A Lesson from the Serpent:

Artificial Intelligence and the Healer's Art

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"Everything done by a physician can be done better by a machine," our lecturer began, "not to mention more effectively, efficiently, and safely—oh, and at a *far* cheaper cost, too." Silence gripped the darkened lecture hall in stark contrast to the excited chatter just moments before. As naive and jubilant first-year medical students in our earliest weeks of classes[1], we were about to be treated with a dose of reality—doctor's orders. Like all industries, we learned, healthcare was ripe for automation. We proceeded to see how every task physicians performed, set of facts they memorized, exact diagnoses they made, or support they provided for patients could—and would—be outsourced to computers. After all, compared with humans, computers did not forget and remembered far more. They were capable of both greater precision and accuracy. They did not get hungry or tired or emotional. They did not burn-out the way you or I might, suffering from disillusionment when faced with copious administrative tasks. In the end, as our lecturer saw it, it was basic arithmetic: the fundamental unit of human intelligence, the neuron, would be outpaced by artificial neurons for a fraction of the energy cost (1). While computers did not yet fully rival the physician, it would only be a matter of time. Medical artificial intelligence (AI) would put physicians to shame.

As we shifted in our seats and traded glances, our lecturer did not spare us with only vague proclamations. No, he went into specifics, and *eagerly*, at that. Beginning with image analysis, a pillar of modern medicine, we learned that AI could already match dermatologists at diagnosing skin cancer (2), beat radiologists at diagnosing pneumonia

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1. Much to the irritation of our (oft comparatively-sullen) upperclassmen colleagues.

from chest radiographs (3), overcome ophthalmologists at diagnosing diabetic retinopathy (4), and triumph over experts in the detection of cervical cancer (5). Beyond imaging, AI had exceeded doctors in using electronic health records (EHRs) to predict patient death from heart disease (6) or curate problem lists to identify clinically significant issues (7). Evidence even indicated that patients preferred talking with a computer over a human, revealing more confidential information without fear of judgement (8). Medical AI could exceed top human scores on tests resembling Step One of the U.S. Medical Licensing Examination (9) and was being applied to a wide array of robotic surgical applications (10). Google, Apple, Amazon, Microsoft, Facebook, and every other Big Tech company was *pouring* resources into medical AI, and Moore's Law was *not* in our favor.[2] In 2011, IBM's Watson took down the King of Jeopardy. Its next target? Medicine.

And with that, the lights flickered back on. Needless to say, the smiles were gone. Dazed, we packed up our things and trickled out from the lecture hall. As the speaker removed his microphone, my eyes were drawn to his pristine white coat—a symbol of our order—and I felt the sharp sting of betrayal. To this day, I am not quite sure why he was so cheery; why he seemed to relish in the destruction of his own profession. Maybe it was satisfaction that he 'got in' right before the end? Hell, maybe he just had a special place in his heart for terrorizing first-year medical students.[3] Whatever his reasons, I found myself

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2. Moore's Law states that every year the number of transistors on a computer chip double while the costs are halved. The law is an observation of the exponential growth of computing power.
3. A far from unheard-of phenomenon.

missing the lecture's point. Why tell us all of that if there was nothing to do about it? There I was, a first-year medical student (an MD/PhD student, at that, with a full 7-8 years of training ahead of me *before* residency) essentially just told that I was wasting my time. As with many of my classmates, shock soon gave way to skepticism, and then to doubt. No, I reassured myself. How could AIs surpass the brain when we still scarcely understood the complexity and nuance of *human* intelligence? Surely medicine, a discipline so dynamic in its practice—a delicate mix of science, humanism, and artistry—would be one of the *last* professions to fall. It was an interesting lecture, but it was not anything that I or anyone else needed to worry about. I shut the idea of AI out of my mind. Yet, despite my best efforts, I could never escape the subject.

The spring of 2017, about halfway through my PhD, the exhilarating and the gut-wrenching happened: my advisor took a job at Stanford University, and the whole lab and I packed up and moved cross-country from the placid fields of Iowa to the suburban jungle of the San Francisco Bay Area. Just like that, I found myself living at the very epicenter of the AI revolution—the whirring, mechanized heart of Silicon Valley.[4] As I continued my research at Stanford before I would return to complete medical training in Iowa, reminders of AI droned all around me. Self-driving cars equipped with LiDAR sensors cruised the streets, security robots affixed with dozens of cameras patrolled parking lots, and giant billboards boldly advertised, "Mission Critical Artificial Intelligence." As if that was not enough, a year later I learned that the first-ever FDA-

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4. An artificial heart does not beat, after all. Beating is *inefficient* (11).

approved *autonomous* medical AI was destined for none other than my intended specialty, ophthalmology.[5] Somehow my journey away from AI had led me right to its thrumming core.

Initially, what drove me away from AI was fear. Fear of the directions medicine and society were headed. Fear that the parts of medicine I loved most would be stripped away. Honestly, I am *still* afraid. Yet, it is clear to me now that fear alone will not do anyone any good; not myself, not my classmates, not physicians, and not the patients we serve. Fear can debilitate, but it can also *galvanize*. In an age when it is hard to discern fact from fiction and hype from hyperbole, I set out here to find truth. When it comes to medical AI, I have learned, not all is what it seems. Rather than see AI as a threat, we should see it as an opportunity. Medical AI has the potential to rekindle the dying flame of something vital our profession has begun to lose: our role as true *healers*. After all, there is more to healing than diagnosis and treatment, and there is more to medicine than information and technology. Future and current physicians should take the time to understand the context and realities underlying medical AI, and endeavor to shape it.

Today we live in an Information Age, one in which the excess of information has mutated from liberating to crippling. In 1950, it was estimated that the time it took for medical knowledge to double was 50 years. By 1980, it was 7 years. By 2010, 3.5 years. In 2020, it is estimated that the wealth of medical knowledge will *double* in just 73 *days* (12). There is no possible way a human can process all of this information. But it is not only the

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5. Developed at none other than our very own University of Iowa, as a matter of fact.

knowledgebase that is increasing, it is also the data. Physicians are expected to process and record more detailed patient information than ever before. In fact, studies have shown that they spend more time entering information into the EHR than on any other activity (13, 14).[6] Pressed for time, physicians conduct the single most important interaction they have—face-to-face with the patient—through the dull glow of a computer screen and over the galling rattle of a keyboard. Not only has this damaged the physician-patient relationship, but it is considered the leading cause of physician burn-out as of 2019 (16). Moreover, today's physicians have unprecedented access to consults, tests, labs, and imaging studies. Soon patients will generate their own biodata from wearable sensors, and physicians will have access to the totality of their genetic information, their "genome". When it comes to "omes," medicine is just getting started. As every facet of a biological system becomes increasingly quantifiable, we will soon also have access to exposomes, metabolomes, microbiomes, proteomes, and transcriptomes (17)! Amongst this dizzying array of data, healthcare spending has skyrocketed without concomitant improvements in outcomes. In the U.S. in 2017, we actually witnessed the average life expectancy decrease—a trend not seen since World War I (18). More technology and information does not guarantee better healthcare. In a recent study looking at the effects of physician behavior on patient outcomes, researchers found that merely the affection demonstrated by a provider could improve treatment of allergic

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6. The problems of the EHR run deep. The system has reduced physician productivity and has even been found responsible for patient harm. To make matters worse, many hospitals signed-on to EHR contracts which included "gag clauses," preventing public discussion and dissemination of their problems (15).

reactions (19, 20). Clearly there is more to healing than simply diagnosing and providing treatment, regardless of the technical sophistication.

At least as far back as six-thousand years ago in ancient Sumer, nestled on the lush banks of Mesopotamia's Tigris and Euphrates rivers, healers met with patients and applied their own brands of trusted remedies (21). Rather than channel their magic through femtosecond lasers or computerized tomographical scans, these ancient healers derived their restorative powers from the eternal battle between gods and demons. It was here that the serpent likely emerged as a medical symbol. Known for its danger and ambiguity, it has been suggested that the snake represents the dual realities of a healer's work: sickness and health, life and death. Medical AI too embodies a duality; a choice between two very different futures. Medicine could either become more callous, or experience a renaissance of healing. From ancient Sumer to Egypt, Greece to Rome, and finally Europe to the Western world as a whole, one element of healing has remained steadfast: the importance of the interpersonal connection between healers and the sick (22, 23). The healer has always done more than simply diagnose and treat; he or she has helped the ill understand what was happening to their bodies in the context of their own values and those of society, and he or she has established a relationship based on trust, compassion, and empathy rooted in a shared human experience. Disease is far from an exclusively biological phenomenon. As F. Gonzalez-Crussi writes in *A Short History of Medicine* (23), "The concept of disease is neither sharply defined nor immutable. Diseases are not entities in themselves, but largely constructs of society." While these ideas are

ancient, their powers remain surprisingly modern. When technology and profits take precedence over the physician-patient relationship, the consequences can be disastrous.

On March 3rd 2019, Ernest Quintana was rushed to the Kaiser Permanente medical center in Fremont, California unable to breathe (24). He was dying of chronic lung disease, and his family expected the worst. That night, as Quintana and his granddaughter Annalisia shared grim and fleeting moments together in the curtained confines of their hospital unit, they were told that the physician would come by shortly. What happened next stunned them. Slowly, a telemedicine "robot" with a video screen for a head was wheeled into the room. On screen, the physician appeared to talk to Quintana. Over the next few jarring minutes, he proceeded to discuss the dismal realities of Quintana's state. He told the pair that the imaging results showed hardly any healthy lungs left to work with, and that he did not know if Quintana would even make it home. Hard of hearing in his left ear, Quintana strained to understand that he was being told he was going to die. Amidst the confusion, Annalisia tried to get the doctor closer to her grandfather to improve the audio quality, but the telemedicine device could not get to the other side of the bed. Two days later, Ernest Quintana died. His family, understandably, was devastated. After the incident, Quintana's daughter Catherine remarked, "If you're coming to tell us normal news, that's fine, but if you're coming to tell us there's no lung left and we want to put you on a morphine drip until you die, it should be done by a human being and not a machine." Surely, Ernest Quintana's story is not representative of all the positive things telemedicine offers, but it does showcase the growing divide between physicians and patients.

As this core relationship between healers and the sick has dwindled, the foundations of humanistic medicine have begun to crumble. Sucked up into the 3-4 trillion-dollar[7] medical-industrial complex (25), physicians have found their roles shift from *healers* to *healthcare dispensers*. Perhaps, in light of this deterioration, it is not surprising to see the rise of anti-vaccination groups, "alternative" medicine charlatans, and a belief that somehow Big Pharma has discovered the cure for cancer but is withholding it because it would cost them their profits. While these disparate events may seem unrelated, they actually share a root cause: a loss of trust. As time and energy to connect with patients has slipped away, so too has the trust integral to the relationship between the physician-as-healer and the sick. While modern technology has brought a vast assortment of new tools to the physician's arsenal, too few have been developed using their perspectives, experience, and insights. We learned this lesson keenly with the EHR, and we risk learning it again with AI. No promise of technology is guaranteed, and physicians must actively shape medical AI. But how might they do that if they do not understand it? The digital cloud around AI has swelled thick, and it is difficult to make out the truth. Difficult, but not impossible. Here we will delve into exactly what AI is and is not, and the realities of its arrival in medicine.

Artificial intelligence is one of the most ambiguous terms of today. More a marketing catch-phrase than a specific technology, AI is a topic that is impossible to

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7. When it comes to gigantic numbers reaching into the millions, billions, and trillions, it can be hard to wrap our heads around how these metrics really compare. I once heard a stunning fact that put this into better perspective for me: 1 million seconds equates to about 12 days. 1 billion seconds equates to about 32 *years*. 1 trillion seconds equates to about 32 *thousand* years.

discuss practically without defining its scope. Colloquially, AI is any technology that mimics the functions of the human mind.[8] Depending on whom you talk to, the term AI encompasses everything from chess playing programs to hyper-intelligent digital beings who exceed humans in every cognitive domain. In this essay I focus on the *current* state of the technologies and extrapolate ideas and predictions only from what has been firmly established as possible. Here it is also worth mentioning that modern concepts of AI are not new. The first generation of AI researchers date back to the 1950s with Alan Turing and the advent of digital electronic computers. While the idea of a "general" AI, one capable of switching between many tasks like a human, has long been anticipated, it currently does not exist. All AIs today remain narrowly specific in their functionalities. For decades, AI developers have demonstrated a penchant for shamelessly bold predictions. AI pioneer and Turing Award-recipient Herbert A. Simon predicted in 1965 that, "Machines will be capable, within twenty years, of doing any work a man can do." Indeed, this rhetoric persists today.[9] For over 60 years we have anticipated this technology. Now, we must actively steward its development.

But if modern AI concepts are not new, why then are we hearing so much about them now? This is an interesting question, considering that some of the most

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8. Interestingly, the "AI Effect" is a phenomenon where the behavior of an AI program becomes discounted as 'not *real* intelligence' once it achieves its goals. Over time, myriad programs have been considered AI only later to be dismissed as mere sub-intelligent *computation*. Thus, the AI Effect seeks to redefine AI as simply anything in computing that has not yet been done.
9. While they are common, inflated beliefs in current AI capabilities are not universal among its creators. Strikingly, Geoffrey Hinton, the very father of deep learning, is today so skeptical that current AI approaches will take us much farther (particularly due to the requirement of extensively labeled datasets) that he actually wants to scrap the whole thing and start over (17, 26)!

sophisticated AI methods have been around for decades. While these approaches have advanced considerably since their development, those upgrades are not the reason for all the hype now. Instead, the modern explosion of AI comes down to two things: more powerful computers and more digital data. Today's AI works by applying high-powered statistics to massive datasets. Typically, the more *high-quality* data, the better the AI. Already we have seen society achieve impressive results using this approach, with both amazing and disturbing consequences. We have seen companies use AI to teach cars to drive themselves, personally-tailor advertisements, predict earthquake aftershocks (27), write poetry (28), and even work to sway the preferences of voters in elections (29-31)! But while these achievements are stunning, they are not magic, and it is important to understand how AI works on a basic level.

In practice, today's AI software are typically based on "machine learning" programs. These programs learn to detect patterns from "input" data, and "output" a prediction, sometimes followed by actions (such as moving a game piece forward or turning a car to the left). While non-AI software follow explicit instructions written into their computer code, machine learning programs use statistical tricks to write their own instructions. Importantly, designers do not know exactly how these algorithms arrive at their solutions, leaving them as inaccessible "black boxes."[10] However, programmers do still select and design the specific model that will be used. While dozens of models exist,

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10. The term "black box" can be confusing. While the phrase is common to the fields of AI, it should not be confused with the black boxes used in the aviation industry. Unlike those of airplanes, the black boxes of AI cannot currently be opened up to reveal step-by-step records or detailed histories.

two relevant to most modern AI applications are artificial neural networks and deep learning (17, 32, 33).[11] Artificial neural networks are programs designed to work like networks of biological neurons. Rather than physical objects, artificial neurons are logical elements in the computer code that behave *analogously* to neurons.[12] Like biological neurons, these artificial neurons receive information, process it, and pass it to other neurons. As they iteratively do this, trying and weighting numerous possible combinations of connections, the network of connections used most often strengthens.[13] Ultimately, the strongest arrangement of connections is what makes the most accurate predictions by the software. Deep learning takes this idea a step further by using multiple *layers* of neural networks, with each layer representing a distinct feature of the input data. In a dataset of images, for example, one layer may correspond to edges in the image and another may correspond to shapes. In this sense, the more "layers deep" a network is, the more specific and complex the features analyzed become. Separately, machine learning programs may be "supervised" or "unsupervised."[14] Supervised programs use labeled data to "train" with, such as digitized X-ray films with the diagnosis labeled. Conversely, unsupervised programs train with unlabeled datasets. To date, the vast majority of AI has used supervised learning. In summary, it is important to understand

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11. Note that the following description is far from the *only* way that neural networks and deep learning might be applied.
12. No evidence exists that the human brain actually functions anything like an artificial neural network. The name comes only from the initial inspiration for the technology and resembles biology only on a very superficial level (34).
13. Technically this is another process called back-propagation, now commonly used in most neural networks.
14. Some programs may be "semi-supervised" as well. This may be thought of as a spectrum.

that these programs have no concept of meaning, and no understanding of context.

Through the combined use of supervised deep neural networks, powerful computers, and massive datasets, the hype surrounding AI has reached a feverish pitch. The technology has become so highly-touted that it is heralded as the Fourth Industrial Revolution (35).[15] But these new powers bring new risks. AI has the potential to amplify biases in datasets, blur truth, increase the gap between the wealthy and poor, invade privacy, and threaten jobs. In one extreme example of "bad learning," a Microsoft AI chatbot named Tay went rogue on Twitter. Within a day, the bot learned to send racist messages and even spouted off Holocaust denials (36)![16] In light of AI's risks, leaders have called for increased regulation, oversight, and discussion.[17] Yet, AI still carries enormous potential for good. It could be the very tool which allows us to effectively use our massive amounts of information to live fuller, healthier lives (37). Amidst all the hype it is easy to see how medicine, with its tremendous problems and unclear solutions, found itself at the forefront. Yet, we should not forget that, at best, medicine remains somewhere in the beginning of the early *Third* Industrial Revolution (17).

When I began medical school in 2013, I watched as we routinely used focused ultrasonic waves and flashing lasers to diagnose and treat, but still relied on pagers to communicate and struggled to use computers to keep track of patients. The state of

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15. Following the advent of the steam engine (1st industrial revolution), mass production (2nd), and computers (3rd) (35).
16. In hindsight, perhaps Twitter is not the best place to train an innocent chatbot on how to behave.
17. Including Bill Gates, Elon Musk, Henry Kissinger, and the late Stephen Hawking, to name just a few.

technology in medicine is heterogeneous to say the least. The same is true when it comes to the state of medical AI. Like other AI, medical AI is not new. One of the earliest medical AIs, developed in the 1960s and 70s, was called MYCIN (38). The program functioned as a question-answering machine to help doctors identify and treat severe infections. While it ultimately never entered the clinic, this was not because of performance issues. Rather, medicine did not have the infrastructure to support the program, and many physicians remained skeptical of using computers in medicine.

Since those early days, medical AI has come a long way—including making it into clinical practice. Thus far, its results have been astonishing. While still variable in its applications, one thing is consistent across all current medical AI: it works to detect patterns from patient data. Be they patterns in images (such as Imagen's software to detect wrist fractures from X-ray images), patterns in ECG tracings (such as atrial fibrillation detectors from Alivecor and Apple), or patterns in ultrasound projections (such as stroke predictors from Neural Analytics), it is clear that medical AI can surpass the detection capabilities of trained physicians in specific contexts (39). Medical AI has even effectively utilized EHR information as an app in the UK, helping to manage emergent kidney injuries. One nurse using the app described how her team was able to triage patients in less than 30 seconds, whereas in the past the process could have taken up to four hours (17, 40). These programs are not purely assistive, either. In 2018, the company IDx developed the first-ever FDA-certified *autonomous* medical AI, capable of making the diagnosis of diabetic retinopathy from retinal image scans independent of a physician (41). This product even carries its own medical liability insurance and

reimbursement recommendations. Recently, FDA applications for medical AIs have skyrocketed (39). This wave has sparked the FDA to develop pipelines to streamline the arrival of new AIs, such as their Digital Health Software Precertification Program. However, despite this rapid pace, we still have a long way to go.

The thrilling arrival of medical AI has brought expectations that it can solve all of medicine's problems and, along the way, render healthcare providers irrelevant. Yet while AI is this shiny new toy, it is largely untested in actual practice. Many of the FDA-approved AIs come with weak track-records of peer-reviewed publications, and their compelling evidence comes predominantly from *in silico* studies rather than rigorous prospective trials (17, 39). Furthermore, the "black box" nature of these programs has also raised concerns. While medicine already employs "black box" techniques, AI promises to push our willingness to accept such inscrutable advice—particularly when it contradicts experienced physicians. Applying AI to healthcare has proven more challenging than anticipated. Despite boastful claims, IBM's supercomputer Watson has not lived up to expectations. Among other problems, it has come under intense criticism for providing erroneous and unsafe cancer treatment recommendations, and IBM has recently reigned back their initial predictions (42). It can be difficult to integrate AIs into existing EHR systems, and a lot of medical information is not "high-quality." Additionally, as with all AI applications[18], privacy and digital security remain major concerns. A multitude of healthcare hacking breaches occurred in 2018 alone, and the problem is likely only

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18. Particularly applications with highly sensitive data, such as protected health information.

beginning (43). When it comes to quality, all AI is not created equal (44). A major push is still needed to lay out clear regulatory structures and quality standards. Thus far, the FDA has focused on assuring that certified AI meet safety (sensitivity), efficacy (specificity), and equity guidelines. We must be sure that medical AI systems perform equally regardless of a patient's race, ethnicity, sex, and other demographic identities. Finally, it remains unclear how current AI approaches could work with rare diseases, as they often do not have corresponding large, diverse, high-quality datasets with which to train an AI.

So what about the elephant in the room, the ever-looming question of AI replacing physicians? Certainly, AI will change the way we practice medicine. Some of the biggest concerns come from physician specialties based on pattern recognition—the very task at which AI excels. While all disciplines identify patterns to some extent, specialties like dermatology, radiology, and pathology are especially focused on this approach (17, 39). For those in these specialties, or those interested in pursuing them, please, for the love of God,[19] let out a long sigh of relief. While the arrival of medical AI will change these specialties, it will not replace them. Even if AI replaced every pattern recognition task perfomed in these fields, it is likely that these specialties would adapt. Consider the game of chess. Back in 1997, the AI Deep Blue beat chess world champion Garry Kasparov and it seemed like the case was closed. But shortly after that match, a new form of chess emerged: freestyle chess. In this style, *teams* of humans and computers work together

19. Or our supposedly-impending robot overlords I guess, if you are so inclined.

to compete against each other. In the end, it is not the best AI nor the best human chess player that wins. Rather, the team that wins is the one that best excels at cooperation between man and machine. Winning teams are astute in knowing when to use the computer versus when to use human judgement (45, 46). Ultimately, learning to work effectively *with* AI will be key. Additionally, these medical specialists do far more than exclusively recognize patterns. Perhaps they could shift more time toward consulting other physicians, seeing more patients, or learning to manage multiple AI systems simultaneously. In the farther future, these specialties could even broaden and redefine themselves as medical Information Specialists (47). Decrying the future relevance of specialties like these is not just incorrect, it is harmful. Dissuading promising medical students from these pursuits might only serve to undermine the supply when demand has never been higher. However, while it is important to ground ourselves in these realities, we should not neglect the technology's fantastic possibilities for physicians overall.

The risks of medical AI are severe, but the potential benefits are wondrous. Imagine if a physician could walk into the exam room and focus solely on interacting with the patient. No computer. No charting. A well-designed system of AIs could automatically and securely record and document the encounter, write-up the notes, send the information to providers for sign-offs, and even negotiate with the insurance companies. What makes this particular scenario so exciting is that the incentives of the patient, physician, insurer, and hospital are all aligned. Moreover, it is well within the realm of possibility. In fact, at JPMorgan, a legal AI called COIN is already able to process commercial-loan agreements and free-up an estimated 360,000 hours of lawyers' time in

mere seconds (48)! Separately, what if medical AI could serve as an extra-level of safety and redundancy for physicians, synergizing as a valued team member while granting diagnostic superpowers? When physicians and AI disagree, the team could step back and carefully reassess. Likewise, AI might be able to serve as an information-gathering team member, finding the most pertinent data for a specific patient case and then presenting it in a digestible format. Ultimately, all of this could serve to free physicians to reclaim their role as healers and rekindle their connections with patients. When I attended the University of Iowa AI Symposium in February of this year, I had a chance to talk with Dr. Michael Abramoff—the founder of IDx. An idea he had stuck with me. He envisioned a world where medical AI could, "enable physicians to do what they do best, see and treat patients." Such a vision is exciting, but far from guaranteed.

Medicine today stands at a crossroads. As we drown in information and layers of administrative duties, healthcare costs explode, and connections with patients fragment, it is clear that our current system is unsustainable. Something fundamental needs to change, especially in light of coming innovations. While some elements of medical AI are threatening to areas of practice, we must remind ourselves that we are not perfect. In 2016, an alarming study found that medical error was the third-leading cause of death in the U.S. (49). If medical AI can make us more accurate while bringing down costs, then for the sake of our patients we must stand aside. AI may give us a lesson in humility, and we should take it in stride. Looking forward, future and current physicians should prepare themselves to play an active role in forming this new technology. Medical students would do well to reflect on the growth rate of medical information. While it is important to stay

proficient in that knowledge, it is even more important to become adept at connecting with patients. Learning how to be *present*, communicate, empathize, and be comfortable feeling vulnerable are all vital skills. Students should also stay informed on medical AI technologies, and learn how to critically appraise them. Perhaps, at Iowa, we should begin a new distinction track in biomedical informatics and biostatistics. For physicians, it is imperative to unite as activists in the face of medical AI. This new technology must not go the way of the EHR. Furthermore, physicians should learn to critically evaluate the evidence underlying AIs and remember that they are not all created equal. Hospitals and medical schools should consider medical AI too, and maximize its potential to improve patient outcomes (while abandoning assembly-line medicine) and revolutionize medical education. Much like the symbol of the serpent, AI consists of multiple dualities. It might help or harm; free or constrain. We must not leave these fates up to chance.

Throughout this essay I have focused on the duality of the serpent. Yet, the serpent is an ancient symbol, and over the ages many explanations have been given for its relevance to healing. While the ancient Greeks are often credited with its introduction, evidenced by the snake wrapped around the rod of their healer-god Asclepius,[20] its association may date back even farther into antiquity (23). As I have reflected on the lessons of the serpent as a symbol, I learned that it also represents regeneration. In order to heal, grow, and remove parasites, the snake must periodically shed its skin. Perhaps modern medicine could learn a lesson from the serpent too. Over the years, physicians have become overburdened with additional duties at the expense of their relationship with patients, such as interacting with insurance companies, considering cost-

effectiveness and reimbursement, completing administrative responsibilities, managing litigation risks, and charting. The list goes on and on. Like the serpent, maybe it is time we shed away our cumbersome skin and leave the machine-like parts of our duties to the machines, and in doing so allow medicine to grow—for ourselves, and for our patients.

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20. Not to be confused with the Caduceus, the winged staff bound by two snakes and a symbol of the ancient Greek god Hermes. While the Rod of Asclepius and the Caduceus have become conflated, Hermes and his staff actually bear no significant association with medicine. Rather, the Caduceus was associated with merchants, thieves, and outlaws. Thus, the symbol's intermixture with medical practice was a historical mistake (50). Oops. In fact, given the current state of things and those pointedly inauspicious associations, maybe its past time we shed the Caduceus too.

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