Quantum Powered Personalized Pharmacogenetic Development and Distribution

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Recent progress in the fields of quantum computing, artificial intelligence (AI), large language models (LLM), cloud computing (including quantum computing as a service or QCaaS), and deep learning stand poised to introduce a new generation of disruptive, exciting, and potentially dangerous capabilities. The single most ground-breaking concept at the intersection of these capabilities may become a medical device concept leveraging exponential growth in the capabilities of computational biology.

Quantum computing stands as a candidate to reduce the timeline of this applied research to such an insignificant scale that a nearly exhaustive and comprehensive collection of drug candidates can be effectively simulated, modeled, and researched in the coming decades. While impressive at face value, this capability will further lend itself to the boutique field of medical research known as pharmacogenomics – the study of how the human genetic makeup affects that individual's response to a particular drug.

Consider the following potential application of this technology: As a routine, outpatient procedure, a person receives an implantable device that enables real time monitoring of numerous vital signs and biological markers. Data provided from this device passes to an AI powered QCaaS data center, where nearly limitless medical observation and monitoring can be conducted autonomously. An individually sequenced genome is predicted. When an anomaly is detected, based on a statistical database constructed over time through deep learning techniques combined with the previously computed and known profile of the patient's individual genetic makeup, the suspected condition is automatically flagged for review by a medical practitioner. *Now the real magic: in near real time, QCaaS will enable the ability to autonomously research, develop, and compound individual, personalized pharmaceuticals that are tailored to an individual's unique DNA and predicted pharmacogenetic response profile.* These individually customized drugs can be manufactured anywhere on the globe and delivered directly to the end user, pending an approval step from a prescribing physician and any necessary consultation. Sick persons could be identified instantaneously and their treatments delivered before they become symptomatic.

Timelines to commercial viability vary among the various requisite component technologies. Ethical concerns are considered, along with potential use cases from employment, future pandemic response, bad actors, absence of clinical trials, suicide prevention, equitable access, and reproductive health issues. A compelling argument is presented for the holistically positive benefit to the human race.

Quantum Powered Personalized Pharmacogenetic Development and Distribution Model

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The world around us is accelerating at an astonishing rate. Recent decades have witnessed the development of nascent technologies into flourishing industries, as the modern hyper-connected world has become a blasé reality. We are entrenched in a vast array of fundamentally life-enhancing systems, and yet these benefits have become so commonplace that their introduction often outpaces any discourse about the ethical and social implications that accompany such a pace of progress. Our world has arrived at an inflection point.

Recent progress in the fields of quantum computing, artificial intelligence (AI), large language models (LLM), cloud computing (including quantum computing as a service or QCaaS), and deep learning stand poised to introduce a new generation of disruptive, exciting, and potentially dangerous capabilities. Potential applications at the synergy of these disciplines include new cryptographic and security protocols (after essentially invalidating current RSA key methods), discovery of new battery chemistries that allow for lighter storage cells with improved charge and discharge characteristics, a dramatic reduction in computational energy consumption due to both increased local efficiencies and economies of scale realized by offloading processes to centralized cloud systems, and decreased carbon output from the transportation and shipping sector as complex logistical problems can be addressed in real-time, resulting in higher load factors in various shipping platforms. All of these advancements will soon be realized at the current pace of development.

Despite this impressive list of potential applications and quality of life improvements, the single most ground-breaking concept at the intersection of these capabilities may become a medical device concept leveraging exponential growth in the capabilities of computational biology. At present, pharmacological progress relies on computer assisted drug development (CADD), utilizing classical computation methods to simulate the structure and behavior of a theoretical molecule or compound. Organizations such as Google have demonstrated, through their AlphaFold and Alphafold 2 projects, the capacity to predict a protein structure at nearly the same accuracy as experimental methods such as x-ray crystallography. This method is largely stochastic, iterating within specified parameters in an attempt to predict, with varying levels of accuracy, how proteins fold or what pharmacokinetics could be expected from a candidate compound. Given the linear nature of such a process, it becomes highly resource and energy intensive, as well as time consuming. While some medium sized molecules can be simulated in weeks utilizing current clustered computing architectures, more complex compounds could take hundreds of years. Such research methodology therefore becomes impractical at best due to the

limitations of available GPU architecture and cloud computing arrays, disregarding any debate over the equity considerations of consuming such vast amounts of resources for an idea that may not be viable nor benefit any substantial segment of the world population.

Quantum computing stands as a candidate to reduce the timeline of this applied research to such an insignificant scale that a nearly exhaustive and comprehensive collection of drug candidates can be effectively simulated, modeled, and researched in the coming decades. While impressive at face value, this capability will further lend itself to the boutique field of medical research known as pharmacogenomics – the study of how the human genetic makeup affects that individual's response to a particular drug.

As access to quantum computing becomes more accessible through QCaaS, wearable or implantable medical devices will be developed that will usher in an era of "quantum powered, personalized pharmacogenetic development". Consider the following potential application of this technology:

1. As a routine, outpatient procedure (similar to the injection of a subdermal RFID chip in a pet), a person receives an implantable device that enables real time monitoring of numerous vital signs and biological markers. This device, like many others in the Internet of Things (IoT), will utilize near-field communications protocols such as Bluetooth low energy (and subsequent improvements) to communicate with nearby internet-connected devices, such as smart phones, to provide ubiquitous connectivity.
2. Data provided from this device passes to an AI powered QCaaS data center, where nearly limitless medical observation and monitoring can be conducted autonomously. Ostensibly utilizing a blood sample, an individually sequenced genome is predicted, which would traditionally have been computationally prohibitive utilizing classical computing architectures.
3. When an anomaly is detected, based on a statistical database constructed over time through deep learning techniques combined with the previously computed and known profile of the patient's individual genetic makeup, the suspected condition is automatically flagged for review by a medical practitioner.
4. *Now the real magic: in near real time, QCaaS will enable the ability to autonomously research, develop, and compound individual, personalized pharmaceuticals that are tailored to an individual's unique DNA and predicted pharmacogenetic response profile.* In other

words, whatever medical issues the AI detects, while still potentially unknown to the patient, a drug developed specifically for that person's genetic structure will have already been developed and stand poised for production.

5. Given the substantially accelerated development rate and corresponding reduction in associated costs, these individually customized, pharmacogenetically engineered drugs can be manufactured anywhere on the globe and delivered directly to the end user, pending an approval step from a prescribing physician and any necessary consultation. As the ubiquity and public acceptance scales, localized production and distribution networks (similar to Amazon pickup lockers) can be installed to potentially reduce the time from detection of an anomaly to treatment drug ingestion down to less than a day.

The development of the monitoring device is a matter of miniaturization, battery longevity, attachment site, and FDA approval, driving an estimated timeline of five to ten years to commercial viability. Quantum computing, while in a period of commercial renaissance, still requires development at scale to realize the requisite qubits to handle such a continuous stream of data to process. Certain QC technologies require substantial energy for thermal management, while the stability of these systems is still in infancy. Beyond these technological hurdles, the fundamental premise will require progress in AI. A casual look into news media will reveal a host of both public and venture capital funded organizations that are working diligently to advance the state of QC and AI, and much of the progress is currently proprietary and confidential. Likewise, well-heeled pharmaceutical companies have a high commercial incentive to develop a device that ensures the utilization of their core business products.

The ramifications of such an integrated and relatively autonomous medical advancement merit careful consideration of the higher order effects and potential unintended consequences of such capabilities. At the surface level, a direct labor impact can be expected, as the need for pharmaceutical researchers, pharmacists, and medical administrators is significantly reduced. The drug costs will initially be high, given the cutting edge nature of the system and the need to leverage multiple technologies at the frontier of research. This innate market characteristic raises numerous questions about how privatized and public medical insurance industries will handle such disruption. Perhaps more significantly, sociology has shown that economically disadvantaged communities will benefit the least from such an advancement and will be afforded only the most modest of adoption rates. A potentially

lifesaving treatment, administered on the fastest possible timeline, cannot be permitted to become a luxury of the affluent.

Digging deeper, such capabilities will initially be extremely resource intensive. From the manufacturing capability to produce the implantable device and the associated requirement for precious raw materials, to the energy requirement to perform such continuous and intensive computation at scale, to the manufacturing and distribution of the drugs themselves, this system will become more efficient as capacity is scaled and vertically integrated, but the initial energy concerns and ecological impacts will likely take a back seat as soon as the technology matures into marketability, as the commercial potential and net benefit outweigh any objection on a resource basis.

At the core of the idea are ethical concerns. The pharmaceutical industry is fundamentally rooted in research, based on double blind testing, control groups, and extensive monitoring for side effects. The idea that a drug can be developed on such a short timeline eliminates any potential for such opportunity to discover the unintended consequences of a particular drug. Furthermore, the nature of pharmacogenetics implies that every drug is different and personally tailored, making every single recipient of these products into the first participant in an ad hoc clinical trial. Risks exist for abuse, as the technology could enable recreational super-drug development, promoted with the promise of low addiction and unfathomable highs, as the technology matures and becomes more accessible. Potential bad actors at a state-sponsored level could, given a target's genetic profile, compound a drug that is highly lethal to only that individual and possibly undetectable in an autopsy. It is entirely likely that society will have access to this technology before all of the potential ethical issues can be adequately addressed.

However, the upside to this proposed technology cannot be understated and outweighs all imaginable drawbacks, provided that the capacity is responsibly leveraged. The applications for the common good test the limits of our imagination. Imagine the global impact of such pharmacogenetic capabilities during the COVID-19 pandemic. The lives lost, alongside the unknown trillions of dollars (or greater) of economic costs endured, could have largely been mitigated with this capability. With a known profile of COVID-19 symptoms, even using such simple parameters as blood pressure, respiratory rate, and pulse oximetry, infected persons could be identified instantaneously and their treatments delivered before they became symptomatic. Vaccines could be modeled in hours (and likewise, effortlessly customized at the individual level), and close contact tracking would become a reality through relatively simple application of an algorithm. Obvious ethical questions again surface, as

certain societies with limited personal liberty would be highly equipped to target infected persons with draconian measures. Given the diagnostic power and treatment response rate, the likelihood is that such a widespread global pandemic could be contained before achieving explosive virility, partially offsetting concerns for governmental humans rights abuses under the auspices of public health.

Consider another application to address the socially uncomfortable but pervasive issue of suicide, alongside the associated ethical implication. Given widespread adoption of this technology, inevitably there will be suicides and suicide attempts. As the data points grow into a mature data set, it is conceivable that AI could detect “suicide risk markers” in someone, whether at a genetic level or at a physiological stress level. It follows that suicide intervention and treatment could be performed at the onset of suicidal ideation, though such proposed medical oversight and invasion of privacy at the most intimate level would certainly explode into an impassioned political debate. Controversially, substances affecting mood and happiness could be compounded into routine drugs with or without the knowledge of the recipient, in major violation of accepted medical practice and ethics, but hypothetically preventing the tragic loss of life. These difficult questions will present themselves at the forefront of public acceptance and adoption of the capability.

A final use case scenario centers around human reproductivity and the associated birth defects that manifest due to rare genetic predisposition. Major ethical and religious concerns notwithstanding, the scientific reality will soon allow for highly accurate prediction of reproductive risk factors between partners based on their genome. Given that, in some cases, parents have elected to terminate a pregnancy when genetic testing reveals a birth defect after eight weeks of pregnancy, ideological disparities surrounding the topic of abortion might well find common ground with the capacity to elect to avoid pregnancy altogether, should a genetic risk analysis demonstrate an unfavorable empirical risk profile.

All of these hypothetical use cases for this proposed ecosystem of real time health monitoring, AI prediction based on genetic sequencing, and pharmacogenetic drug development present the astute mind with far more questions than answers. The applications seem limitless, with implications that are orders of magnitude greater in potential than human innovations such as the introduction of the first vaccines. For the first time in human history, our species could hold the prospect of equal access to bleeding edge medical treatment and incredibly effective pharmaceuticals, interrupting the disturbing cycle of healthcare disparity. At this intersection of vast computing power with our basic human anatomy is a startling conjecture that seems much less implausible in the current era. It is merely a question of when these advancements, and other associated use cases beyond our current imagination,

will arrive. The pace of innovation of these technologies warrants an urgent, intellectually rooted, open minded, and egalitarian debate.