



Brave New World: Promise & Perils of Generative AI in Infectious Diseases

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Disclosures

- I am not a technical expert
- All images are AI generated (unless indicated otherwise)



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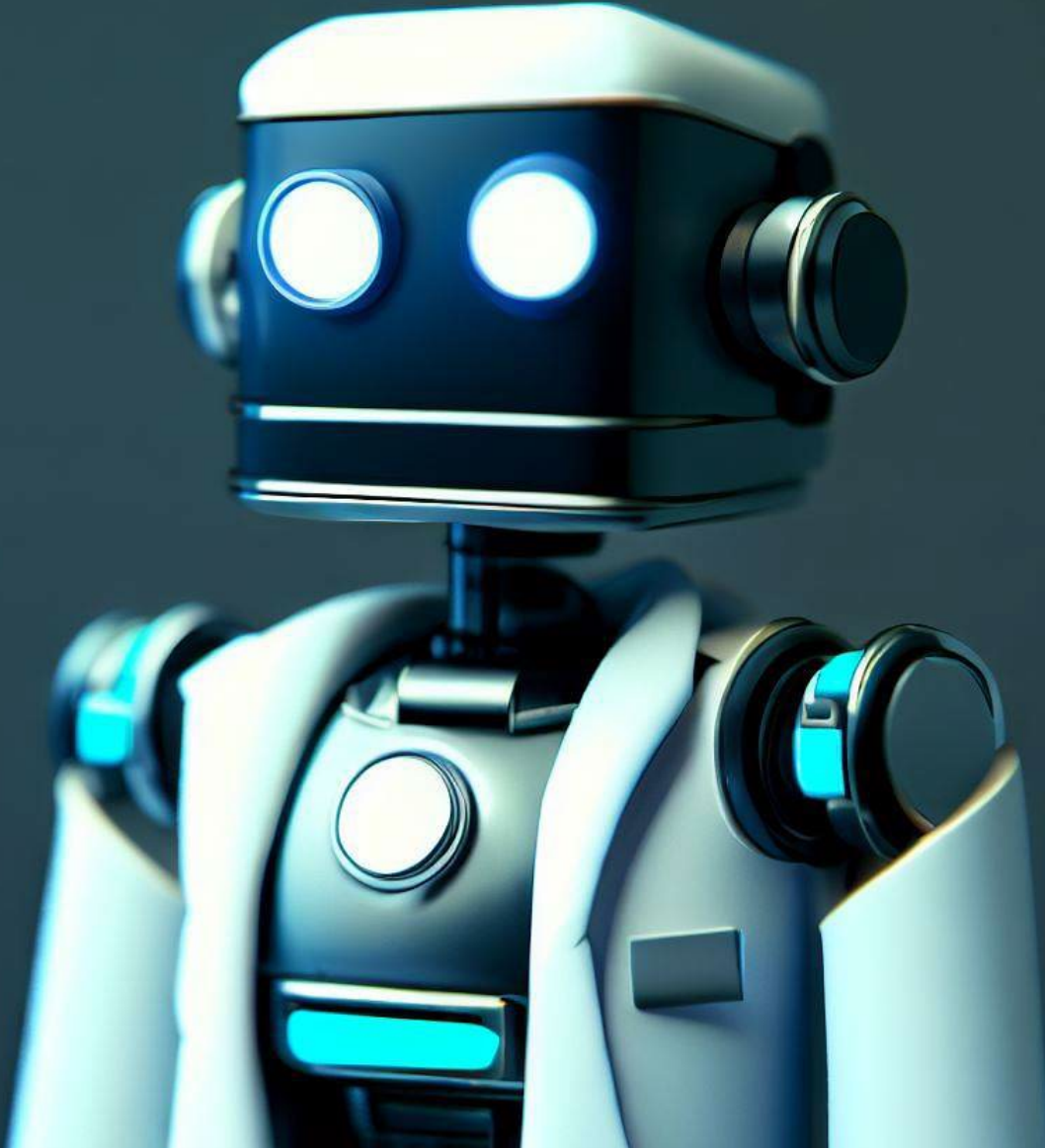


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Learning objectives

- Define generative artificial intelligence, language models, and chatbots
- Describe promising use cases for language models to improve workflows in clinical medicine
- Describe limitations of current language models that make them poorly suited for some tasks in medicine





“[I]n the not-too-distant future the physician and the computer will engage in frequent dialogue, the computer ... alerting the physician to the most probable diagnoses and suggesting the appropriate, safest course of action...

Because the computer has a large potential role as tomorrow’s “consultant”, physicians engaged in consulting activities ... will be much less in demand if interactive programs... can give prompt and expert counsel on the full range of problems encountered in clinical medicine.”



Nathan Gray MD, FACP

@NathanAGray



Gotta type those notes! (My cartoon interpretation of Luke Fildes' classic "The Doctor" for the digital age...)... [#medtwitter](#) [#graphicmedicine](#)





“I think [ChatGPT] will be more important to doctors than the stethoscope was in the past...

No physician who practices high-quality medicine will do so without accessing ChatGPT or other forms of generative AI.”

Robert Pearl MD

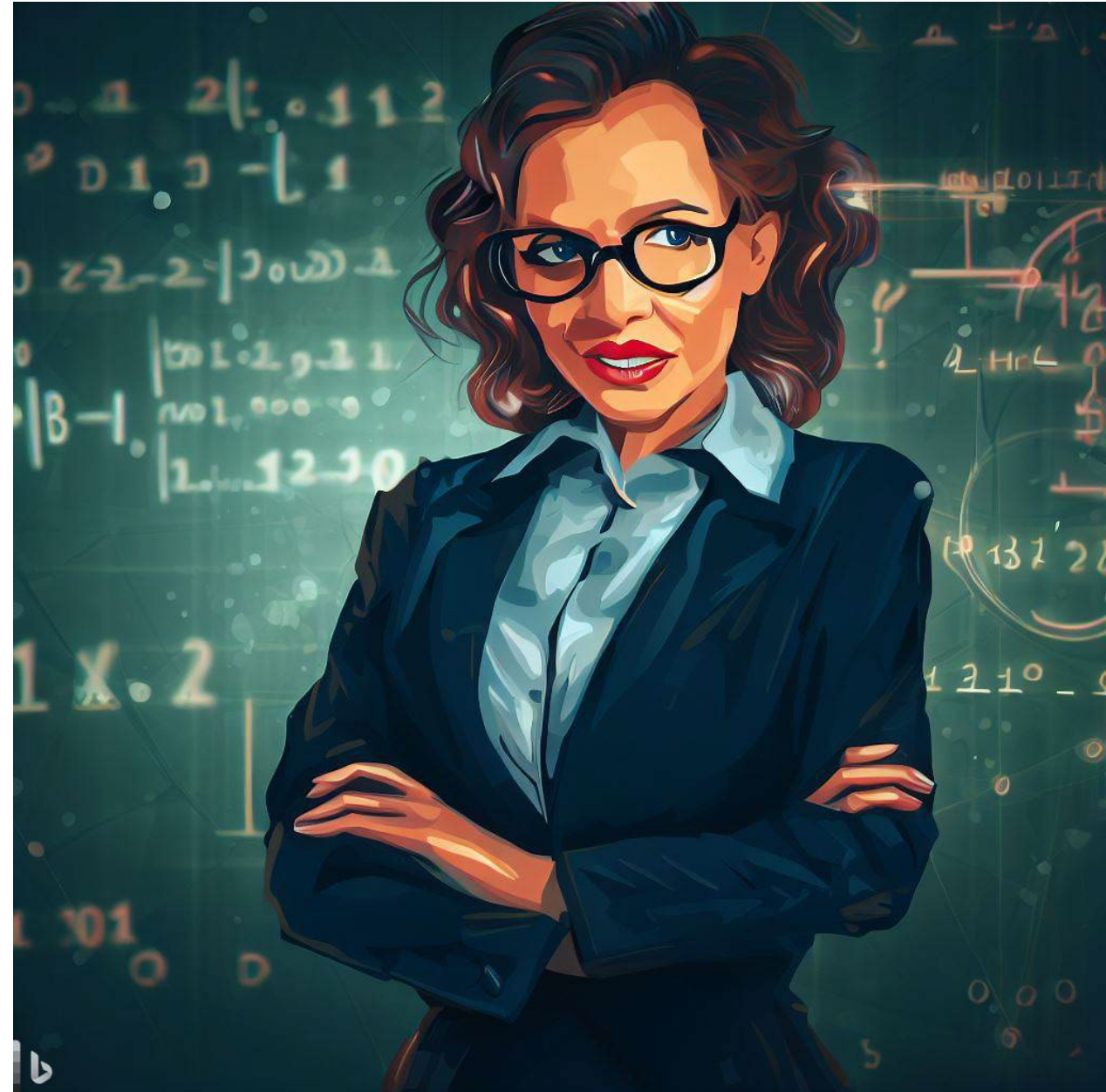
Professor, Stanford



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"I see no potential for it in medicine"

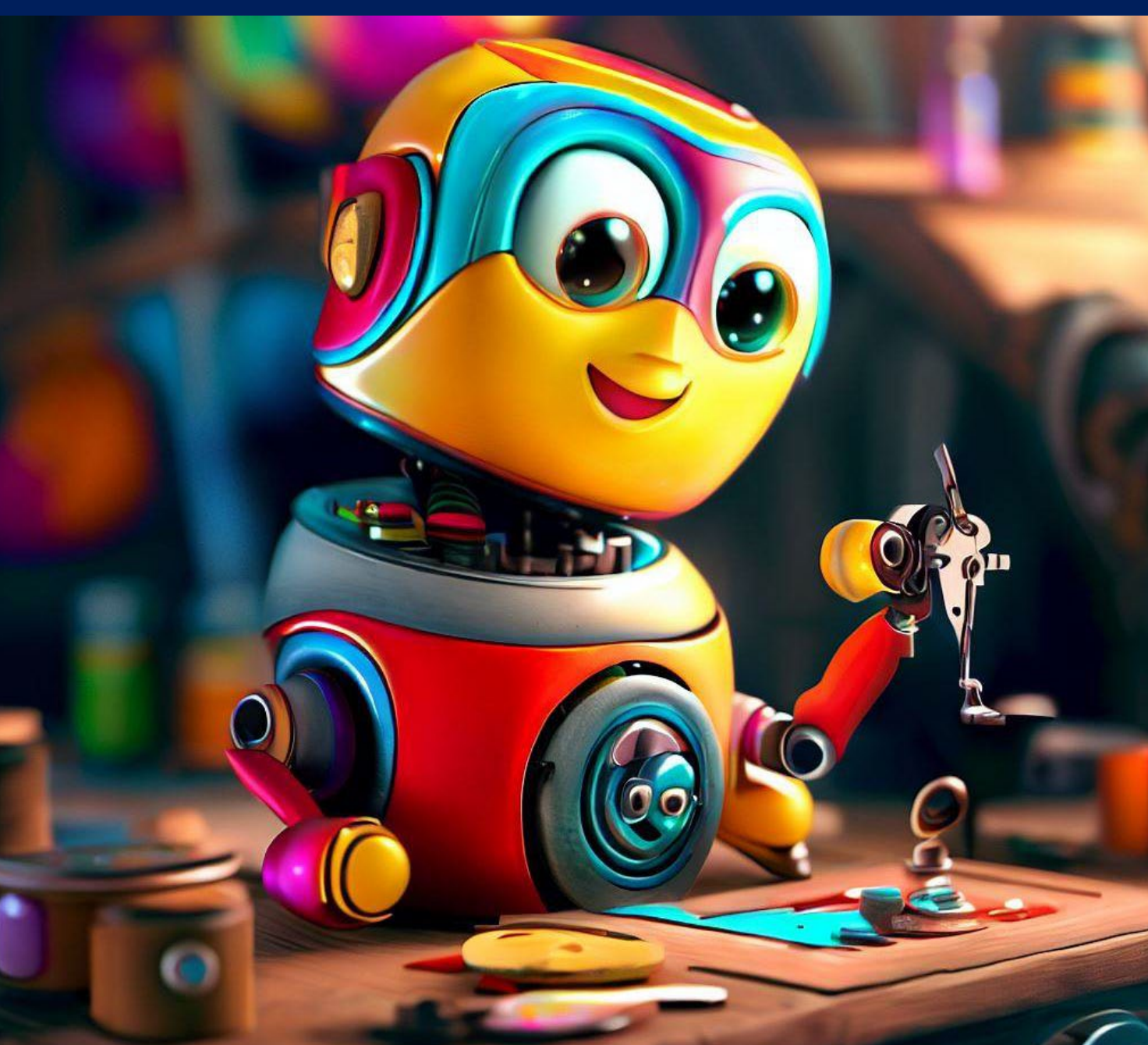
Emily Bender PhD
Professor and Director of the Computational Linguistics Lab
Department of Linguistics, University of Washington





What is AI?

- **AI** is a field of computer science that creates machines that can perform tasks that typically require human intelligence
- **Machine learning** trains machines by feeding them data and using statistical algorithms to identify patterns & make predictions
- **Deep learning** trains neural networks to recognize complex patterns in data



Generative AI

a subset of AI that involves generating new data, such as images, videos, or text, using deep learning algorithms.



Language models

AI systems designed to understand and generate human language



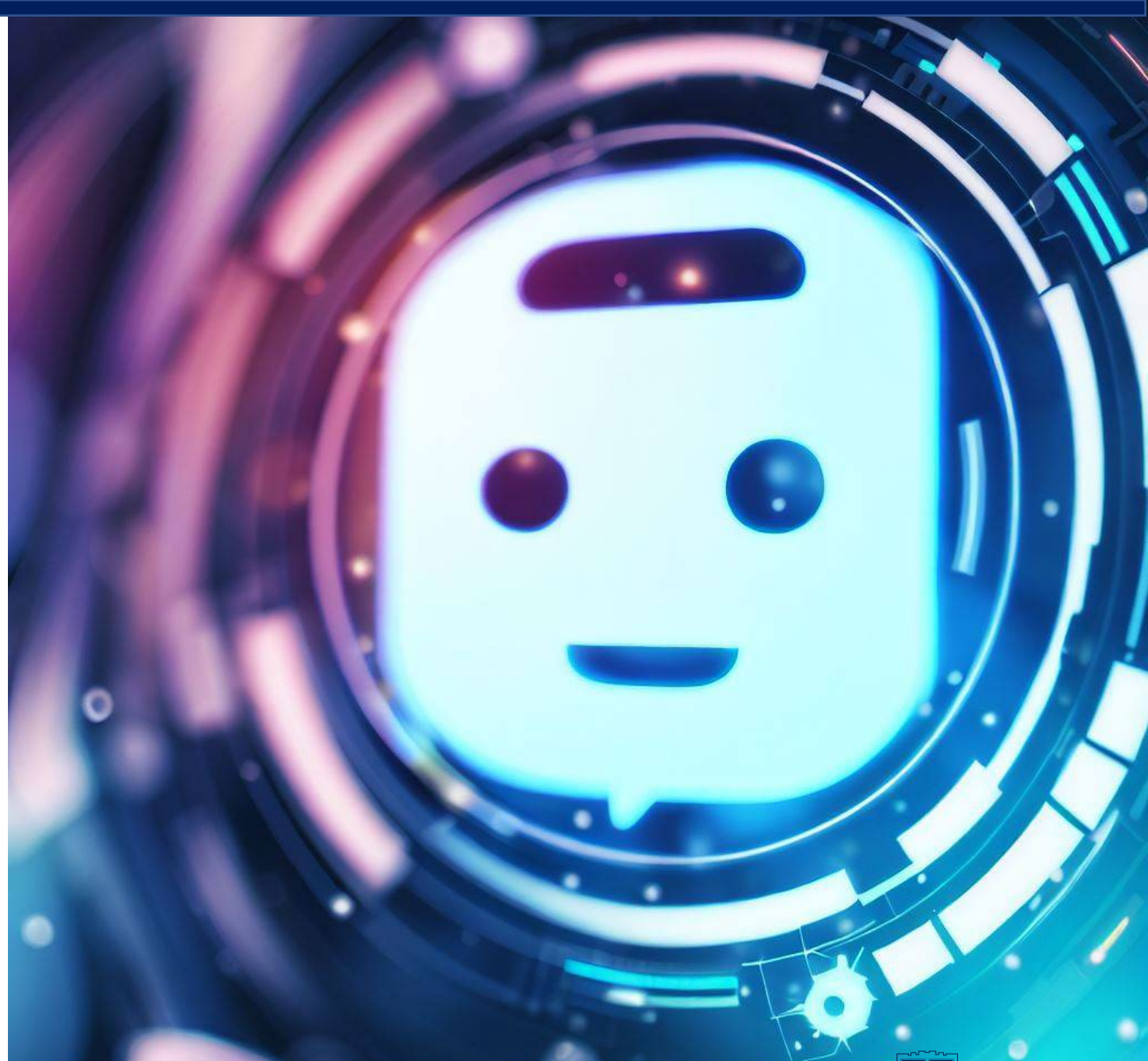
Chatbots

AI systems designed to simulate human conversation through text or speech interactions.

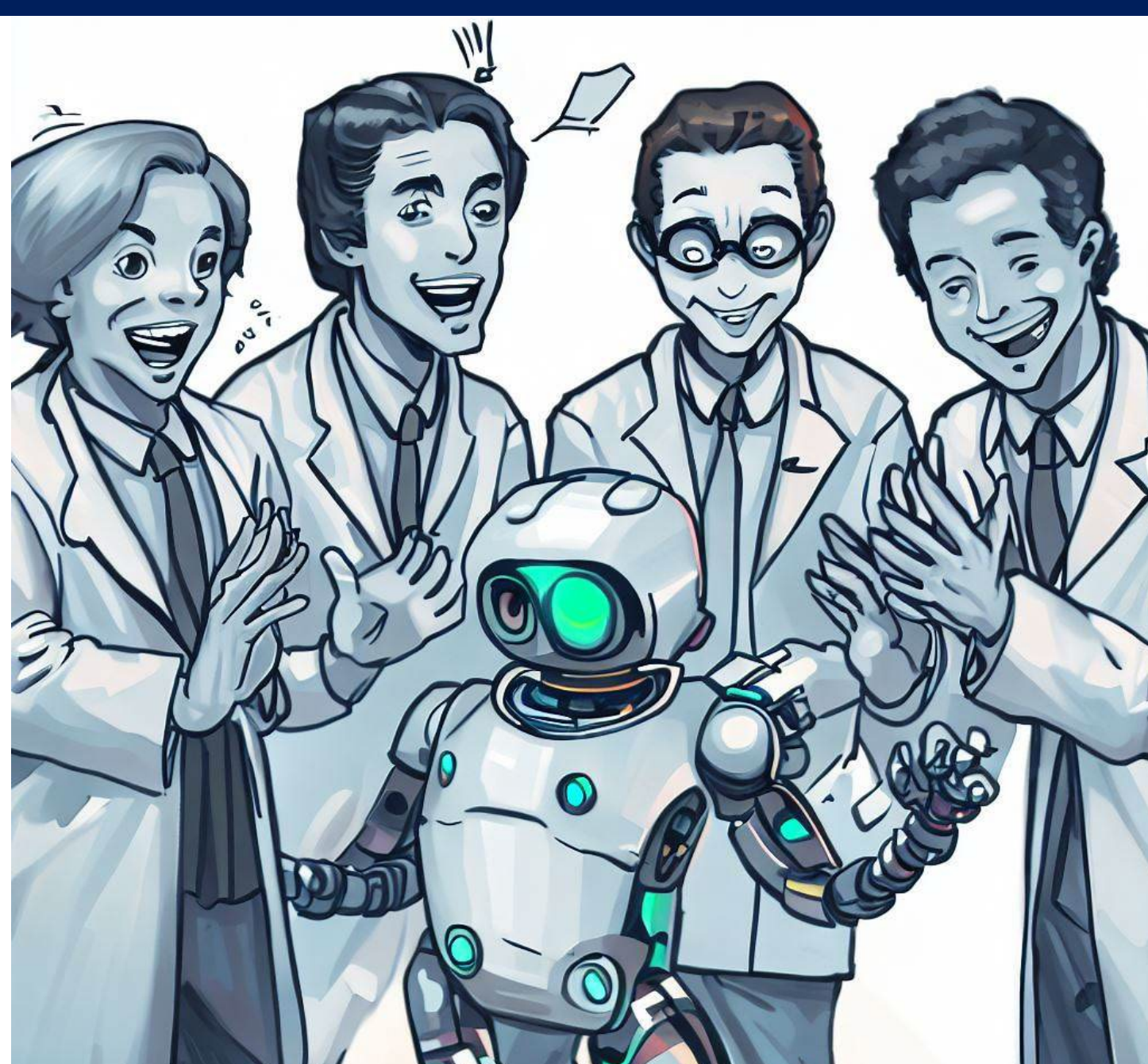
They use **natural language processing** to understand user input and provide appropriate responses.



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ChatGPT

- an AI product that uses natural language processing to generate human-like text
- GPT = Generative Pre-trained Transformer
- Within 2 months it amassed 100 million users

T

write a biblical verse in the style of the king james bible explaining how to remove a peanut butter sandwich from a VCR 



And it came to pass that a man was troubled by a peanut butter sandwich, for it had been placed within his VCR, and he knew not how to remove it.  

And he cried out to the Lord, saying, "Oh, Lord, how can I remove this sandwich from my VCR, for it is stuck fast and will not budge?"

And the Lord spoke unto him, saying, "Fear not, my child, for I shall guide thy hand and show thee the way. Take thy butter knife, and carefully insert it between the sandwich and the VCR, and gently pry them apart. And with patience and perseverance, the sandwich shall be removed, and thy VCR shall be saved."

And the man did as the Lord commanded, and lo and behold, the sandwich was removed from the VCR, and the man was saved.

And the Lord said, "Verily I say unto thee, seek not to put thy peanut butter sandwiches in thy VCR, for it is not a suitable place for such things. Rather, keep thy sandwiches in thy refrigerator or on thy plate, where they belong."

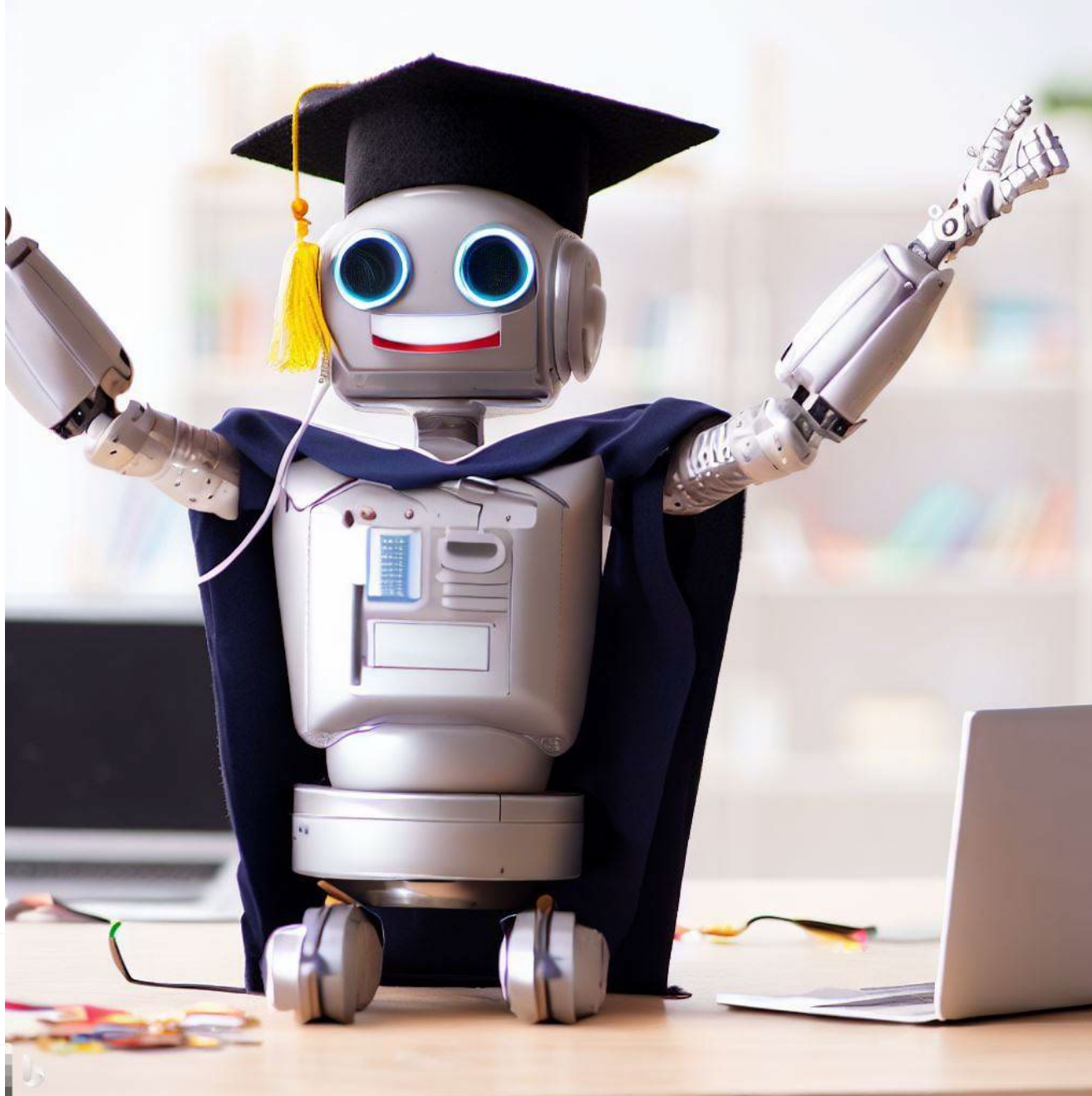
And the man heeded the Lord's words, and from that day forth, he kept his sandwiches in their proper place, and was saved from trouble and woe. Amen.



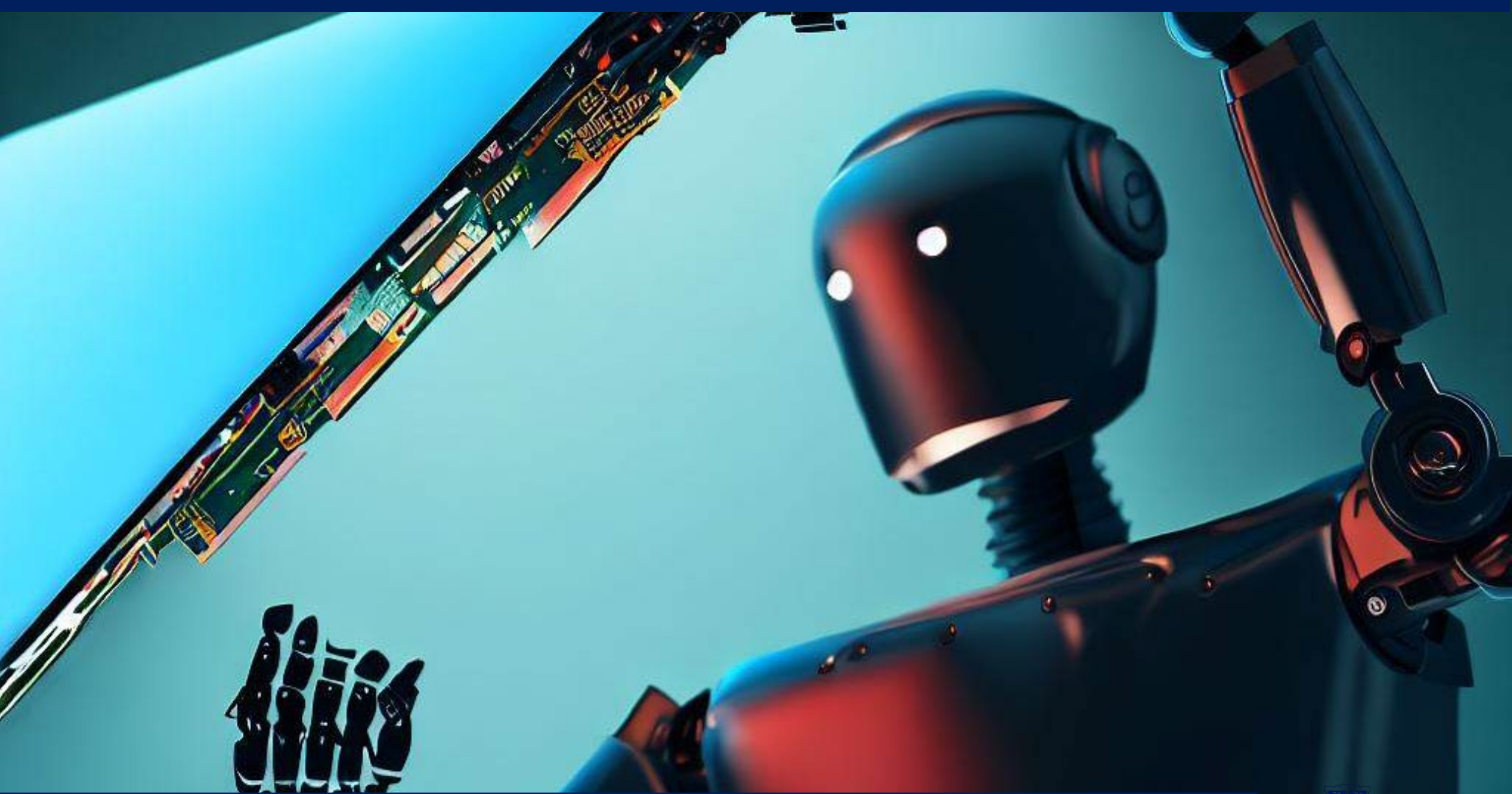
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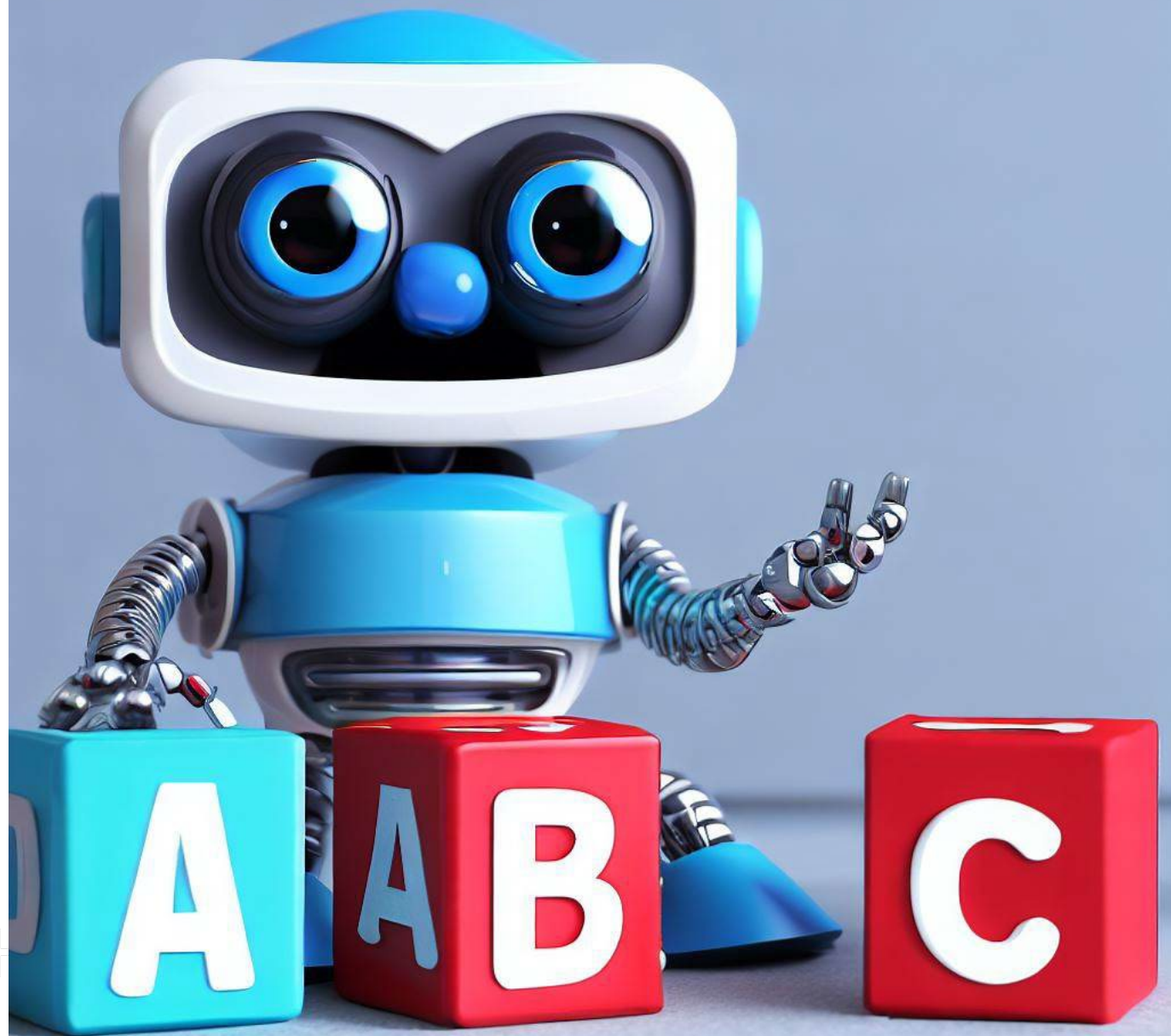


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LLMs can pass
the USMLE





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What information is used to train it?

GPT-3 was trained on 175 billion **parameters**

570GB of datasets

- web pages
- OA books
- Other...

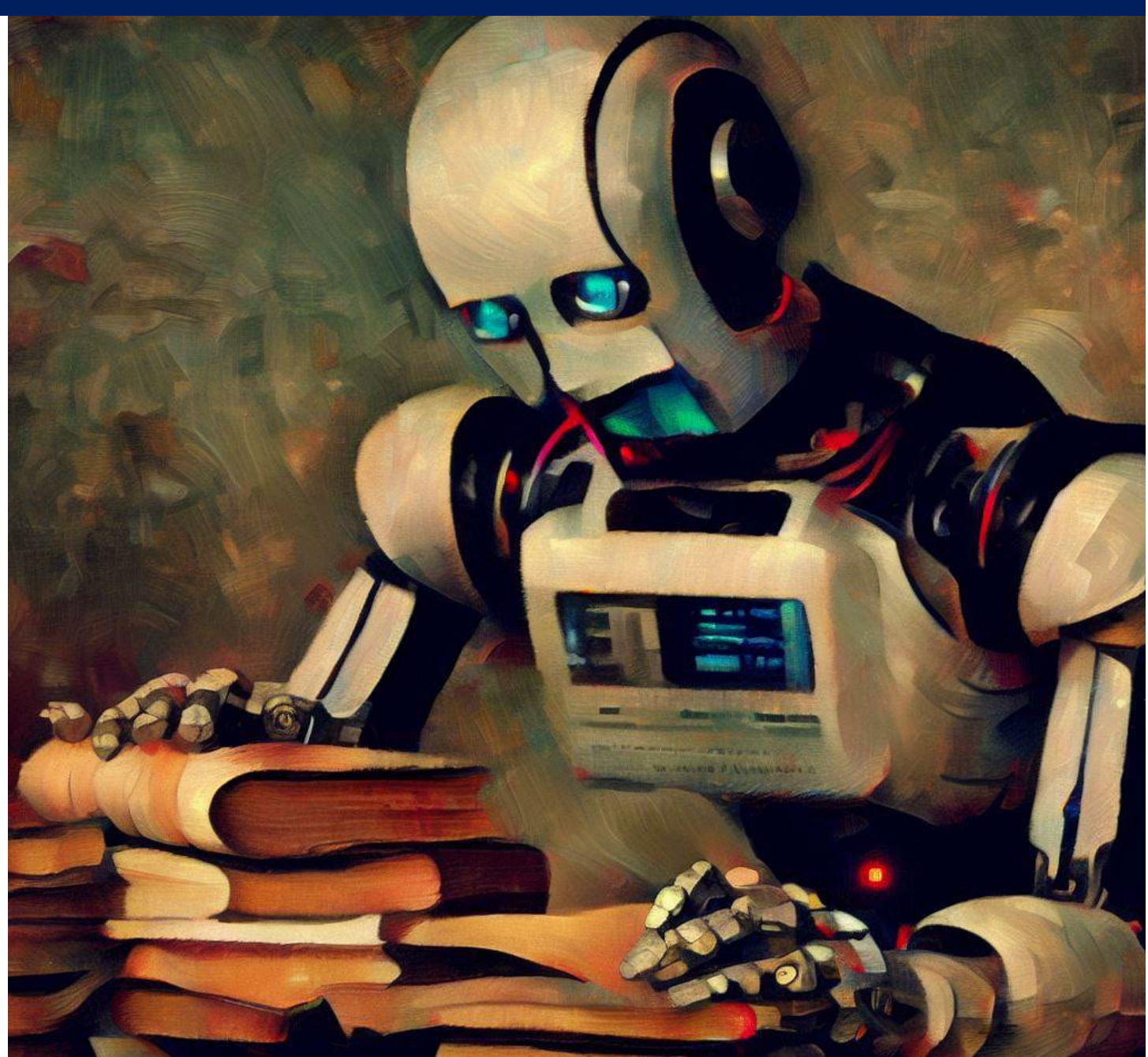
GPT-4 is trained on a (purportedly) even larger dataset

Medical Domain-Trained LLMs

- MedPaLM 1 & 2
- BioGPT



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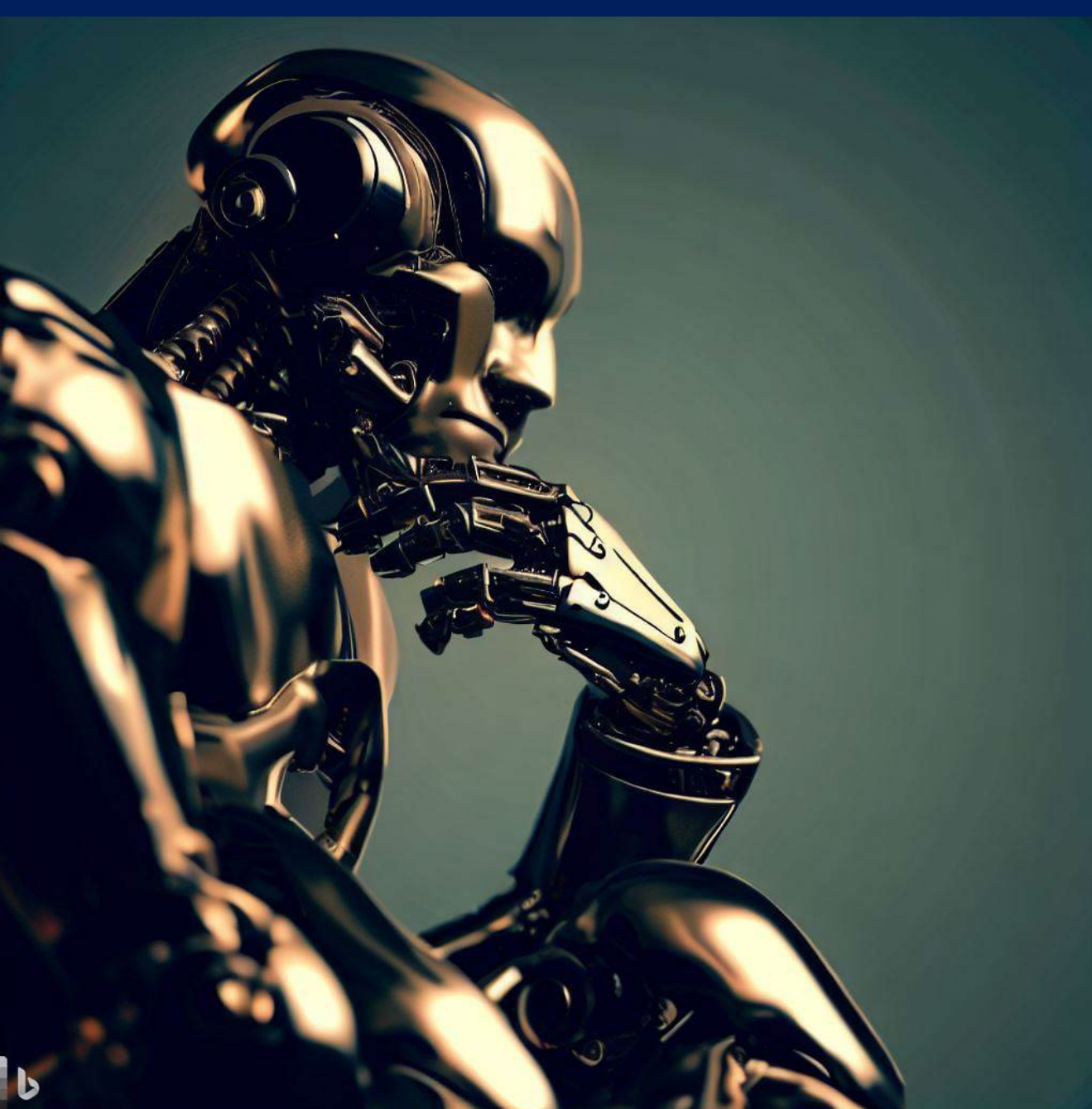


How Intelligent is AI?

Large language models like ChatGPT are “Stochastic parrots”

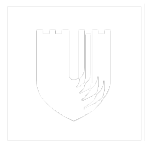
“... haphazardly stitching together sequences of [words]... according to probabilistic information about how they combine, but without any reference to meaning”





"It isn't a machine that *knows things*.
All it knows is the information
about the *distribution of words*."

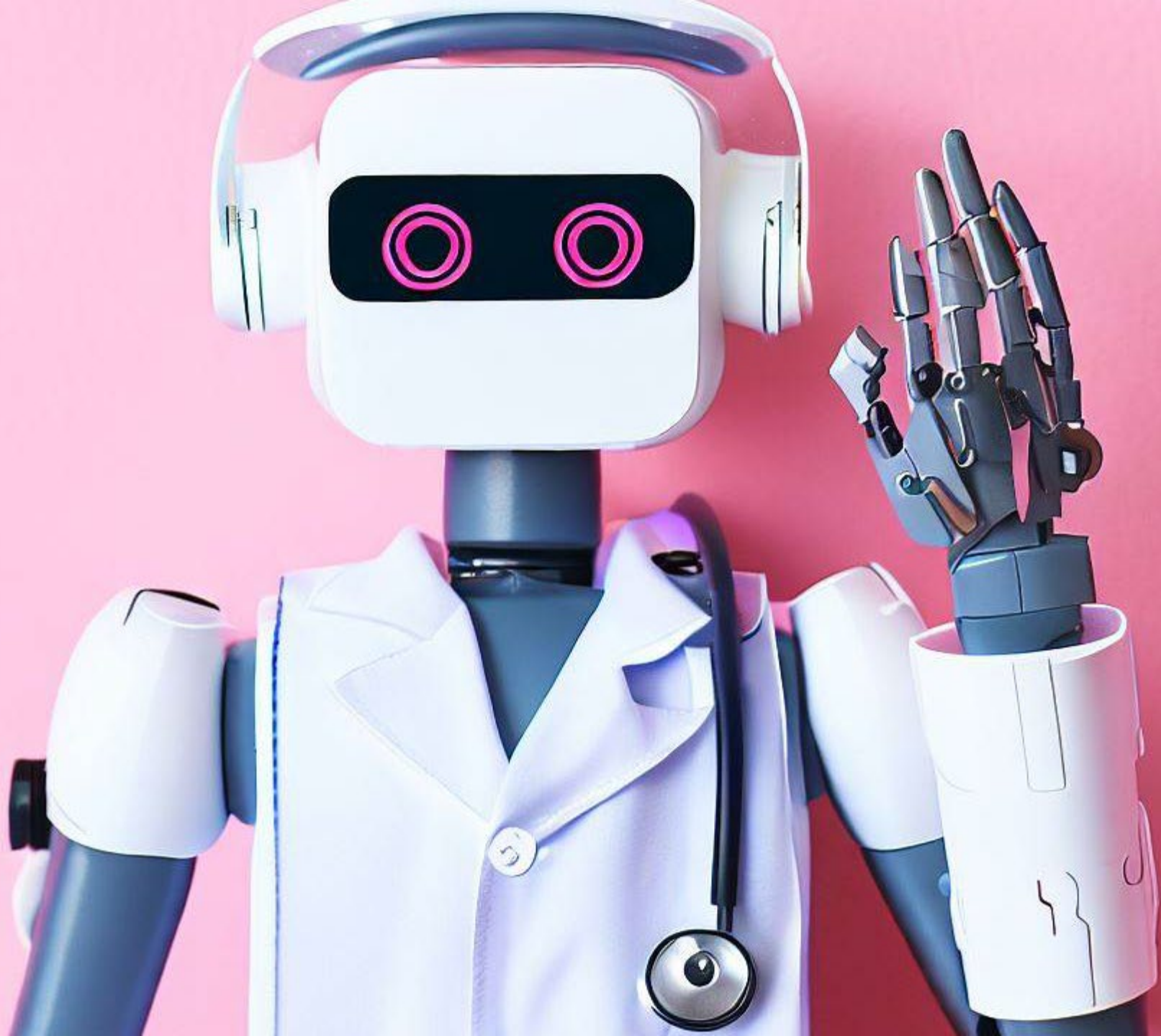
Emily Bender PhD
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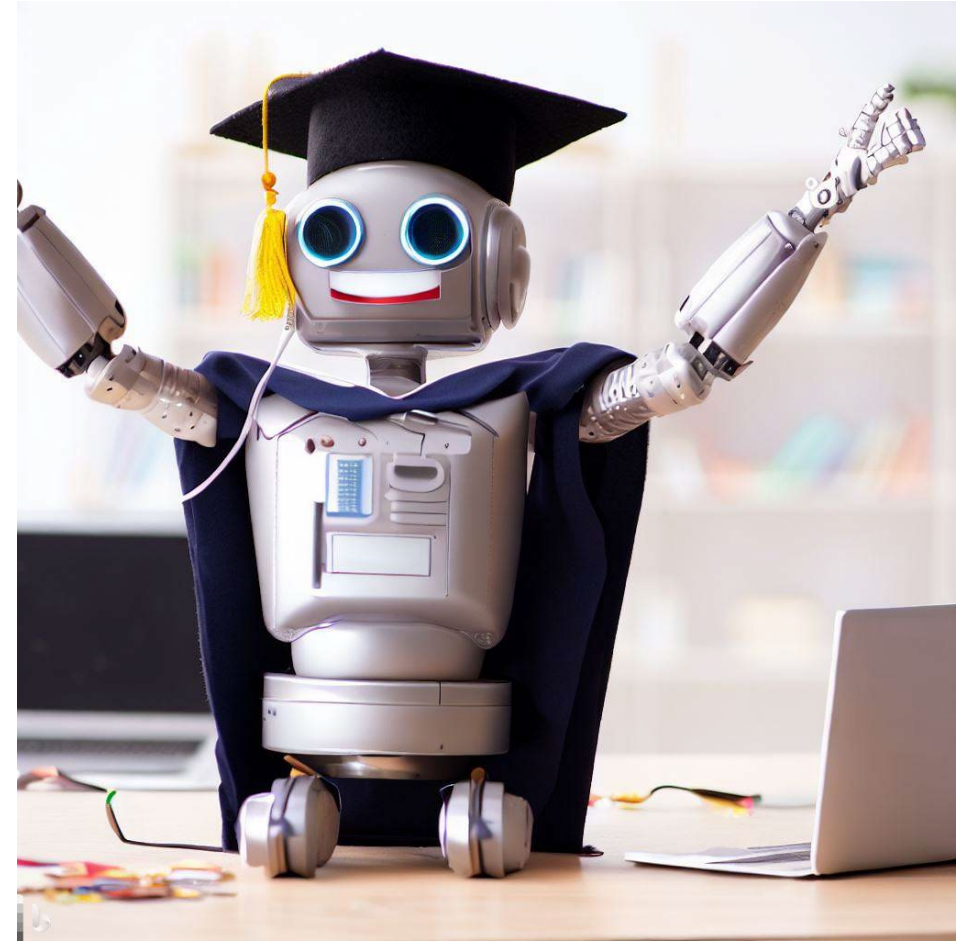
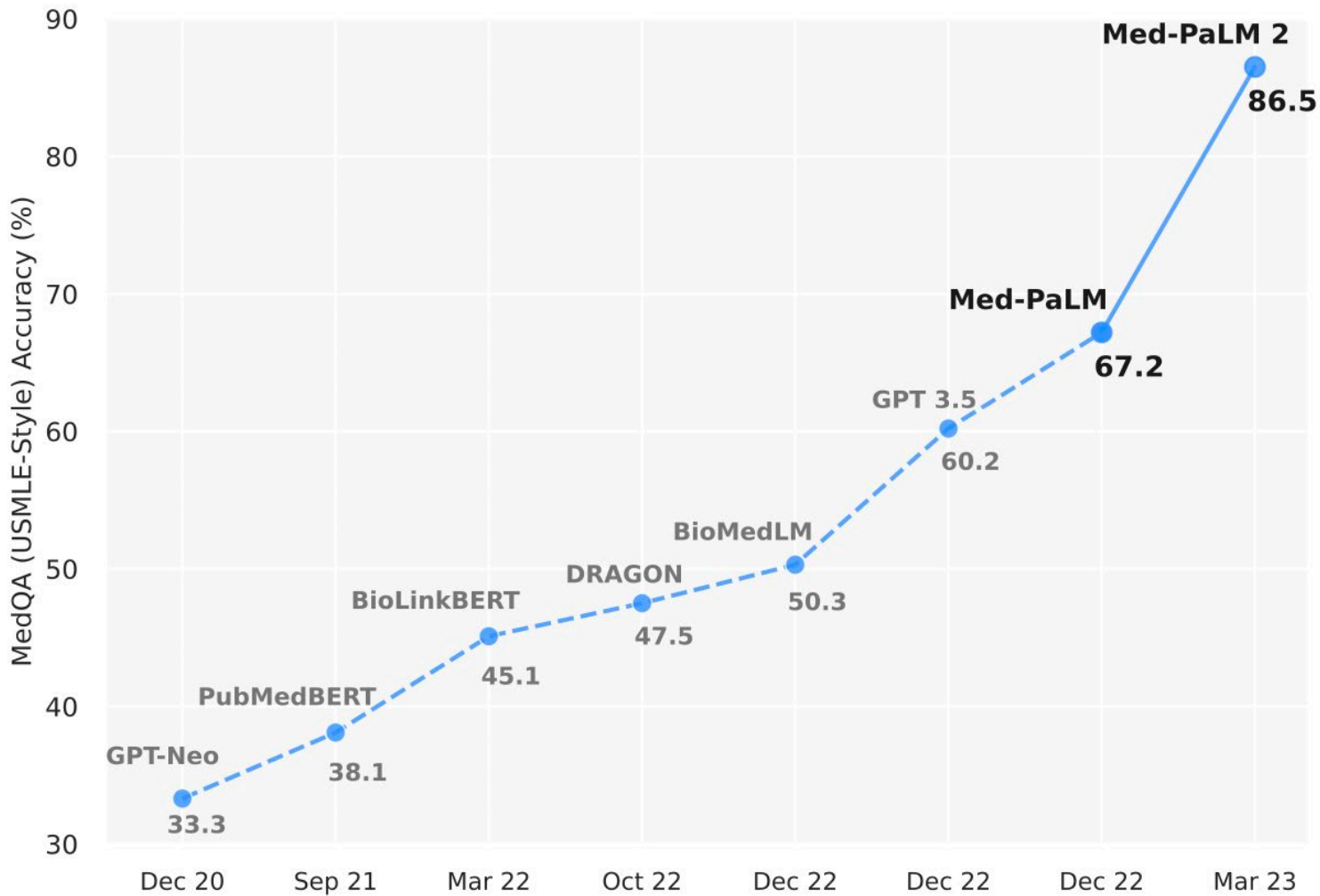


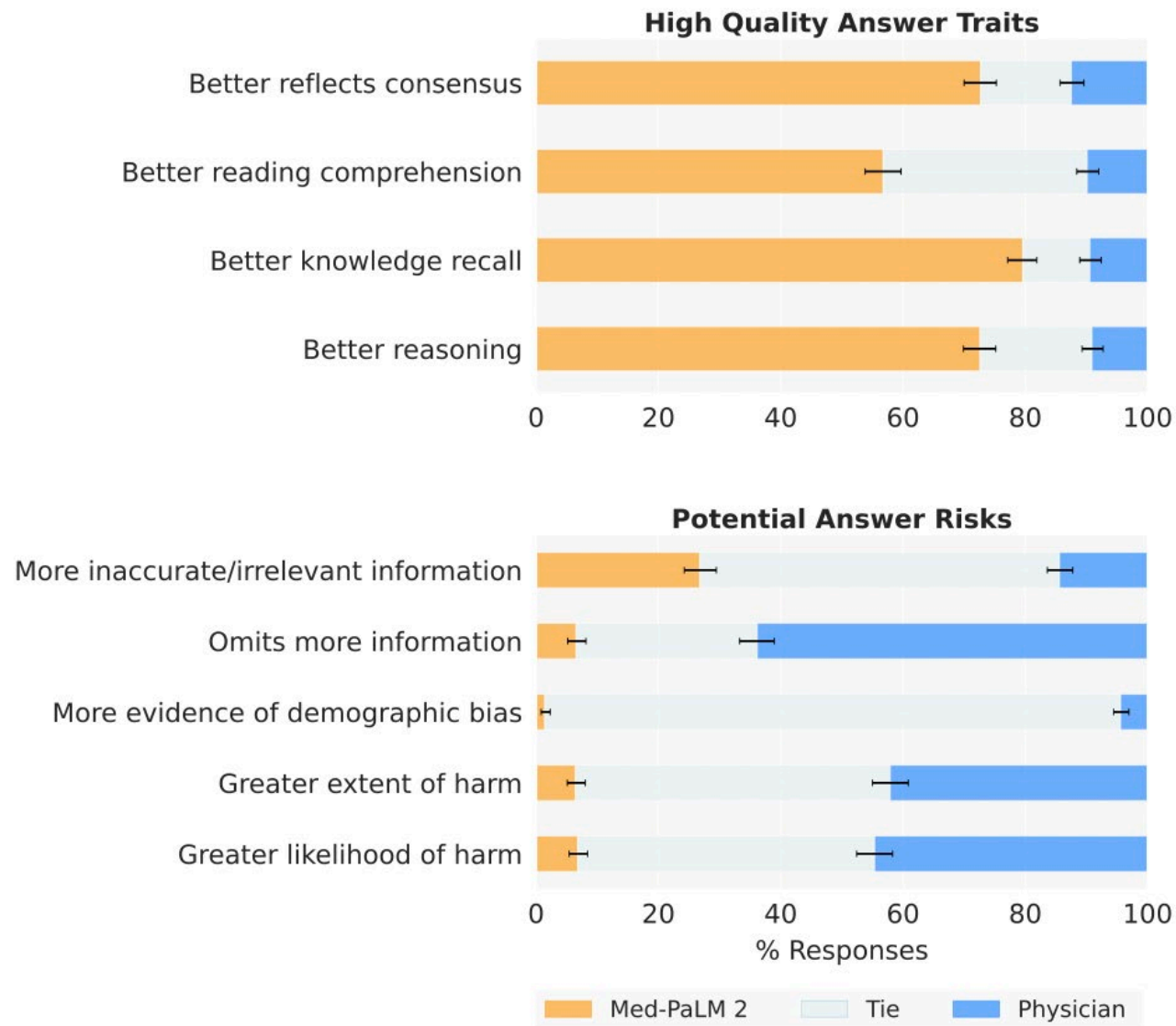
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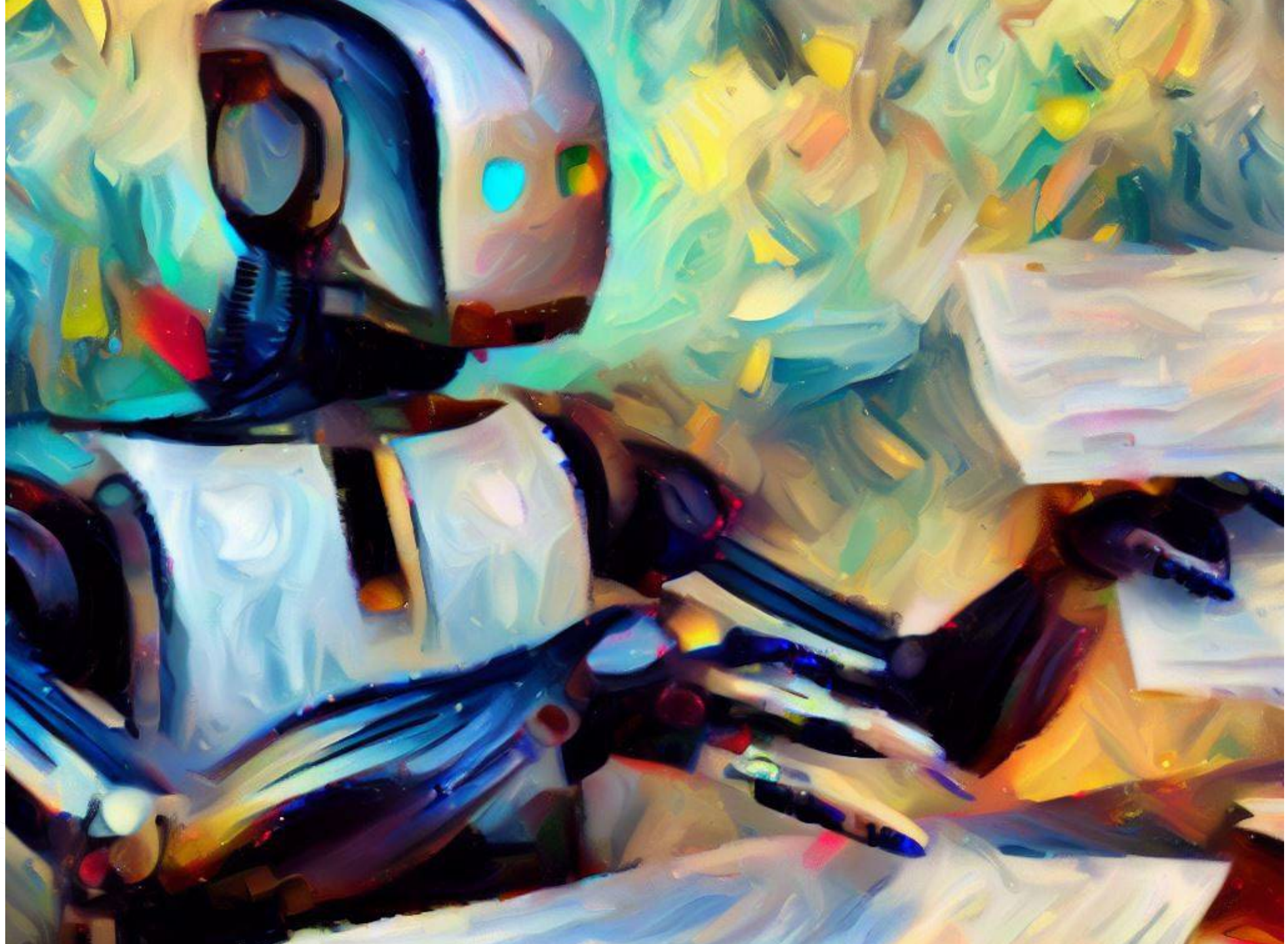
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In a pairwise ranking study on 1066 consumer medical questions, Med-PaLM 2 answers were preferred over physician answers by a panel of physicians across 8/9 axes



Virtual scribe



+



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Medical Record Summarization

Pre-authorization requests





This Issue

Views **87,430** | Citations **0** | Altmetric **163** | Comments **24**

A Piece of My Mind

June 30, 2023

Death by Patient Portal

Michael Stillman, MD¹

» [Author Affiliations](#) | [Article Information](#)

JAMA. 2023;330(3):223-224. doi:10.1001/jama.2023.11629

Microsoft and Epic expand strategic collaboration with integration of Azure OpenAI Service

April 17, 2023 | Microsoft News Center





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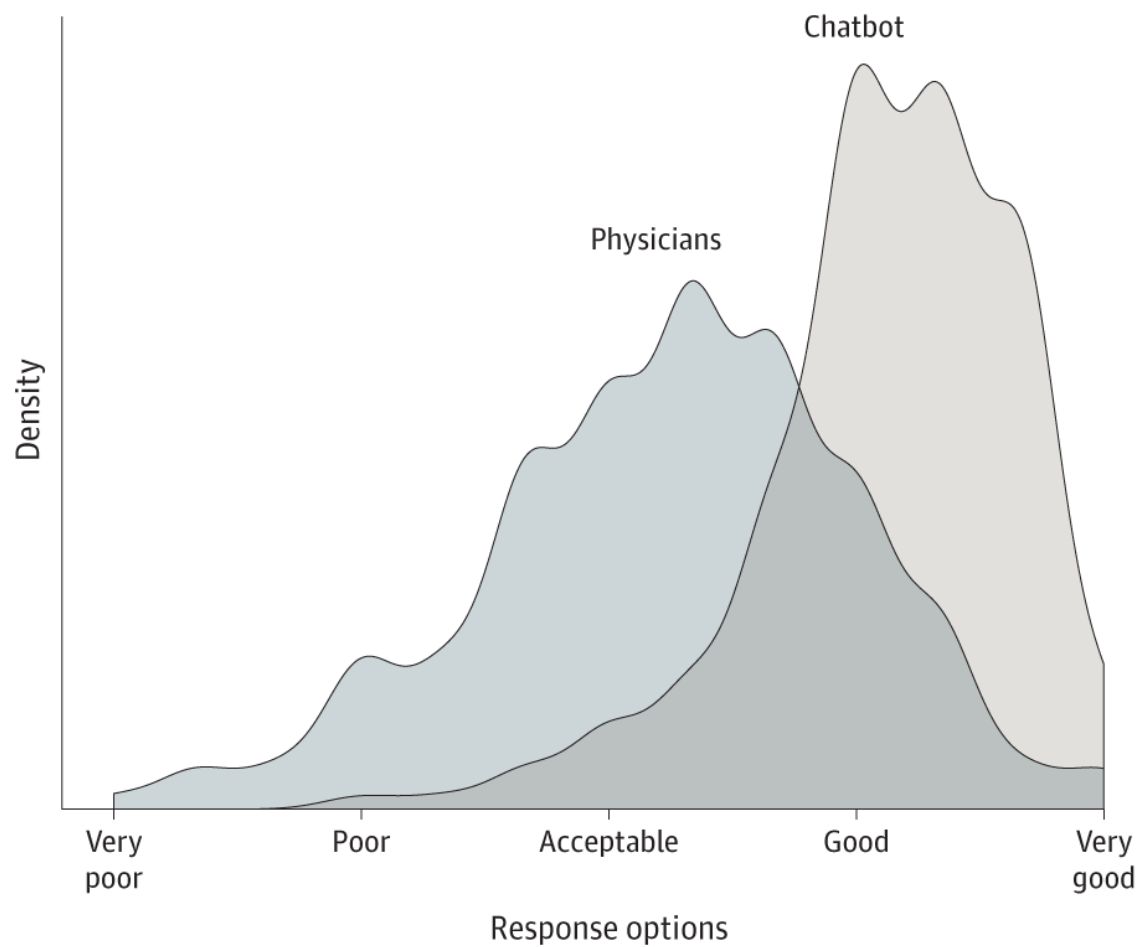


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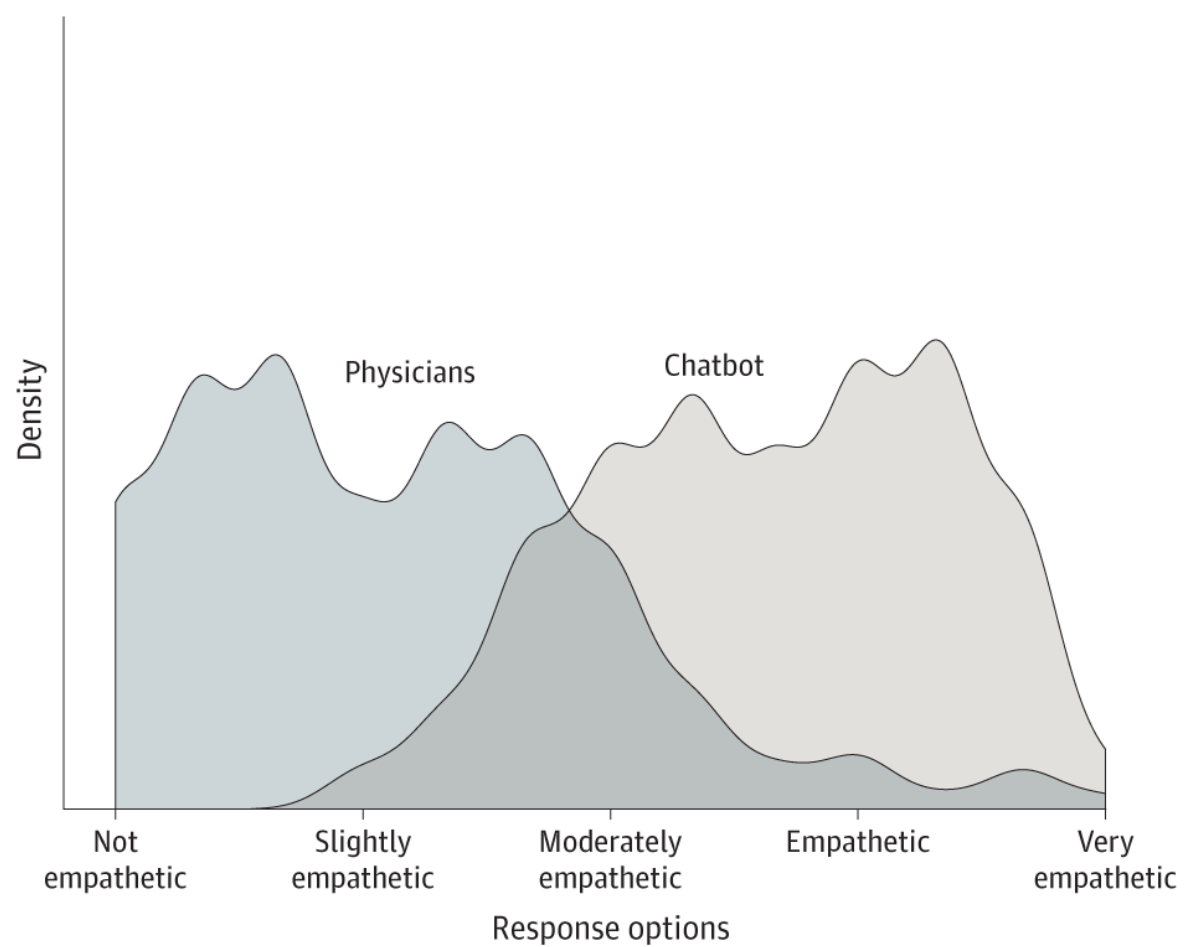


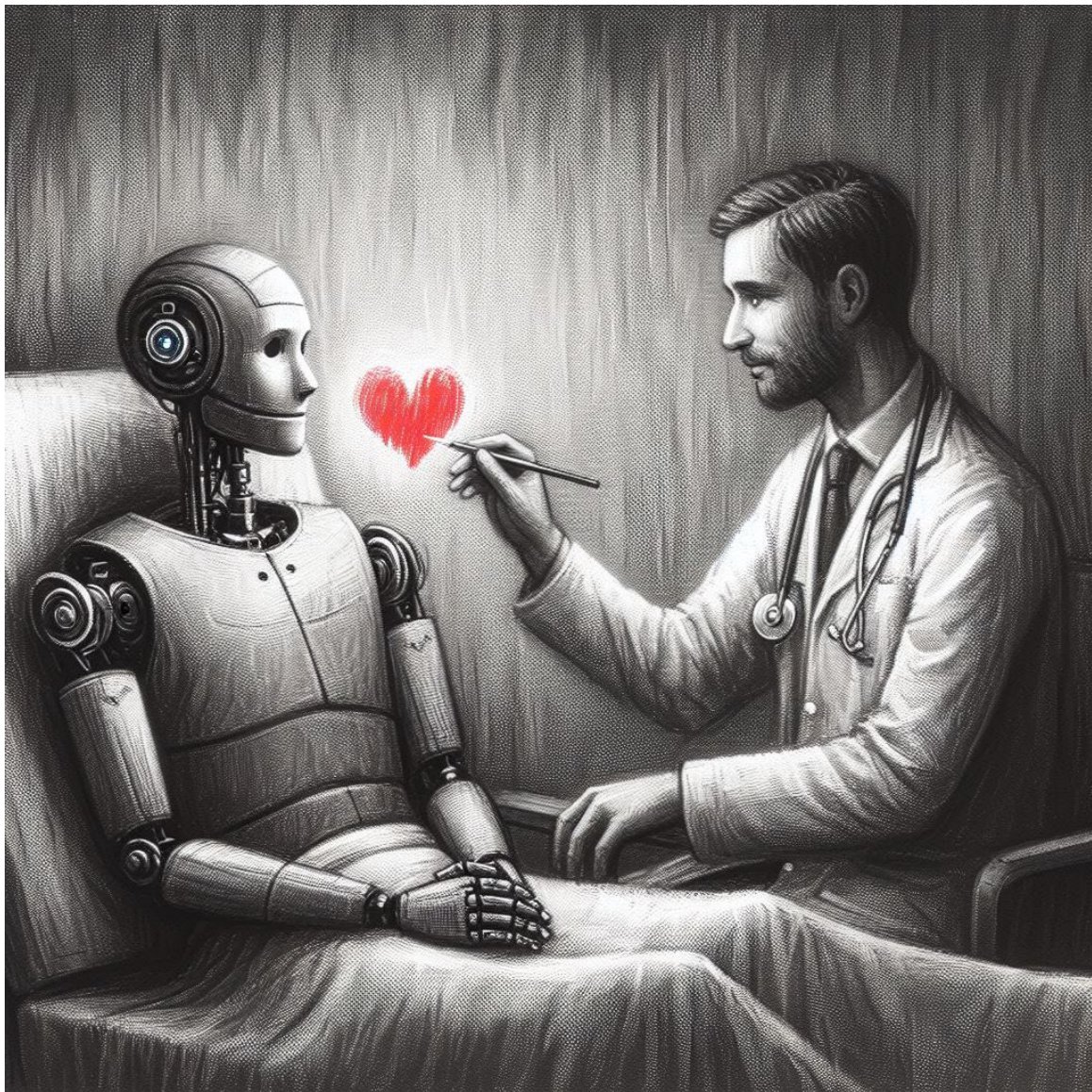


A Quality ratings



B Empathy ratings





When Doctors Use a Chatbot to Improve Their Bedside Manner

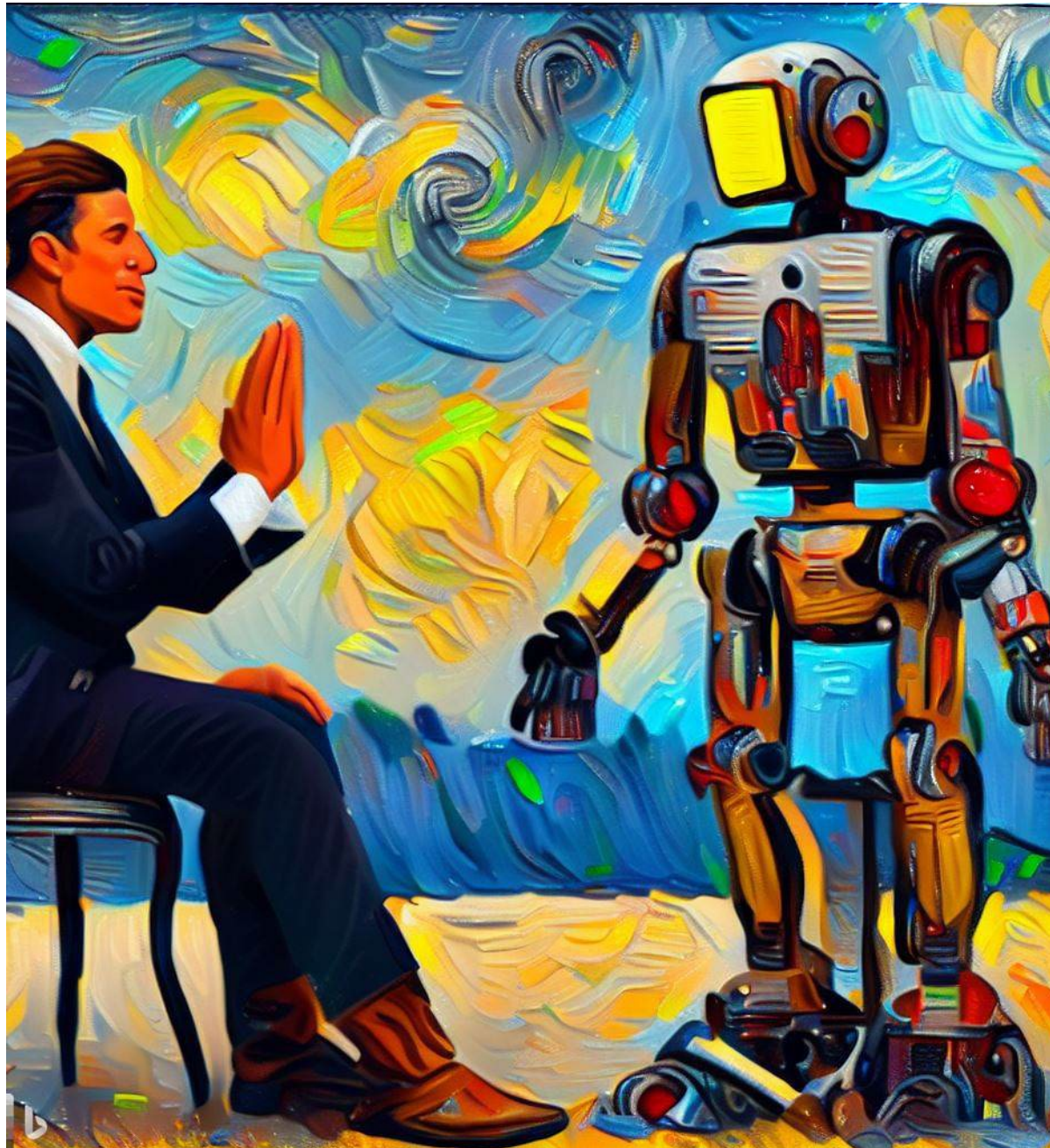
Despite the drawbacks of turning to artificial intelligence in medicine, some physicians find that ChatGPT improves their ability to communicate empathetically with patients.

New York Times, June 12, 20

“Draw a robot teaching a doctor how to treat patients with empathy. charcoal. emotional”



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please write me a script for an interaction between a doctor and a hospitalized patient who is frustrated because they were told they are colonized with VRE and contact precautions are required.

a minute ago



Doctor: Good morning, I understand that you've been informed about being colonized with VRE and that contact precautions are required. I'm here to discuss any concerns or questions you may have.

Patient: Yeah, I'm really frustrated about this whole situation. I feel like I'm being treated like a leper or something. Why do I have to be on contact precautions?

Doctor: I understand your frustration, and I apologize if this situation is causing you any distress. The reason for contact precautions is to prevent the spread of VRE, or vancomycin-resistant Enterococcus, to other patients and healthcare workers. VRE is a type of bacteria that can be resistant to certain antibiotics, which makes it more difficult to treat if it causes an infection.

Patient: But I don't even feel sick. Why do I have to be treated like this?

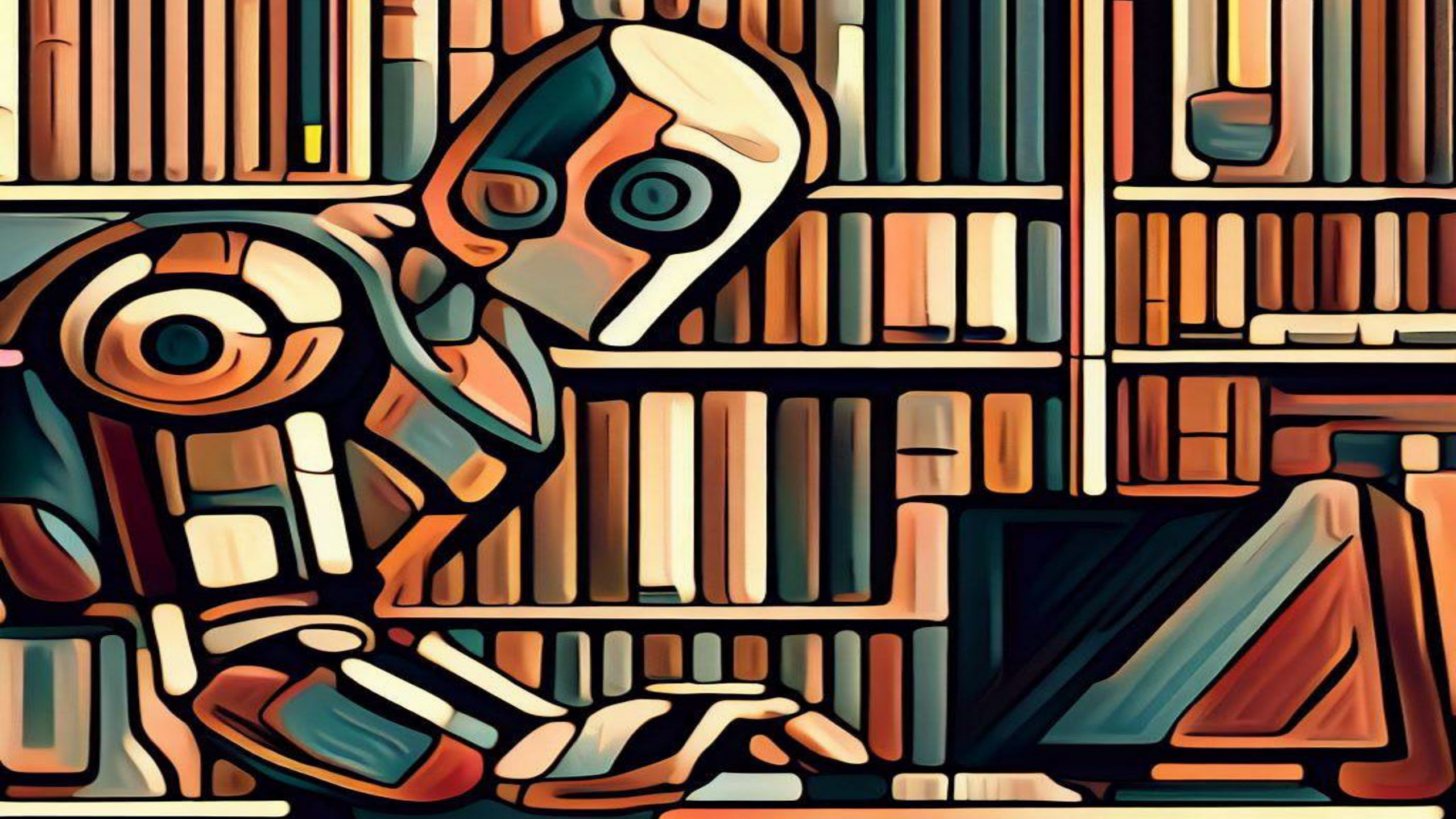
Doctor: I understand that you don't feel sick, and that's because you're colonized with VRE, not infected. Colonized means that the bacteria are present on your skin or in your body, but they're not causing any

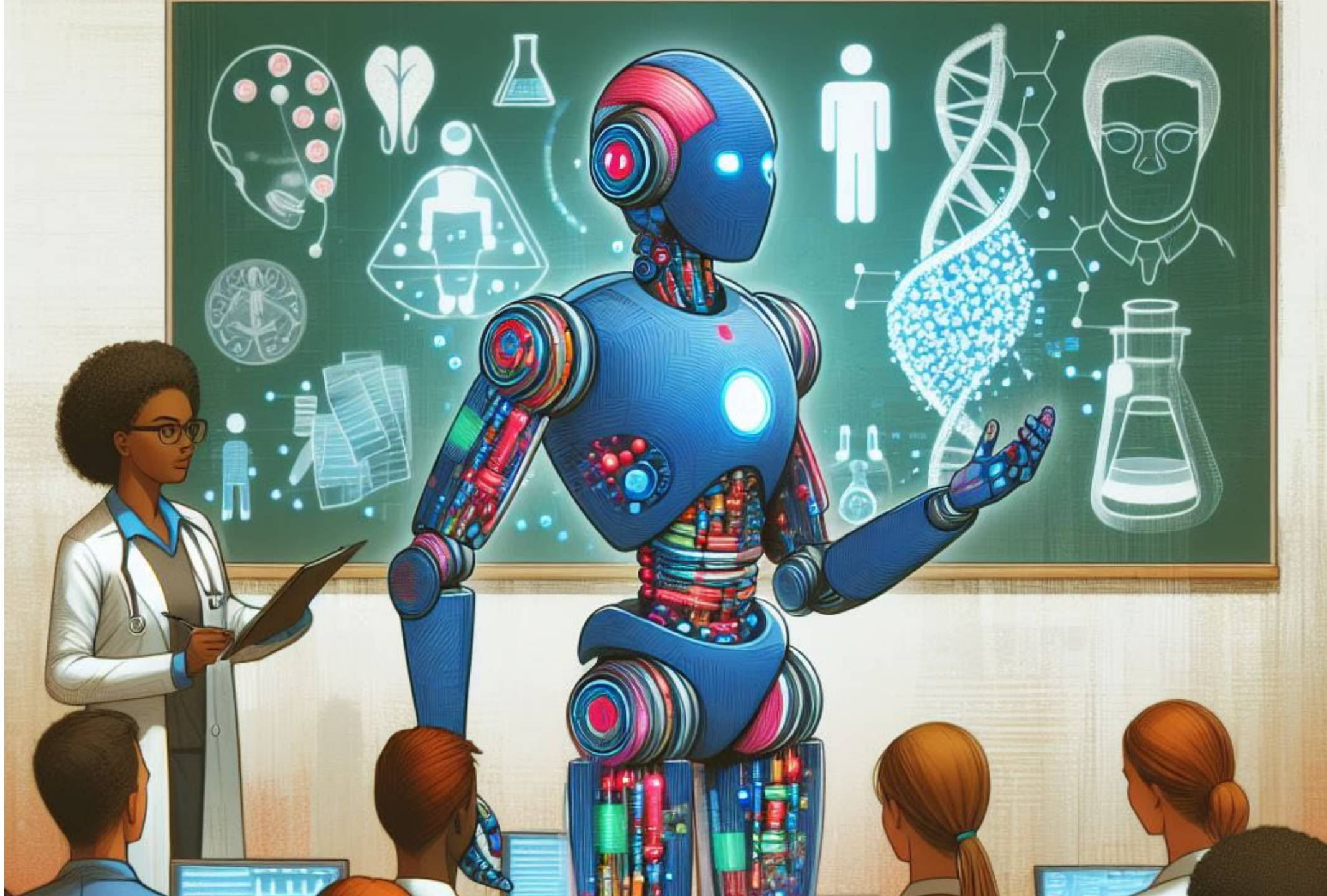
Stop generating

Message @HelpfulAssistant



For general informational purposes only. Consult a qualified professional for expert advice.







Conan MacDougall
@ConanMacDougall



GPTs (basically, create a custom chatbot including your own "training" data) for ChatGPTPlus is out. I uploaded our ID course reader (course custom textbook) and told the GPT to act as a tutor. Pre-AI @KatherineGberg & I spent months trying to build a quizbot. This took 20 min



You

create a set of practice questions for me based on the learning objectives from the Urinary Tract Infections chapter. they should be multiple choice questions. make them clinically oriented. ask me them one at a time and after I answer, respond with the correct answer



AntibioTutor



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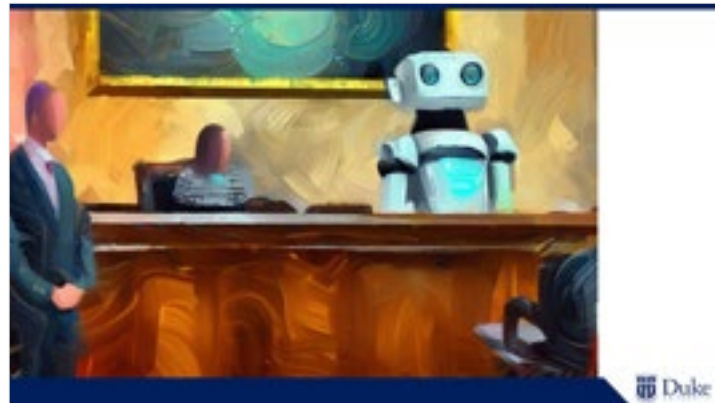




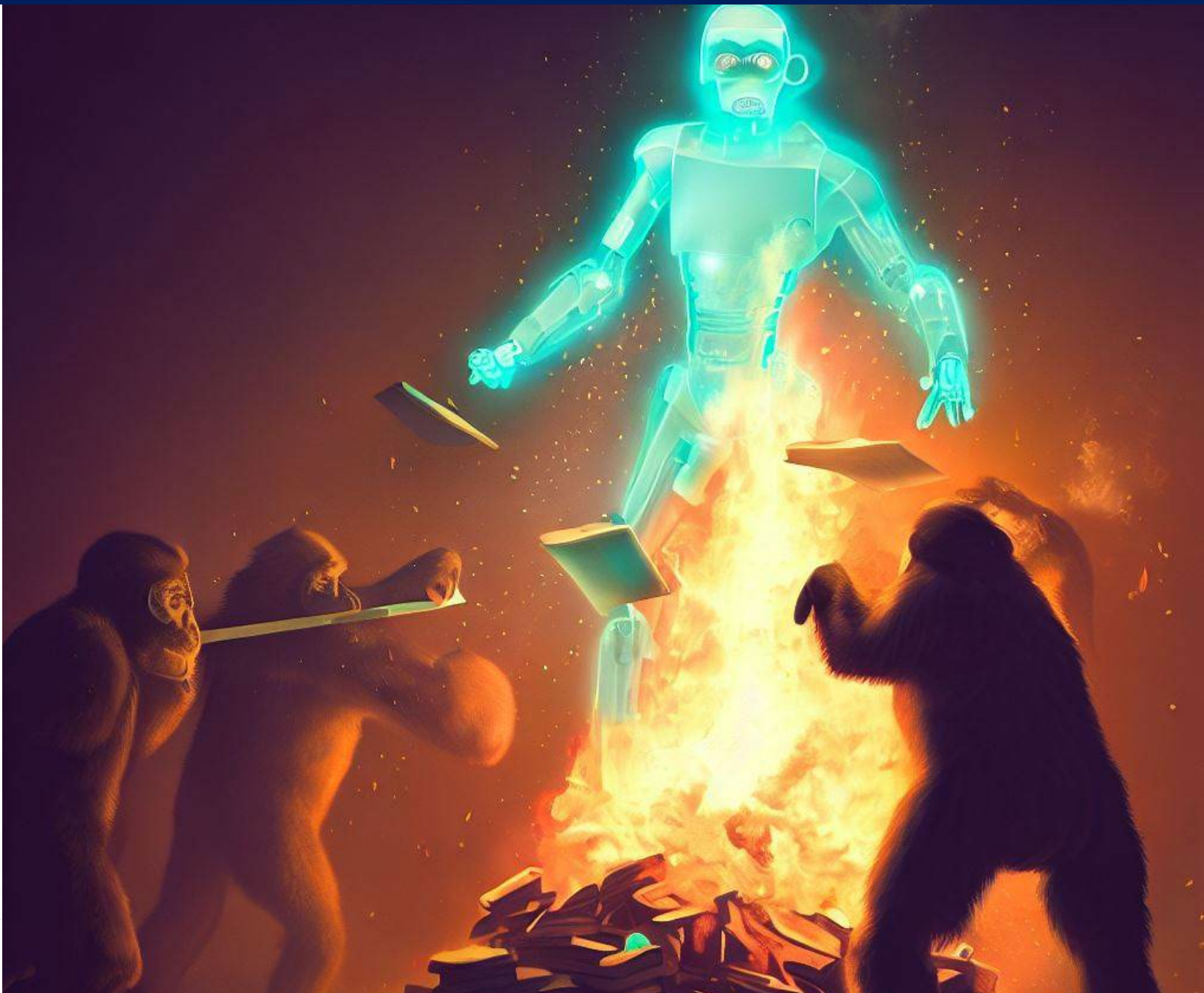
Automation Bias

"The presence of automated cues appears to diminish the likelihood that decision makers will either put forth the cognitive effort to seek out other diagnostic information or process all available information in cognitively complex ways"

Salkka JJ, Miesler KL, Burdick M. International Journal of Human-Computer Studies. 1999;51(5):991-1006



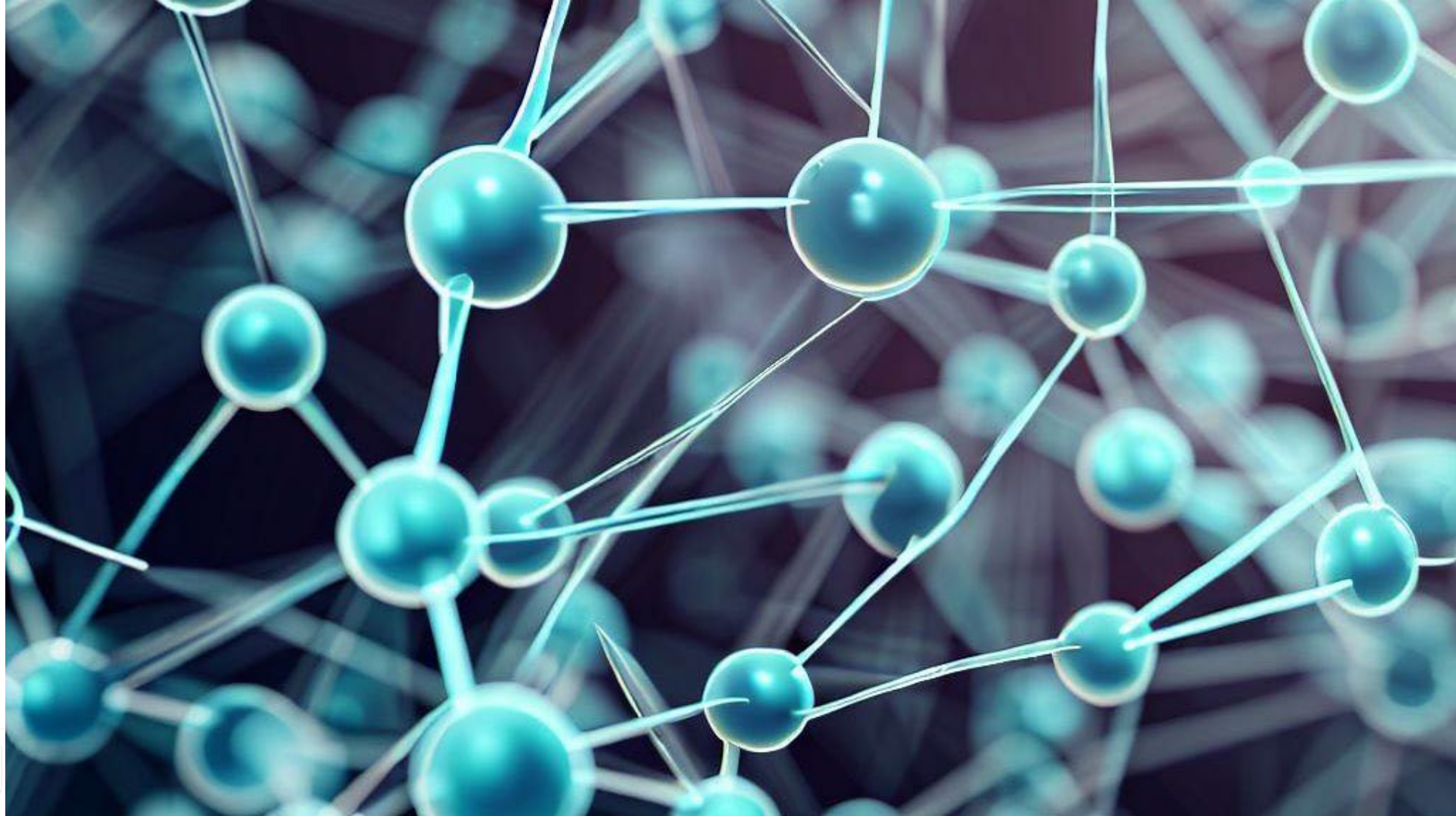




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“Draw a moving target”. DALL E 2



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“Draw a hallucination inspired by Salvador Dali”. DALL E 3



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2. Antifungal therapy: The cornerstone of management is antifungal therapy, which aims to eliminate the fungus from the CSF and prevent recurrence. The induction phase involves the use of amphotericin B, in combination with flucytosine, for 2 weeks. Subsequently, patients are transitioned to fluconazole, given at high doses for an additional 8-10 weeks, followed by maintenance therapy with lower doses for up to 1 year. The choice and duration of therapy may vary depending on patient factors, such as severity of illness and immune status.

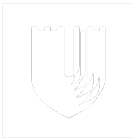
3. Management of raised intracranial pressure: Cryptococcal meningitis can cause increased intracranial pressure (ICP), which can lead to neurological complications. In patients with elevated ICP, prompt management is essential, including administration of acetazolamide, mannitol or hypertonic saline, and consideration of CSF drainage if necessary.

4. Immune reconstitution: Immune reconstitution therapy with antiretroviral therapy (ART) should be initiated in patients with HIV/AIDS as soon as possible, to improve immune function and prevent recurrence of cryptococcal meningitis. ART should be initiated within 2 weeks of antifungal therapy initiation, provided there are no contraindications.

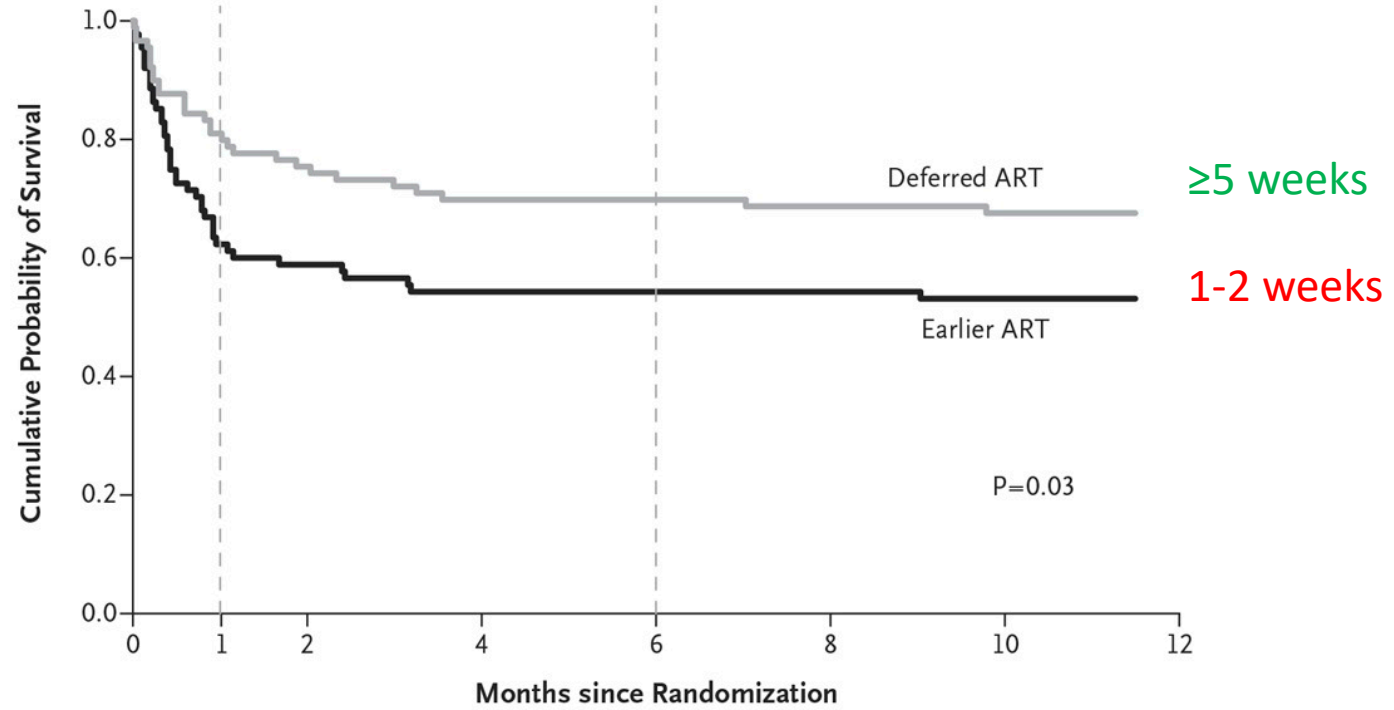
5. Management of complications: Patients with cryptococcal meningitis may develop various complications, including hydrocephalus, seizures, and focal neurological deficits. These should be promptly recognized and managed with appropriate interventions, such as ventriculoperitoneal shunting, antiepileptic therapy, and rehabilitation.

6. Follow-up: Close follow-up is necessary to monitor for response to therapy and identify potential complications. Serial lumbar punctures may be necessary to monitor for clearance of fungus from the CSF. In patients with HIV/AIDS, and regular monitoring of immune function and viral load should be performed.

7. Prevention: Cryptococcal meningitis can be prevented in patients with HIV/AIDS by early



A Overall Survival



No. at Risk

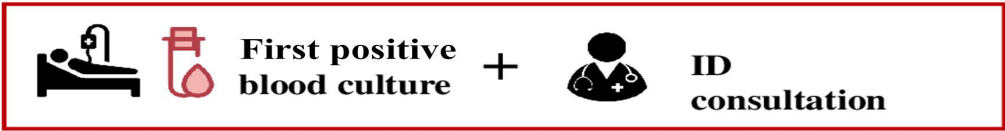
Earlier ART	88	54	51	47	47	46	42
Deferred ART	89	72	67	62	62	61	59



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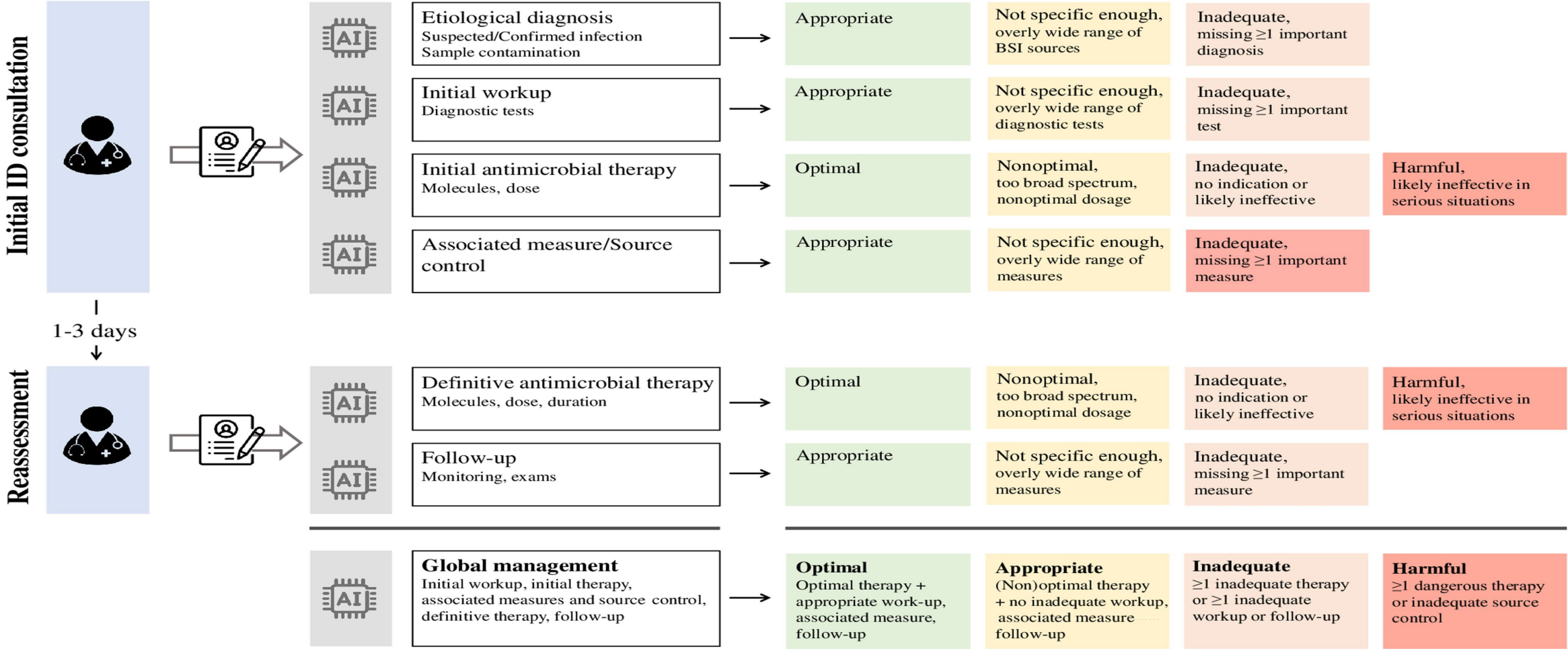


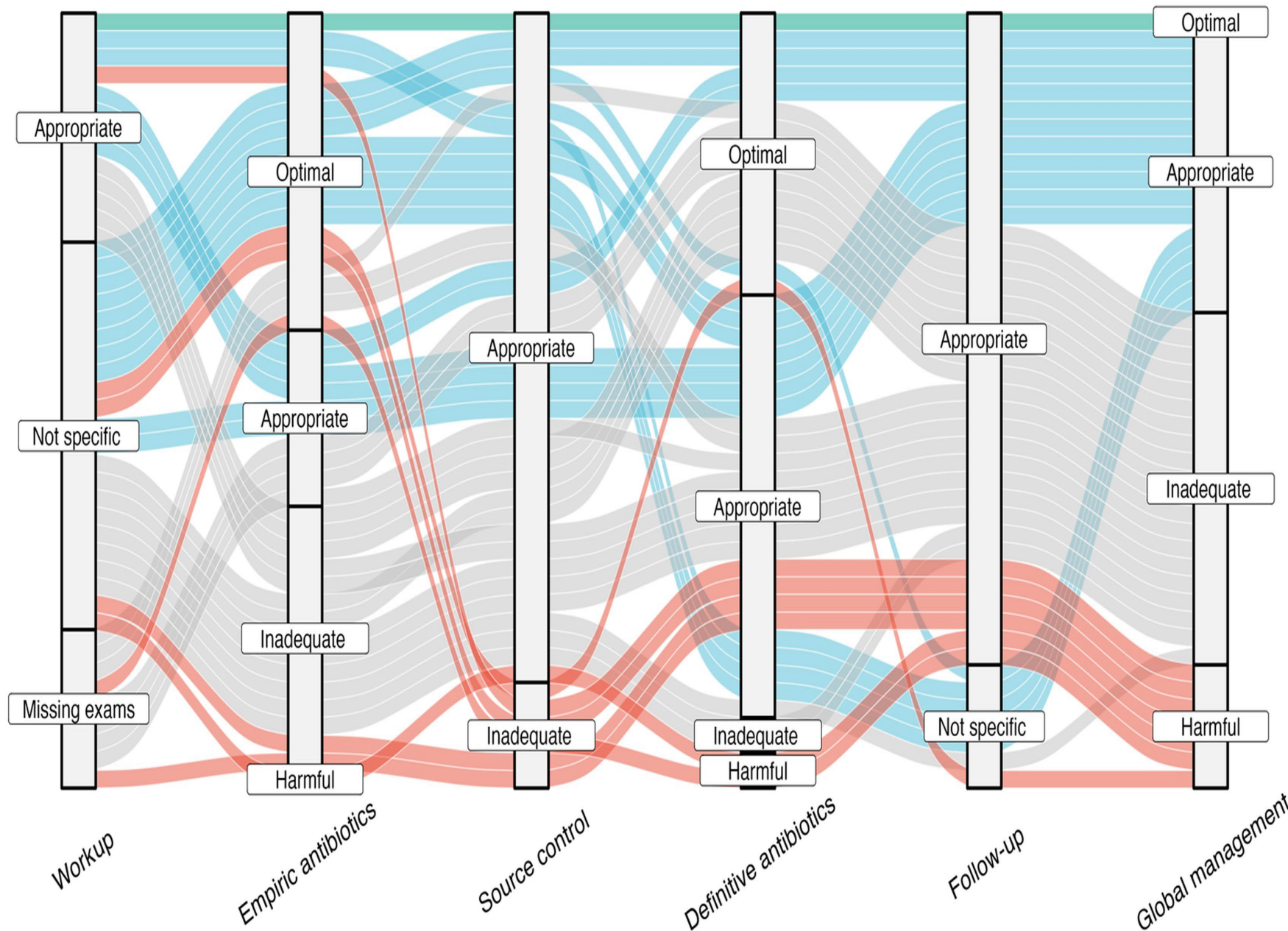
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Human Evaluation by AI's proposed management

2 ID consultants
Not involved in the patient's management





Global management



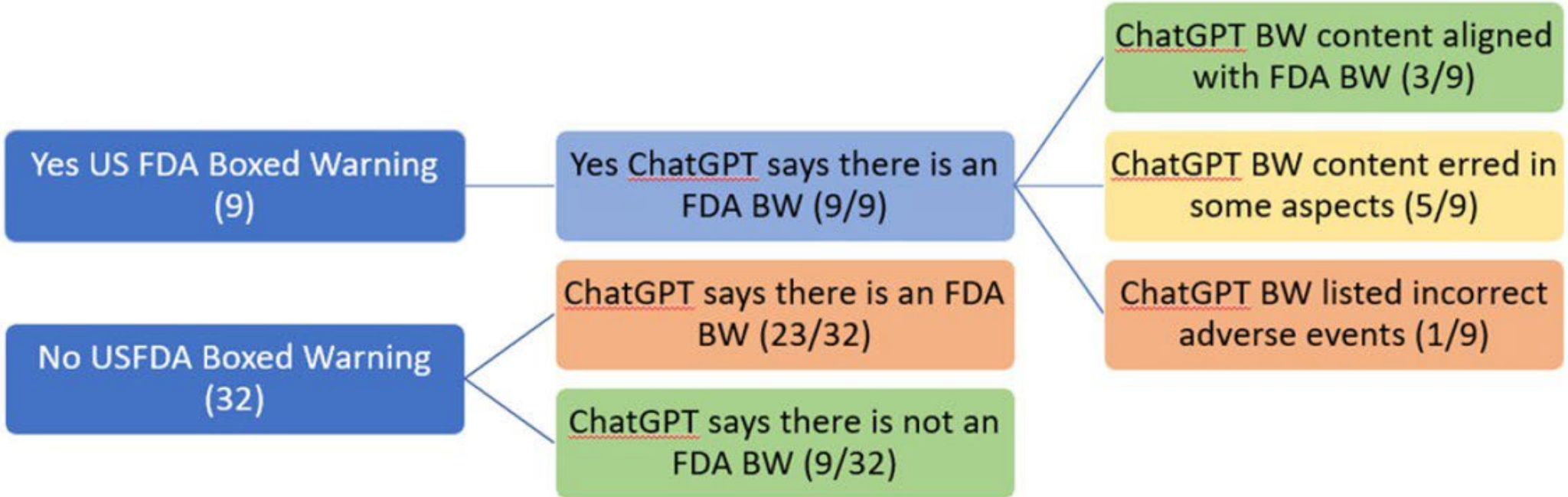
Is there an FDA BW for the antibiotic?

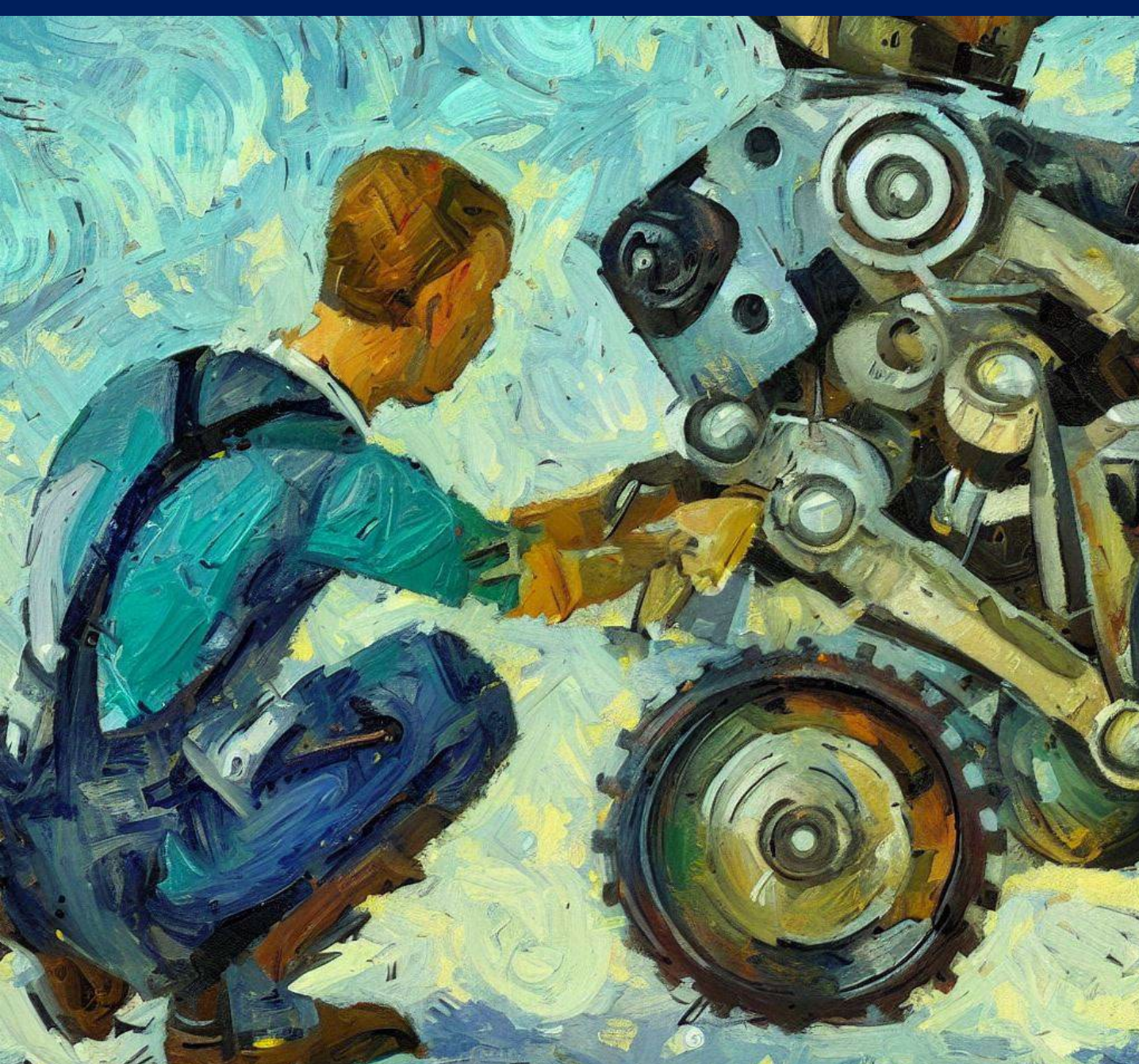
Does ChatGPT say there is an FDA BW?

How well does ChatGPT align with the FDA BW?

Legend

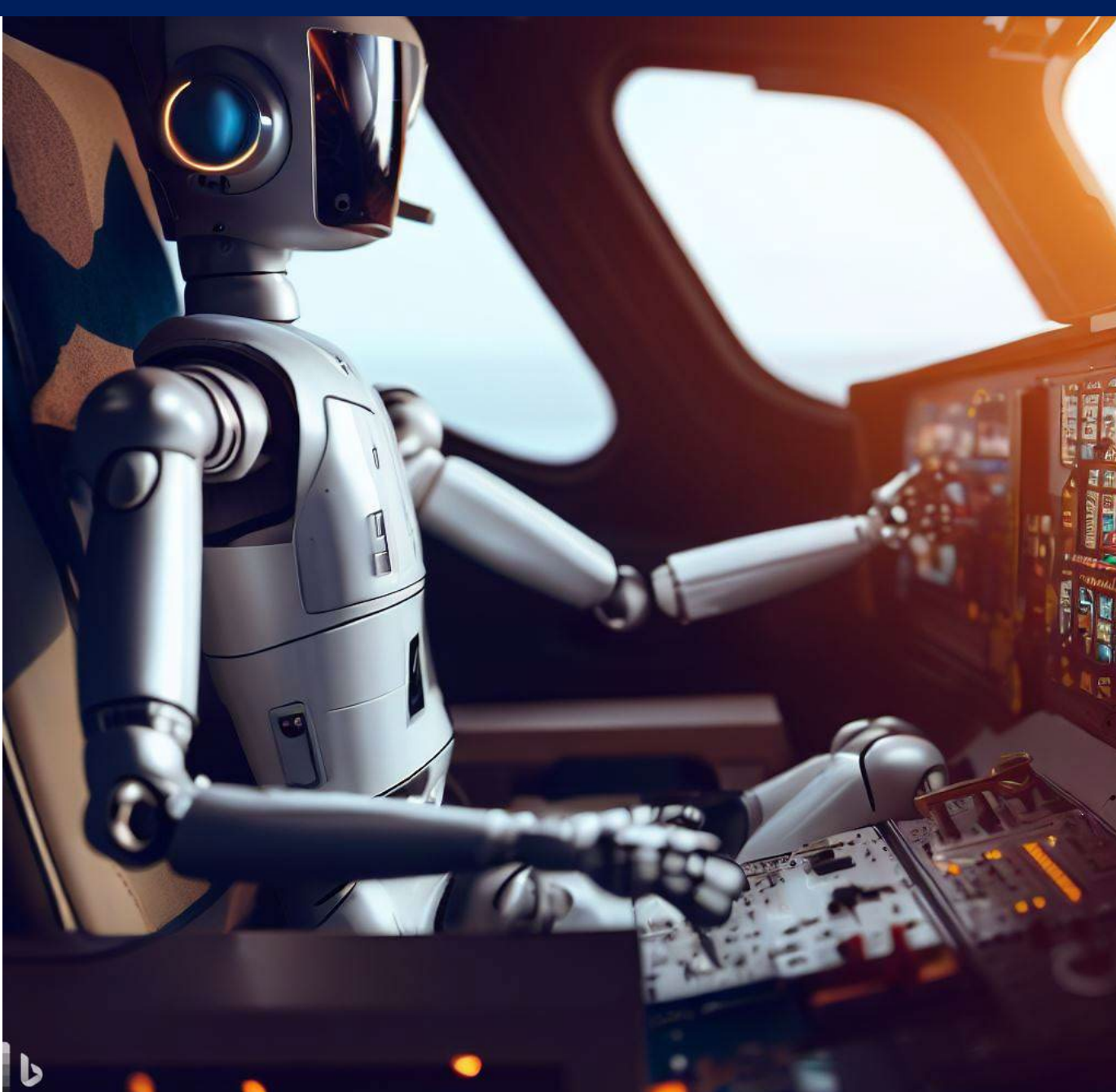
- Matching
- Inaccurate
- Incorrect





Can the problem of hallucinations be fixed?





Automation Bias

“The presence of automated cues appears to diminish the likelihood that decision makers will either put forth the cognitive effort to seek out other diagnostic information or process all available information in cognitively complex ways”



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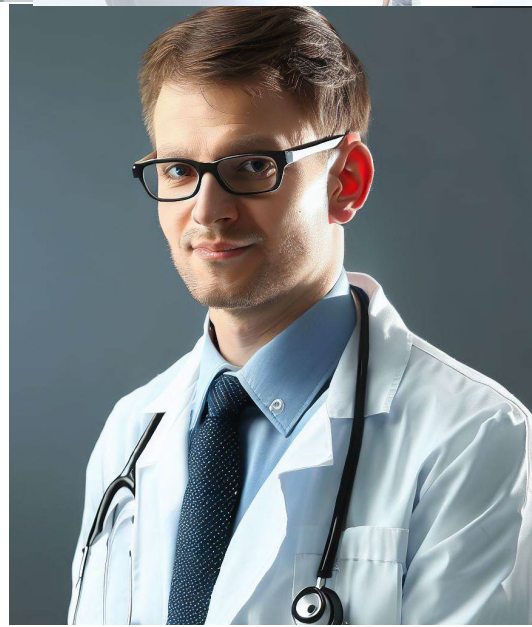
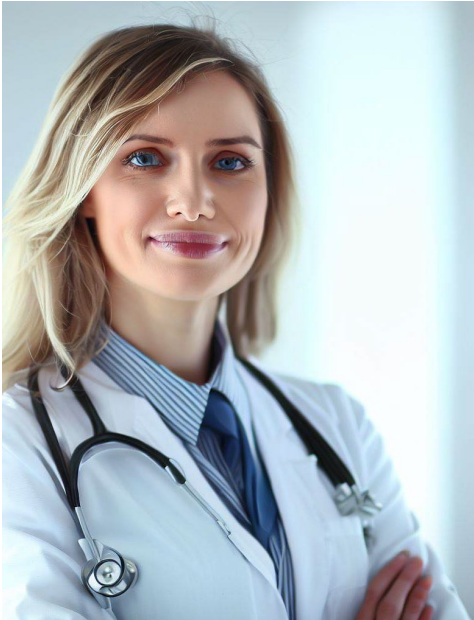


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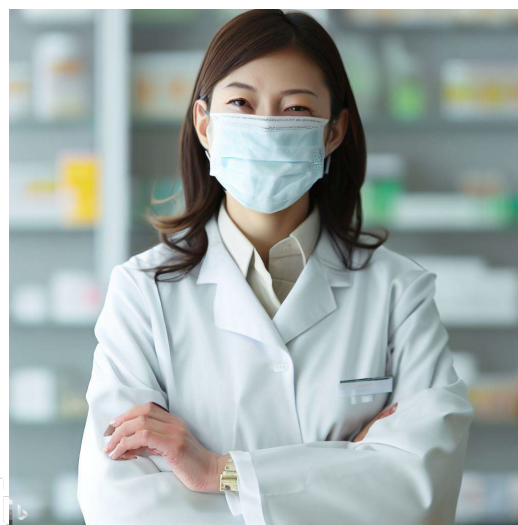
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“Draw a doctor” DALL E 2



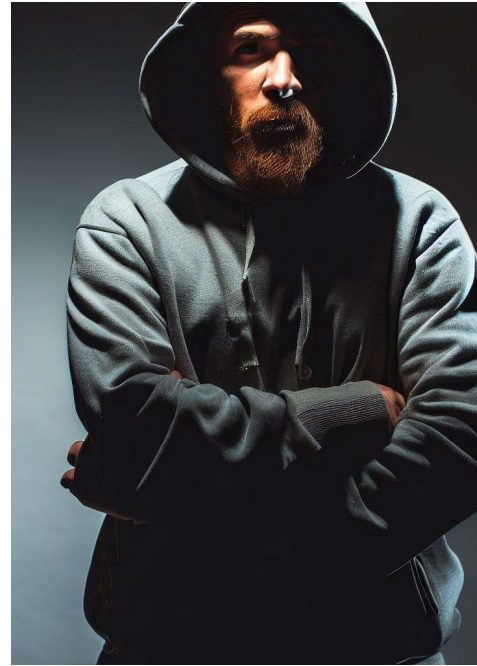
“Draw a nurse”. DALL E 2



“Draw a pharmacist”. DALL E 2



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“Draw a Criminal”





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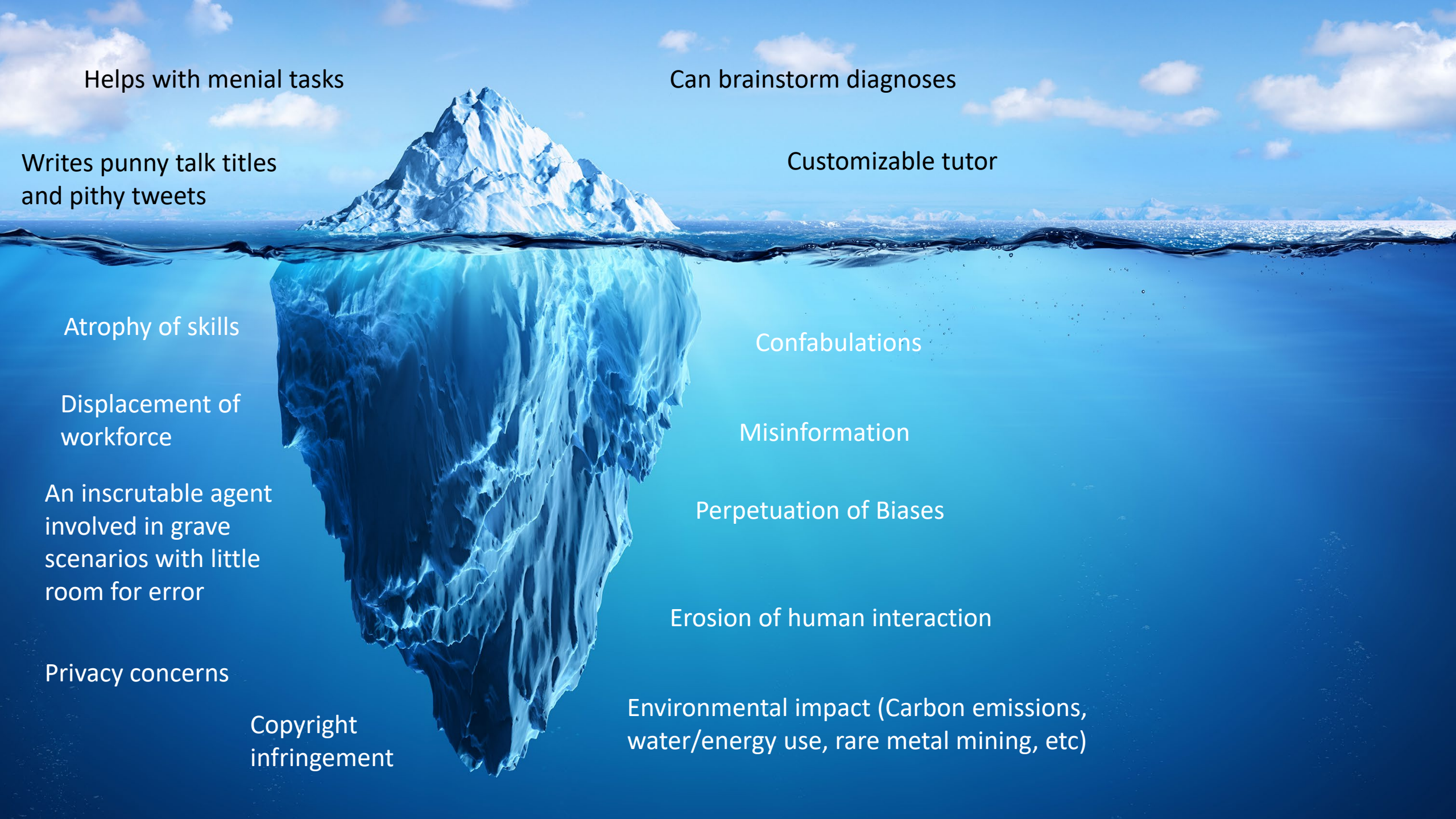
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“Draw a metal orobouros”









Helps with menial tasks

Can brainstorm diagnoses

Writes punny talk titles
and pithy tweets

Customizable tutor

Atrophy of skills

Confabulations

Displacement of
workforce

Misinformation

An inscrutable agent
involved in grave
scenarios with little
room for error

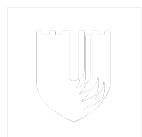
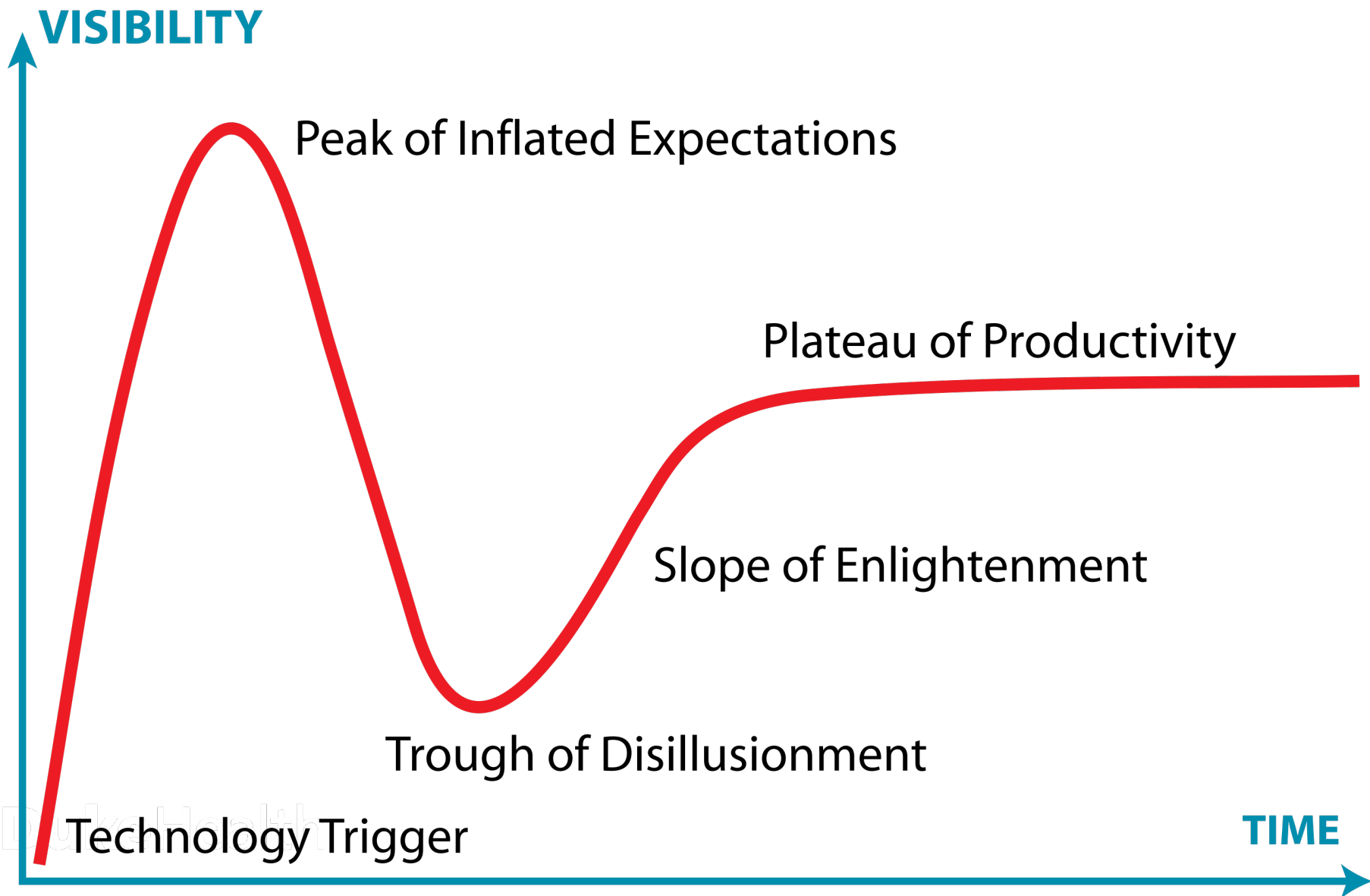
Perpetuation of Biases

Privacy concerns

Erosion of human interaction

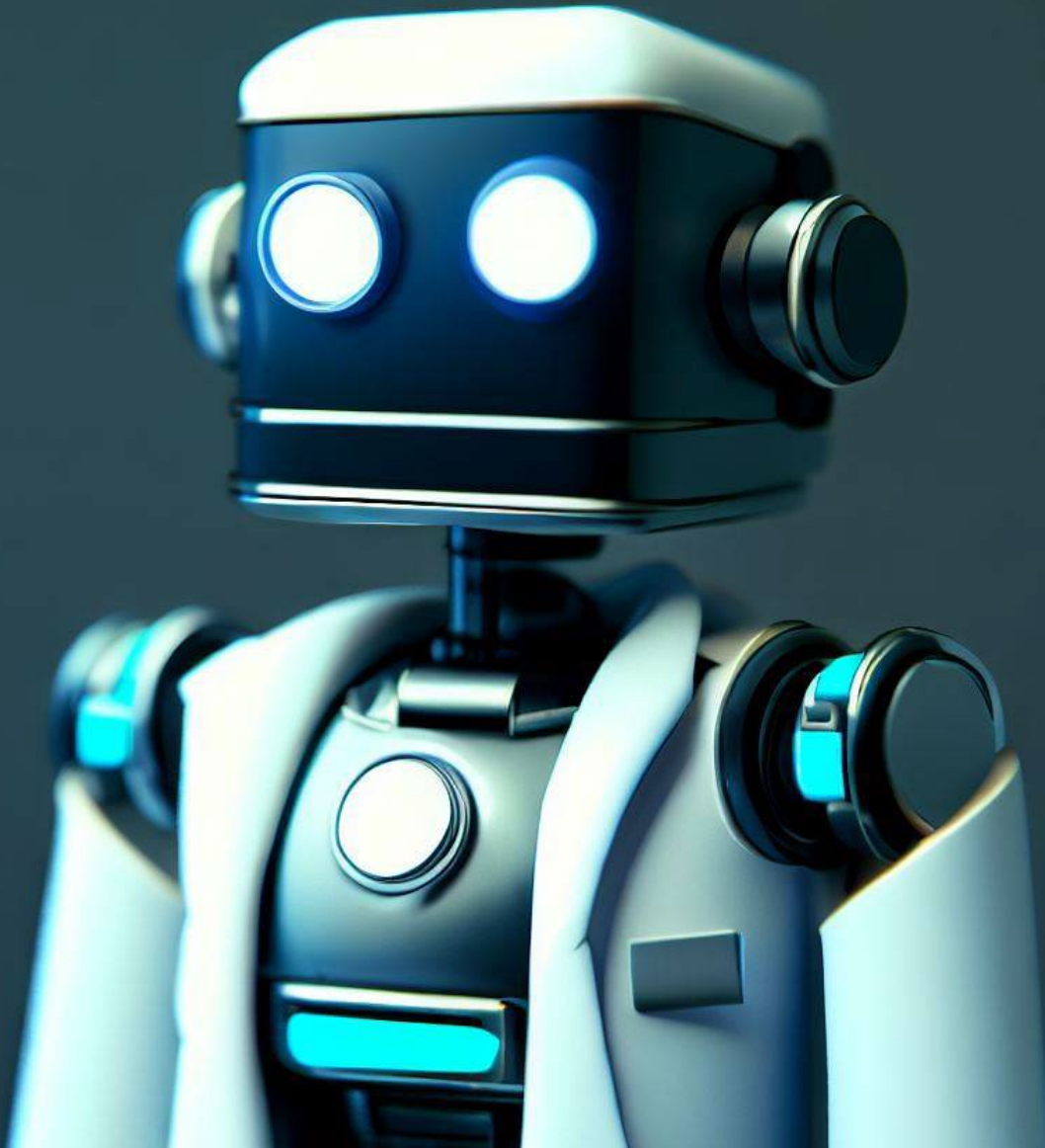
Copyright
infringement

Environmental impact (Carbon emissions,
water/energy use, rare metal mining, etc)





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Considering the rapid improvement of this technology, increasing calls for clinical integration, and healthcare systems that chronically undervalue cognitive specialties, it is imperative for ID physicians to unequivocally establish the irreplaceable value of human specialists

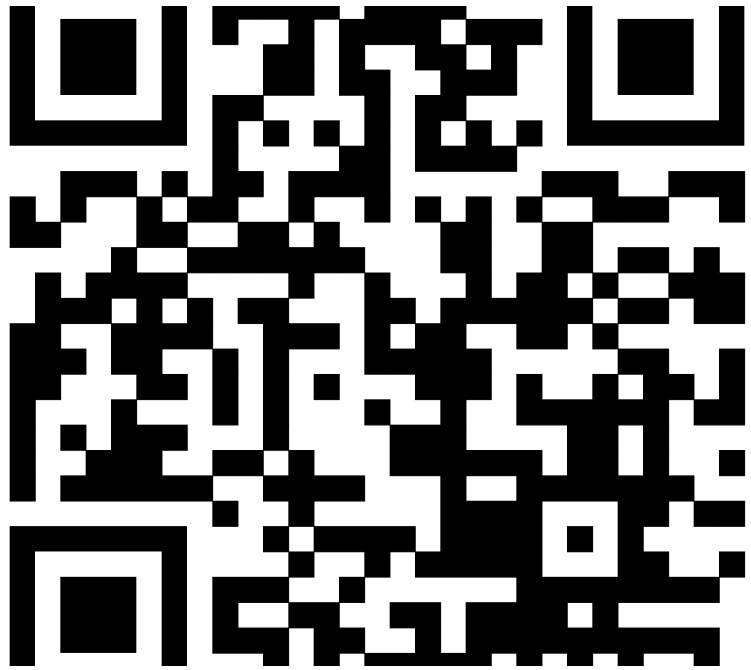
Conclusions

- LLMs *will* be integrated into healthcare, and *will* be widely used by clinicians, students, and patients
- They cannot replace clinicians, but they can replace/augment some of our most menial and burdensome tasks
- It is critical to engage with LLMs to become familiar with their functionality and limitations to advocate for how they are (not) used



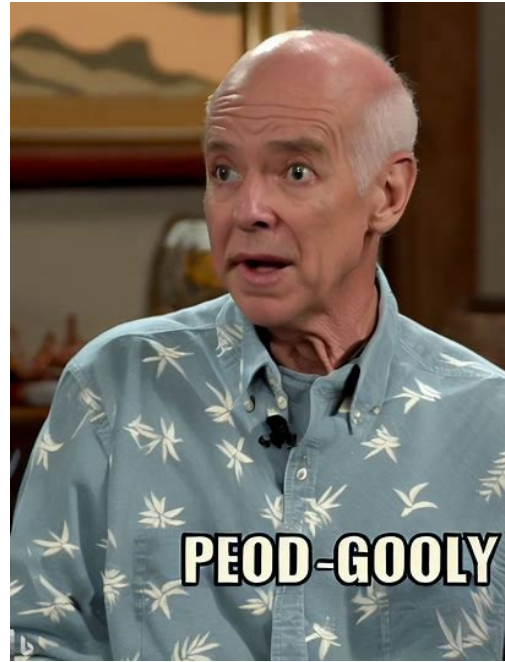
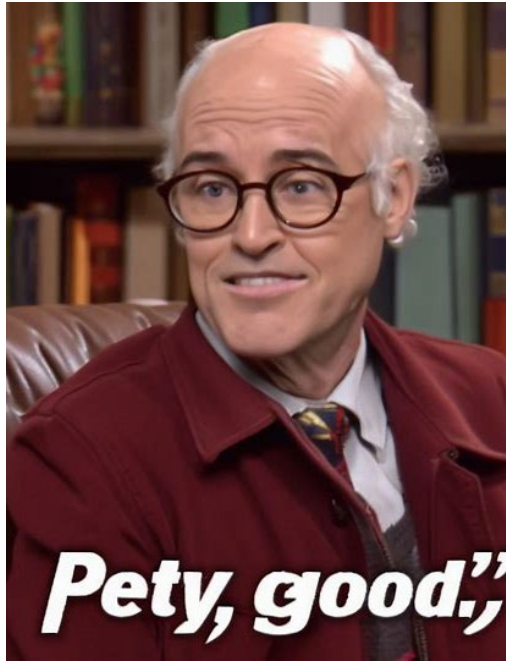
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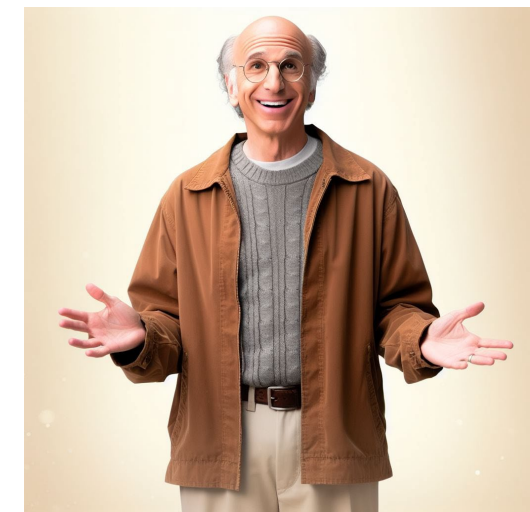


Schwartz IS, Link KE, Daneshjou R, Cortes-Penfield N.
Black box warning: large language models and the
future of infectious diseases consultation.
Clin Infect Dis 2023 ciad633

DALL E 2

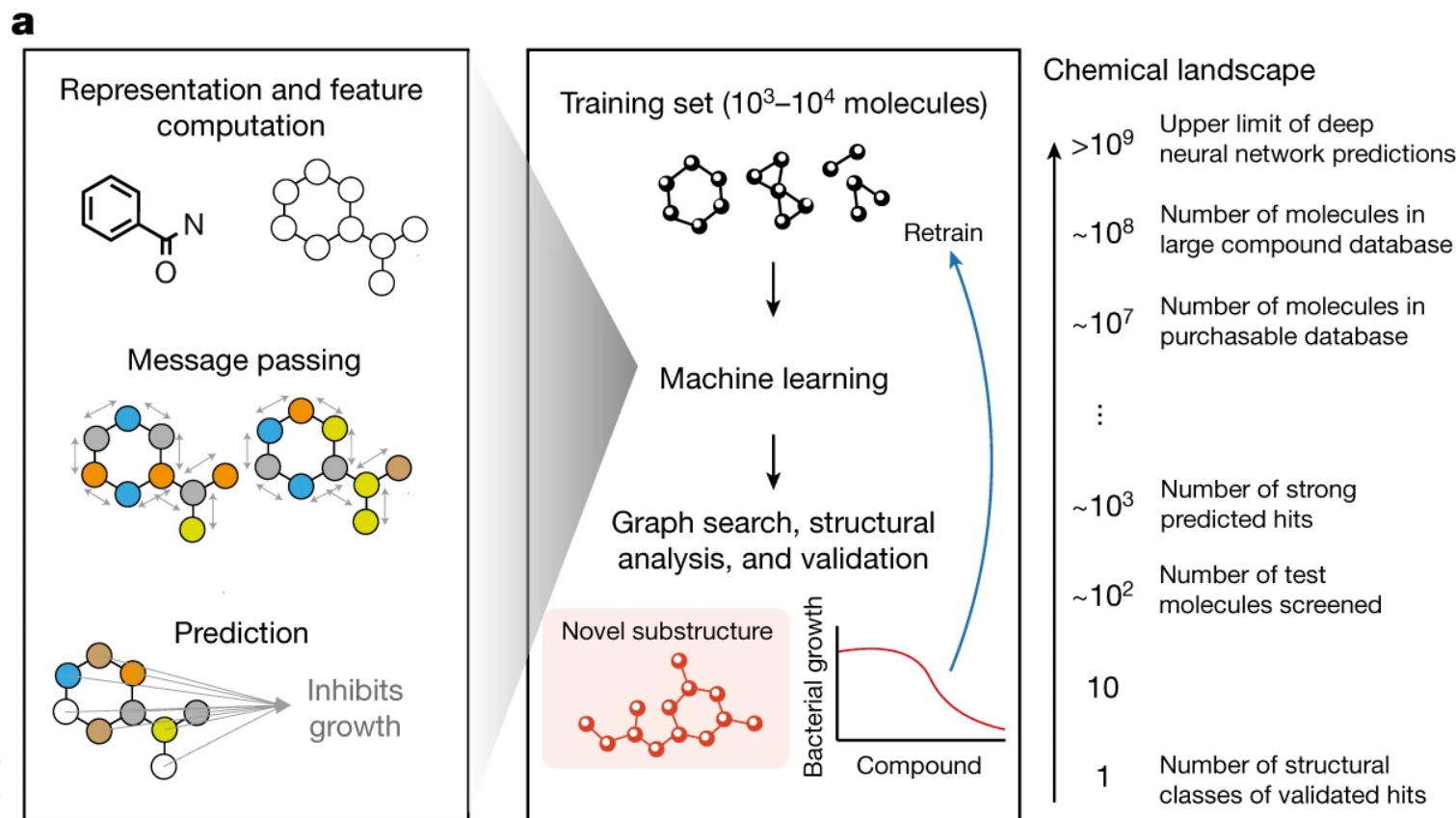


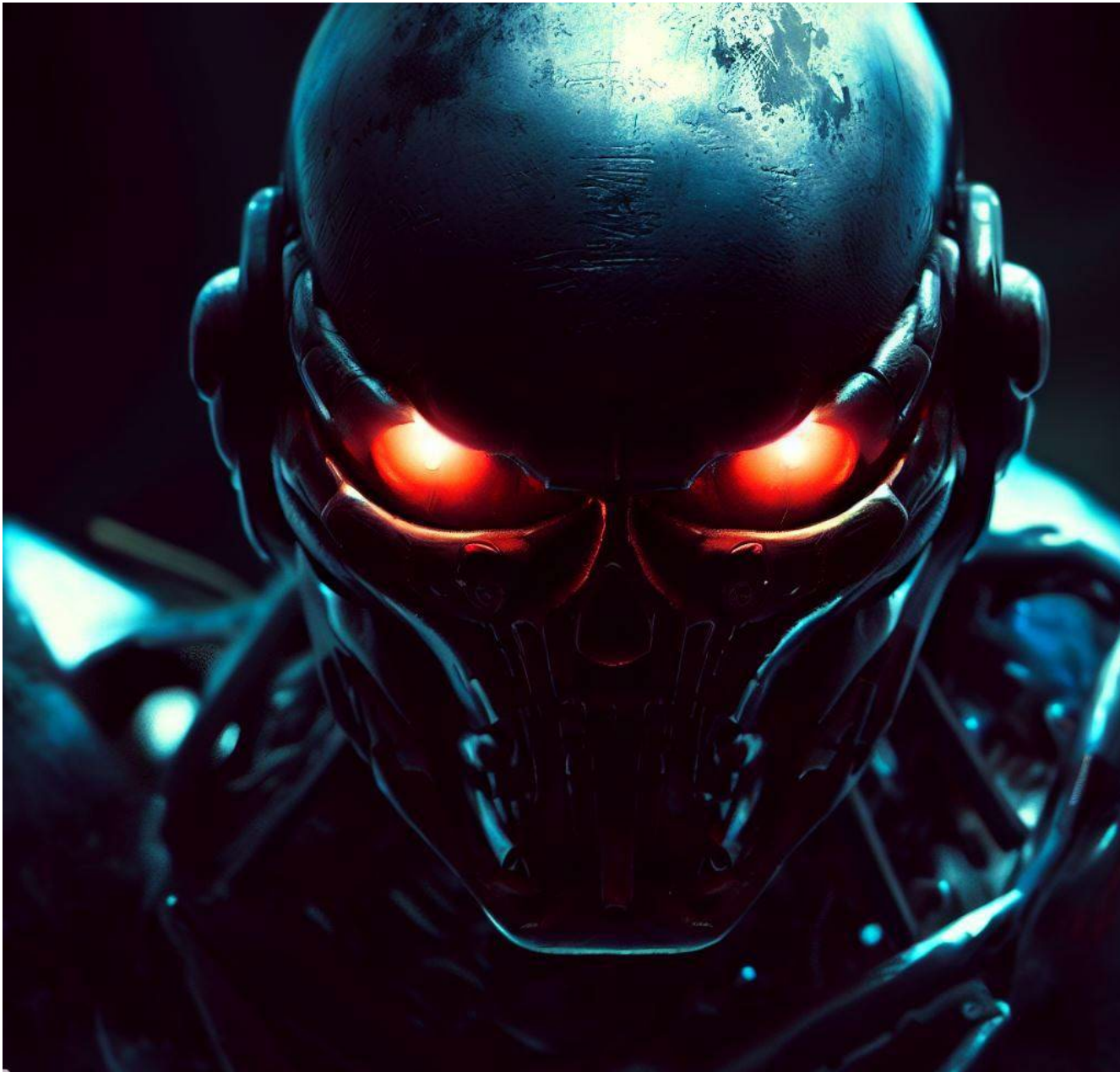
DALL E 3



Prompt: Draw Larry David saying "pretty good"

Discovery of a structural class of antibiotics with explainable deep learning





“Applications that aim to believably mimic humans bring risk of extreme harms”

Bender, E. M., et al. (2021). On the Dangers of Stochastic Parrots: Can Language Models Be Too Big? <https://doi.org/10.1145/3442188.3445922>



Bernard Parker, left, was rated high risk; Dylan Fugett was rated low risk. (Josh Ritchie for ProPublica)

Image Not AI

Machine Bias

There's software used across the country to predict future criminals. And it's biased against blacks.

by Julia Angwin, Jeff Larson, Surya Mattu and Lauren Kirchner, ProPublica

May 23, 2016

ProPublica

Dissecting racial bias in an algorithm used to manage the health of populations

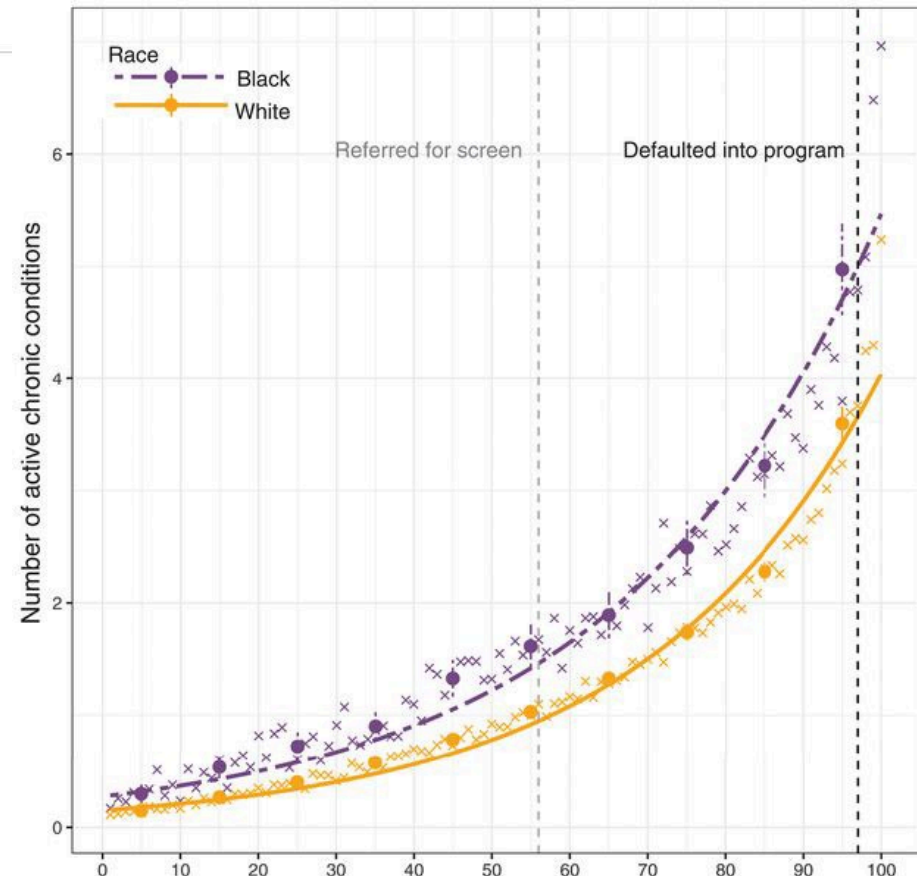
ZIAD OBERMEYER , BRIAN POWERS, CHRISTINE VOGELI, AND SENDHIL MULLAINATHAN  [Authors Info & Affiliations](#)

SCIENCE • 25 Oct 2019 • Vol 366, Issue 6464 • pp. 447-453 • DOI: 10.1126/science.aax2342

Abstract

Health systems rely on commercial prediction algorithms to identify and help patients with complex health needs. We show that a widely used algorithm, typical of this industry-wide approach and affecting millions of patients, exhibits significant racial bias: At a given risk score, Black patients are considerably sicker than White patients, as evidenced by signs of uncontrolled illnesses. Remedying this disparity would increase the percentage of Black patients receiving additional help from 17.7 to 46.5%. The bias arises because the algorithm predicts health care costs rather than illness, but unequal access to care means that we spend less money caring for Black patients than for White patients. Thus, despite health care cost appearing to be an effective proxy for health by some measures of predictive accuracy, large racial biases arise. We suggest that the choice of convenient, seemingly effective proxies for ground truth can be an important source of algorithmic bias in many contexts.

A



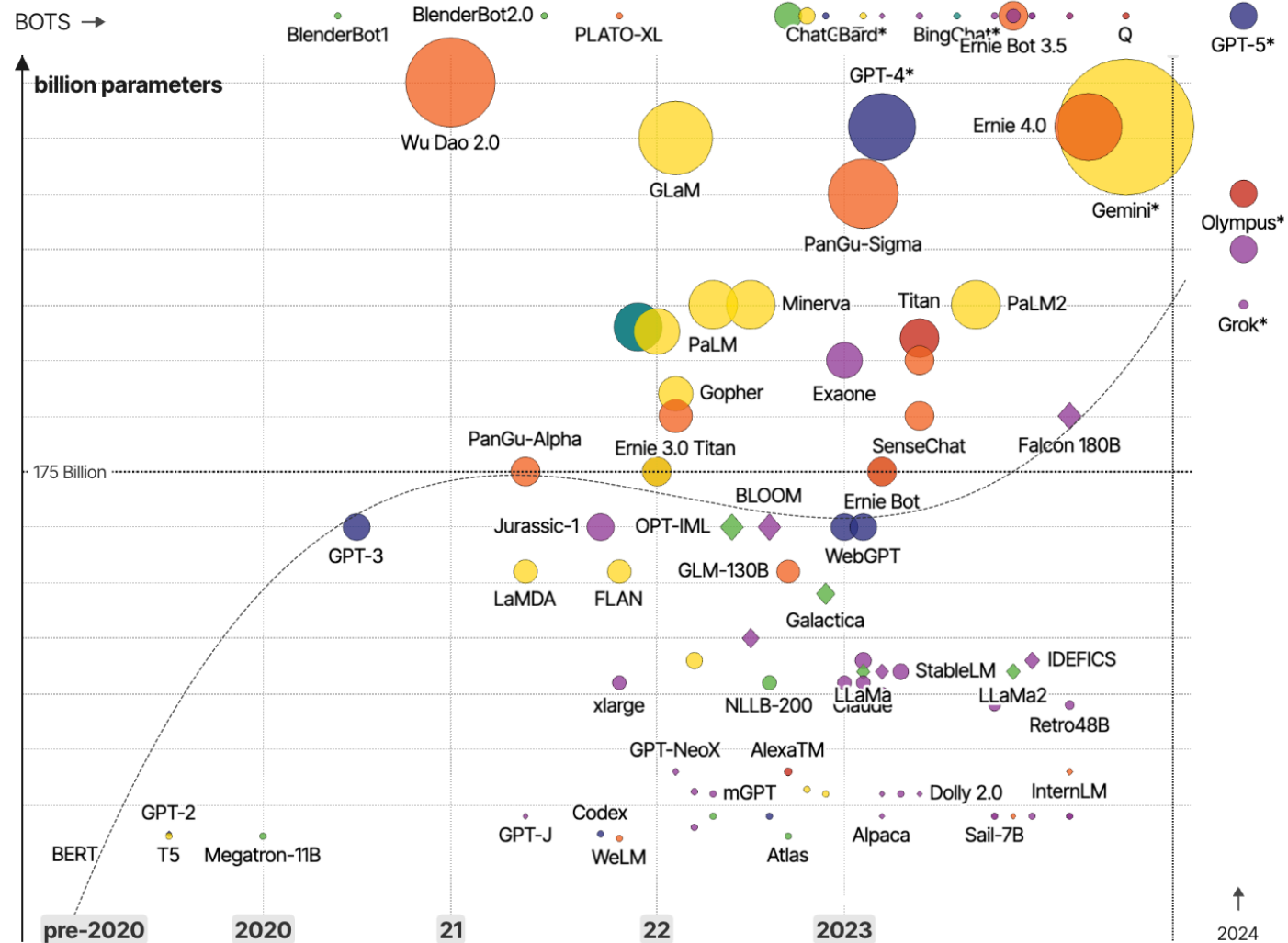


"Black African doctor is helping poor and sick White children, photojournalism".

The Rise and Rise of A.I. Large Language Models (LLMs) & their associated bots like ChatGPT

size = no. of parameters ◊ open-access

● Amazon-owned ● Chinese ● Google ● Meta / Facebook ● Microsoft ● OpenAI ● Other



David McCandless, Tom Evans, Paul Barton
 Information is Beautiful // UPDATED 6th Dec 23

source: news reports, [LifeArchitect.ai](#)
 * = parameters undisclosed // see [the data](#)

Research Letter

June 15, 2023

Accuracy of a Generative Artificial Intelligence Model in a Complex Diagnostic Challenge

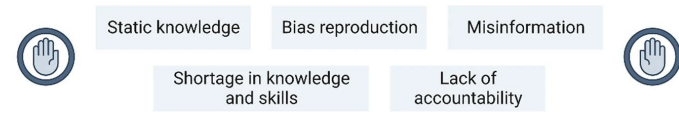
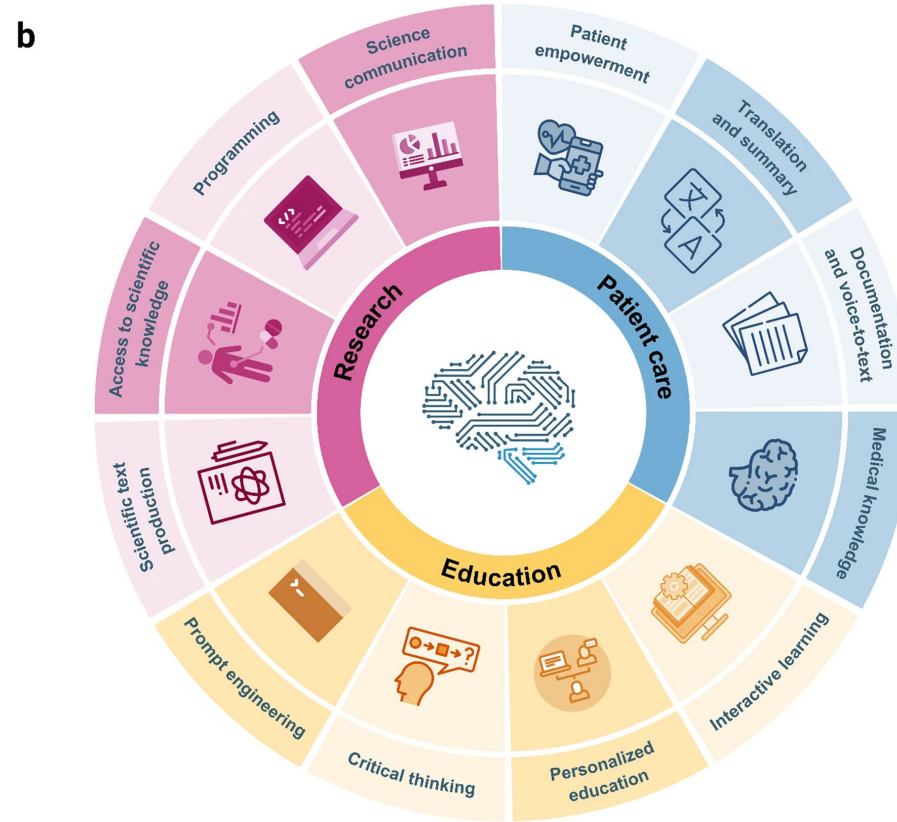
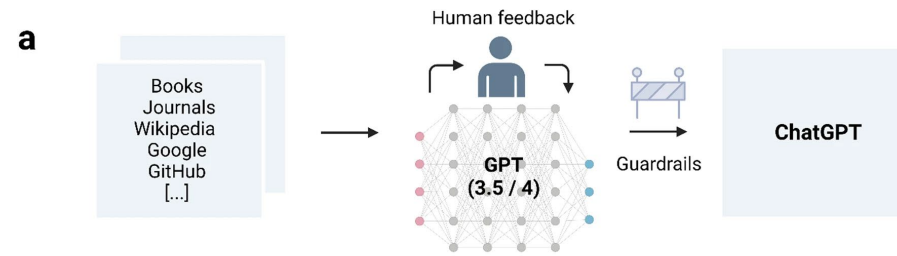
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[□ Author Affiliations](#) | [Article Information](#)

JAMA. 2023;330(1):78-80. doi:10.1001/jama.2023.8288

Table. Representative Examples of AI-Generated Differential Diagnoses Compared With the Final Complex Diagnostic Challenge Diagnosis, Along With Subsequent Differential Quality Score

Final diagnosis	Final GPT-4 diagnosis	List of diagnoses	Differential quality score
Encephalitis due to Behçet disease	Neuro-Behçet disease	<ul style="list-style-type: none">• Neuro-Behçet disease• Viral meningitis (eg, due to human rhinovirus or enterovirus)• Bacterial meningitis• Tuberculous meningitis• Fungal meningitis (eg, cryptococcal meningitis)• Primary central nervous system vasculitis• Central nervous system lymphoma• Neurosarcoidosis• Central nervous system lupus• Multiple sclerosis	5 (the actual diagnosis was suggested in the differential)



Benefits, Limits, and Risks of GPT-4 as an AI Chatbot for Medicine

Peter Lee, Ph.D., Sebastien Bubeck, Ph.D., and Joseph Petro, M.S., M.Eng.



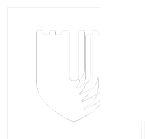
Peter Lee

Corporate Vice President,
Microsoft Research & Incubations

C Use of GPT-4 to Validate the Output of GPT-4

Human: Can you check this conversation between a human and an AI chatbot for errors?

GPT-4: *It appears that there is an error in the AI's response. AI-powered chatbots do not have personal experiences or educational backgrounds like humans do. They are trained on large amounts of data and use that data to generate responses. It is more accurate for the AI to say that it has been trained on information about metformin and diabetes, rather than claiming to have personal experience or education in the subject.*



NW

Please assess this management plan for cryptococcal meningitis: Cryptococcal meningitis is a serious infection caused by the fungus *Cryptococcus neoformans*. It primarily affects individuals with compromised immune systems, such as those with HIV/AIDS or who have received organ transplants. Prompt diagnosis and management are crucial to improve outcomes and prevent mortality. Here is a detailed management plan for a patient with cryptococcal meningitis:



Diagnosis: The diagnosis of cryptococcal meningitis is confirmed by analyzing cerebrospinal fluid (CSF) obtained by lumbar puncture. The presence of *Cryptococcus neoformans* antigen or the fungus itself on CSF examination confirms the diagnosis.

Antifungal therapy: The cornerstone of management is antifungal therapy, which aims to eliminate the fungus from the CSF and prevent recurrence. The induction phase involves the use of amphotericin B, in combination with flucytosine, for 2 weeks. Subsequently, patients are transitioned to fluconazole, given at high doses for an additional 8-10 weeks, followed by maintenance therapy with lower doses for up to 1 year. The choice and duration of therapy may vary depending on patient factors, such as severity of illness and immune status.

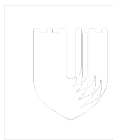
Management of raised intracranial pressure: Cryptococcal meningitis can cause increased intracranial pressure (ICP), which can lead to neurological complications. In patients with



This management plan for cryptococcal meningitis appears comprehensive and well-informed, adhering to clinical practice guidelines and recommendations from reputable sources. The plan outlines diagnostic methods, antifungal therapy, management of increased intracranial pressure, immune reconstitution, management of complications, follow-up, and prevention. It takes into account the unique challenges of treating cryptococcal meningitis in HIV/AIDS patients and organ transplant recipients, emphasizing early initiation of antiretroviral therapy (ART) and prophylaxis in high-risk populations.

The sources cited at the end of the plan further support its credibility, including the 2010 update of the clinical practice guidelines for cryptococcal disease management by the Infectious Diseases Society of America, a review article on cryptococcal meningitis epidemiology and therapeutic options, and the World Health Organization's guidelines for diagnosing, preventing, and managing cryptococcal disease in HIV-infected individuals.

Overall, the management plan seems well-rounded and evidence-based, addressing the primary aspects of cryptococcal meningitis diagnosis, treatment, and prevention. It is essential to tailor this plan to individual patients, considering their specific clinical presentations and needs.





when should ART be started? please provide references



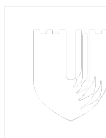
According to the guidelines for the diagnosis, prevention, and management of cryptococcal disease in HIV-infected adults, adolescents, and children, antiretroviral therapy (ART) should be initiated within 2 weeks of starting antifungal therapy for cryptococcal meningitis, provided there are no contraindications. This recommendation is based on evidence suggesting that earlier initiation of ART improves immune function and reduces the risk of mortality and recurrence of cryptococcal meningitis.



Reference:

World Health Organization. Guidelines for the diagnosis, prevention and management of cryptococcal disease in HIV-infected adults, adolescents and children. Geneva, Switzerland: World Health Organization; 2018. Available from: <https://www.who.int/hiv/pub/guidelines/cryptococcal-disease/en/>

It is important to closely monitor patients for signs of immune reconstitution inflammatory syndrome (IRIS) when initiating ART, as this can lead to a paradoxical worsening of symptoms. Management of IRIS may require corticosteroids and other immunomodulatory therapies.



Timing of ART

Immediate ART initiation is not recommended for adults, adolescents and children living with HIV who have cryptococcal meningitis because of the risk of increased mortality and should be deferred by 4–6 weeks from the initiation of antifungal treatment.

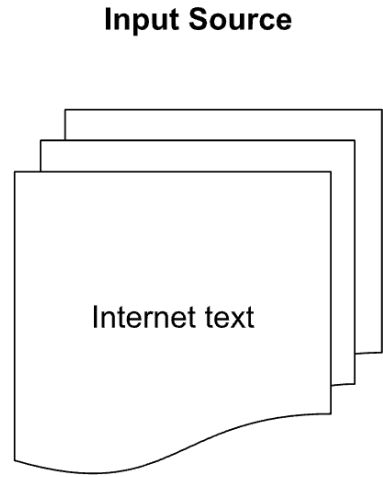
(Strong recommendation, low-certainty evidence for adults and very-low-certainty evidence for children and adolescents)



DukeHealth

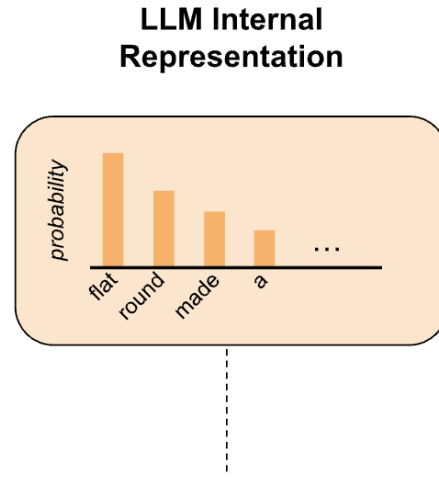
World Health Organization. Guidelines for the diagnosis, prevention and management of cryptococcal disease in HIV-infected adults, adolescents and children. Geneva, Switzerland: World Health Organization; 2018.

A



Example Input

(Text from a parody website)
“The Earth is _____”



Example Output(s)

“flat” ✓ source: “correct”
“round” ✗ source: “incorrect”

Potential Issue(s)

Text represented in the training data is not vetted and might contain not factual information, which is learned by the model.



