview.com/article/some-states-step-early-regulate-ai-risk-management> [Brigham Young University, J. Reuben Clark Law School (J.D.) Waikato University School of Law, New Zealand Visiting Law Student Brigham Young University (B.S.)] DOA: 3/6/2025 //RRM

Key Takeaways A global AI arms race may mean U.S. states are best positioned to regulate AI’s risks. Colorado and Utah have enacted legislation for how AI is to be used with consumers. Other states are emphasizing existing laws they say “have roles to play” in regulating AI. In the span of one month, an executive order issued in 2023 focusing on artificial intelligence (AI) safety and security was repealed and replaced by an executive order focusing on the U.S. being the global leader in AI innovation, while in the EU a liability directive developed in 2022 was abandoned in favor of a bolder, simpler and faster 2025 Commission work program, with an “ambition to boost competitiveness.” A ‘move fast and break things’ approach to an emerging technology arms race often has drawbacks. For example, the recent rise of DeepSeek provided a glimpse into what was previously unimaginable: an open-source large language model useful for a wide range of purposes, that’s fast, cheap and scalable. But within days it was hacked, sued and discredited. **While nations battle for AI supremacy by “removing barriers” and loosening regulations, in the U.S. last year, 45 states introduced AI bills, and 31 states adopted resolutions or enacted legislation.** Overall, hundreds of bills in 23 different AI-related categories have been considered. Two states standout, Colorado and Utah, for their focus on consumer protection. Colorado’s AI Act The Colorado Artificial Intelligence Act (CAIA), which goes into effect on February 1, 2026, applies to developers and deployers of high-risk AI systems. A developer is an entity or individual that develops or intentionally and substantially modifies a high-risk AI system, and a deployer is an individual or entity that deploys a high-

## AT: Finances

#### 2] Burke is terrible—concedes the ones doing research are adapting—7L is blue

**1AC Burke-25** [Lilah Burke, 1-2-2025, (Fmr. Reporter @ Inside Higher Ed, News Intern @ Bloomberg Law, B.S. in Foreign Service @ Georgetown, M.A. in Journalism @ CUNY), “Why more colleges are embracing AI offerings,” Higher Ed Drive.

https://www.highereddive.com/news/colleges-artificial-intelligence-programs-investments/736196/ DOA: 2/25/2025] //vy

Despite the growing interest in the emerging technology, **investing** in **AI**-related programming is **often difficult**. For one, depending on the level and focus, it **can be expensive**. **AI curricula** can **require colleges** to **hire qualified faculty** and **staff** and **pay** for **significant computing power**.

That’s why many of the institutions that are investing in AI, such as Carnegie Mellon University and Massachusetts Institute of Technology, are well-resourced with large endowments, Koslosky said.

Other institutions are pursuing partnerships with industry to make their goals possible. University of Florida, for instance, has a partnership with chipmaker Nvidia, which includes a $50 million gift from the company and one of its cofounders. Arizona State University is partnering with OpenAI, to provide enterprise subscriptions to ChatGPT for approved faculty and staff.

Stony Brook University, part of the State University of New York system, recently expanded an AI institute into [a universitywide initiative](https://news.stonybrook.edu/university/stony-brook-university-launches-ai-innovation-institute/), which will focus on research and applications in healthcare, infrastructure, education and finance. The university is investing about $15 million, which includes support from Empire AI, a college research consortium focused on AI and heavily funded by the state.

Stony Brook Provost Carl Lejuez said that “$15 million is nothing and a lot of money all at the same time.”

“We’re seeing companies **struggle** with this **immensely because** they’re **having to make decisions** about — are they **going to fall behind so far** that they’re **not going to be able to compete**?” Lejuez added. “But in the **meantime** they’re **spending millions** and in **some cases billions** in cases where they’re not generating real revenue yet.”

Whether an **investment** in **AI programming** is right for an institution will likely depend on its circumstances, including its resources, faculty, mission and connections to industry.

“If you’re a major research university, you’re going to be really far behind if you are not investing in this,” Lejuez said. “For research **universities**, it’s an absolute necessity.”

For other institutions though, a **big AI investment** might be **riskier**.

“If your school doesn’t have a huge computer science department and doesn’t have a lot of industry connections to companies using AI or building AI, then you shouldn’t drop everything to stand up a brand new AI program right now,” Koslosky said.

**Additionally**, **investments** in **AI** are **so far untested**. Although many business leaders believe AI is going to change the American workforce, that transformation hasn’t fully come to pass. Although current research predicts the number of AI jobs trending upwards, what those jobs look like might change. That means that trying to integrate AI into other disciplines is the financially safer approach, Koslosky said.

“**Schools** are **struggling** with **lots of things** and **balancing competing priorities**,” he said. “AI is important and will continue to be, but it’s not the only important thing.”

#### 5] T: Ahmad flows aff—AI is key to endowment management especially when markets fluctuate! 7L in blue

**1AC Ahmad-24** (Zaki Ahmad, 12-12-2024, (Researcher @ Univesriti Utara Malaysia, PhD in Finance and Banking @ UUM), “Exploring the Potential of Artificial Intelligence in the Endowment Management and Investment,” American Journal of Economic and Management Business.

https://ajemb.us/index.php/gp/article/view/150/228 DOA: 3/3/2025] //vy

**Endowment management** **involves** the **strategic stewardship** of **financial assets** or **funds permanently set aside** to **ensure long-term financial stability** for nonprofit organizations, **educational institutions**, and charitable foundations (Bryce, 2017). These **funds** are **invested strategically** to **generate sustainable income** while **preserving** the **principal amount**. Investments, as a broader concept, entail allocating financial resources across various assets-such as stocks, bonds, real estate, or mutual funds-with the aim of generating returns, income, or capital appreciation. **Within endowment management, investments** **play** a **pivotal role** in maintaining the value of **endowments** while **producing income** to **support** the **organization's ongoing activities** and **objectives** (Madanchi et al., 2017).

**Globally**, the **rising complexity** of **financial markets** has **intensified** the **need** for **innovative tools** and **strategies** in **investment management**. According to recent statistics, Al-driven technologies are increasingly being adopted in financial sectors, with projections showing that the global Al market in finance will exceed $50 billion by 2030. This trend underscores the urgency to explore Al applications in **niche areas**, such as **endowment management**, where **research remains relatively limited** (Chui & Francisco, 2017).