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QUANTUM GENOMICS INTELLIGENCE EMPOWERS DRUG EXALTATION

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ABSTRACT
Pharmaceutical companies seeking quantum innovation to focus on developing precision medicine, and personalized medicine. Drug discovery is a complex, and lengthy daunting process. The symbiotic integration of quantum computing, genomics, and artificial intelligence have emerged to constitute *quantum genomics intelligence (QGI)* to disrupt drug discovery process cutting down efficacy failure boosting a success rate significantly while minimizing investment. Pharmaceutical companies have not yet adopted to think holistically to apply QGI through the unique strength of quantum systems thinking to empower drug discovery exaltation. The aim of this conceptual research is to investigate the influences of quantum systems thinking from the perspective of QGI applications developing new drugs for unmet medical needs disrupting pharmaceutical industry to create quantum opportunities to attain quantum value co-creation (QVCC). The research methodology utilizes an exhaustive literature review on the historical perspective ofquantum systems thinking, QGI, and the quantum value co-creation. Furthermore, the application of *KLAS (Kanban, Lean, Agile, Scrum)* methodology with *perpetual product, process, service innovation(P^3SI)* is confabulated to focus on the best possible evidence-based research for drug discovery quintessence. The contribution of this research provides quantum systems thinking approach for the QGI applications to the drug discovery and development process to attain *quantum value co-creation (QVCC)* transcendence and stakeholder satisfaction.

Keywords: Quantum Computing, Genomics, Artificial Intelligence, Drug Discovery, Quantum Systems Thinking, Quantum Value Co-Creation.

INTRODUCTION

The quantum revolution is poised to emerge with prominent and eye-catching disruptive technologies to fundamentally transform the economy from digital to quantum. The symbiotic integration of quantum computing (QC), genomics, artificial intelligence (AI) are emanating to form the quantum genomics intelligence (QGI) to disrupt drug discovery process.

Quantum computing is an exciting new computing paradigm and is the ultimate in parallel computing, with the potential to tackle problems conventional (classical) computers can't handle. A quantum computer, completely different from a classical (digital) computer, performs quantum computing using quantum-mechanical phenomena and would theoretically be able to solve certain problems much more quickly than any digital computer. Where current digital computers would require tens of thousands of years to solve some of the world's most challenging problems, a quantum computer would be able to find a solution in only minutes, hours, or days enabling researchers to develop new catalysts and materials, improve drug discovery process significantly, and even answering questions about the origins of the universe. In a quantum computing world, it would take minutes, if not seconds, to run through all the possible permutations[1].

Genomics is an interdisciplinary field of biology focusing on the structure, function, evolution, mapping, and editing of genomes. A genome is an organism's complete set of DNAs, including all its genes. Quantum computing in genomics offers fundamentally a new set of algorithmic tools which could accelerate the development of precision medicine, personalized medicine, accurate drug discovery and provides huge advantage in the area of genome sequencing to determine the order of the nucleotides (A, C, T, G) that make up the basic structure of the DNA [2].

Quantum genetics is a science about the essence of biological structures on their molecular level. A genetic algorithm is a type of artificial intelligence that picks a series of instructions at random to serve as a piece of DNA and checks the fitness of the result as well as solves optimization problems by creating a population or group of possible solutions to the problem[3].

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When one think about drug discovery, one must approach it as a quantum systems thinker. One should look for components of the problem that characterizes as a system. Meaning where are the inputs, outputs (overall objective), throughput, boundaries, feedback and control mechanisms, interactions with other systems.

To build systems kinetics models that capture a system, one should explore how cycles and delays affect the overall behavior of the system. Also, one always looks out for emergent properties that arise as a result of interactions across a system. As shown in figure 1, the author has introduced quantum systems thinking approach with a novel orientation to QGI applications to achieve simplicity for the drug discovery process.

In this research, the author has coined the term quantum genomics intelligence (QGI) which signifies the symbiotic integration power of QC, Genomics, and AI that can sort through massive volume of data to answer a single question in a highly complex process of drug discovery and dealswithin genetics that concerns the sequencing and analysis of an organism's genome - the entire DNA content present within one cell of an organism.

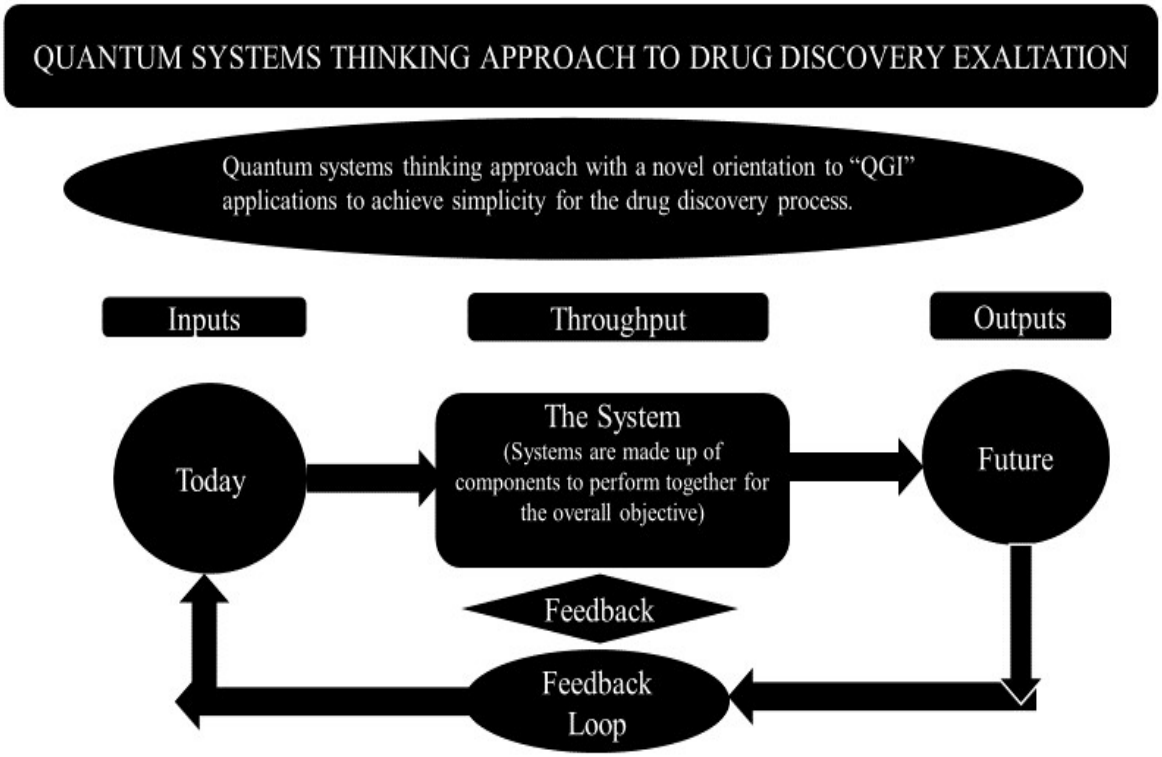

Fig.1 Quantum systems thinking approach to drug discovery process

PROBLEM FORMULATION & STUDY JUSTIFICATION

Pharmaceutical companies have not yet adopted to think holistically to apply the unique strength of quantum systems thinking approach in the QGI applications to achieve drug discovery eminence. So far, no academic study has investigated to fill the void in the literature with regards to symbiotic integration relationship between quantum computing (QC), genomics, and artificial intelligence (AI) that creates disruptive market opportunities and widespread applications in the drug discovery process. Furthermore, the QGI integrated concept as a system is still largely undiscovered discipline in the drug discovery process. The convergence of QGI applications has not received its fair share of scholarly attention yet in the drug discovery literature. Projects in practice devoted to this groundbreaking symbiotic integration of QGI applications is not pursued by the pharmaceutical companies yet. Hence, the author has ventured to investigate the influence of quantum systems thinking approach in the QGI applications to demonstrate its enormous benefits to accelerate drug discovery process boosting success rate significantly while minimizing investment while providing new knowledge important for all stakeholders in the drug discovery process.

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RESEARCH BACKGROUND

The genomic era is now a reality. The future of genomics research shows a timeline of landmark accomplishments in genetics and genomics. Recognition of DNA as the hereditary material, determination of its structure, elucidation of the genetic code, development of recombinant DNA technologies, and establishment of increasingly automatable methods for DNA sequencing set the stage for the Human Genome Project (HGP) happened in 1990.

Researchers spend on average more than a decade comparing the interactions and effects of different chemical compounds on a range of diseases to determine the best drug. This process can be significantly shortened with quantum computing that have enough computational power to disrupt all possible outcomes and find solutions more efficiently, quickly, reduce the cost of creating a new drug. Underlying solutions to diseases such as Alzheimer's was not able to discover without appropriate computing power.

The disruption by quantum computing in drug discovery means:

- Quicker drug discovery and production
- More precise drugs
- Fewer drugs with side effects
- Cures for incurable diseases
- Better understanding of the human body on a molecular level

Developing new drug involves the identification of candidates, characterization, synthesis, assays for therapeutic efficacy, screening, and development of the drug prior to clinical trials. It starts with the identifying the molecule that can activate or block the receptor involved in a disease. Identifying and validating a chemical compound identification and validation is one of the key steps in the drug discovery process. Scientists have already developed quantum processor capabilities with quantum bits (qubits) that can complete a task in 200 seconds (3 minutes 20 seconds) which would take 10,000 years for the state of the art classical (super) computer. Such quantum supremacy of power can be applied for drug discovery and development work where researchers can find a molecule from thousands of molecular compounds to confirm in few minutes for the molecule involved with the disease in question. It is like searching huge haystacks to find a diamond needle in minutes[4].

The costs of developing a new drug doubles every decade. The implication is that the increasing costs of drug discovery prevents economic agents in the market investing huge resources needed for therapeutics development for rare and yet unsolved diseases. To solve this daunting problem, new methods of drug discovery are essential.

Affymetrix, a gene technology firm, recently have made impressive breakthrough to analyze and manipulate the human genome with the commercial launch of a microarray for analysis of the whole genome on a single chip that carries over one million oligonucleotide probes capable of analyzing 50,000 RNA transcripts from the 30,000 or so genes in the human genome. The Affymetrix gene expression chip (Genechip®) is about to be challenged by similar whole human genome chips competitors, companies like Applied Biosystems and Agilent Technologies.
https://www.the-scientist.com/news-analysis/the-human-genome-on-a-chip-50961

Bio-technological science is populated by a plethora of ‘omics’ spawning into the so called ‘Big Data’ pool. Given there is no apparent end to knowledge, the greater challenge in a modern world of ‘Big Data’ is its conversion to useful and actionable data. In the context of drug discovery, it is therefore imperative to take advantage of quantum computing and quantum data processing in a manner that provides a direction to undertaking drug discovery whereby the information is pertinent, valuable and grows useful actionable knowledge. The increasing availability and growth rate of biomedical information, also known as ‘Big Data’, provides an opportunity for future personalized medicine programs that will significantly improve patient care. “Big Data” has affected biomedicine, life sciences and scientific research. Genetics and genomics information are key enablers for predictive, precision and personalized medicine. The combination of genomics and clinical health data combined with ‘Big Data’ analytics can leverage personalized medicine. Recent advances in quantum technology (QT) applied to biomedicine will change the landscape of privacy and personal information, with patients getting more control of their health information.

Translating genomics into precision and personalized medicine with AI

In the discipline of genomics, the genetic information offered by next-generation sequencing technologies and rapid growth in biotechnological science publications has led to the advent of the ‘Big Data” era. Integration of artificial intelligence (AI) approaches such as deep learning, natural language processing, and machine learning to tackle the

scalability and transformation of big data into clinically actionable knowledge is becoming the foundation of precision medicine and personalized medicine. AI will remain the primary driver to precision medicine and personalized medicine. Precision medicine is an approach for disease prevention and treatment based on the specific genetics, and lifestyle choices of an individual patient. AI applications in the field of genomics are shaping the precision oncology field.

Paradigms in drug discovery

The new emerging therapeutic modalities are cell and gene therapies. The cells themselves are developed as medicines and their full potential realization requires a new paradigm, where new organizational approach, management strategy, technology development, manufacturing is conducted in parallel from the earliest stages of research to the clinic. The drug discovery and development process for small molecules dictates that 5000 to 10,000

(or more) chemical compounds initially undergoes laboratory screening. Approximately 2.5–5% will go through preclinical testing. 0.1% will enter clinical testing. This entire process from discovery to marketing of a chemical drug can take 10–15 years. Cell-based and gene therapies have certainly turned a page with multi-step processes resulting gene-expressing cell product.

Drug development challenges

- Drug discovery is a complex, and lengthy process with a high degree of uncertainty.
- The unknown psychophysiology makes target identification challenging.
- Animal models cannot recapitulate an entire disease.
- Heterogeneity of the patient population with extended clinical phenotype is a challenge.
- Emphasis on data lead to increased target identification and validation.
- Lack of validated diagnostic and therapeutic biomarkers to calibrate biological states.

Quantum theory to accelerate drug discovery

Molecular mechanics (MM) is a computational approach to modeling in medicinal chemistry, synthetic organic chemistry, and various aspects of drug design. But MM methods have limitations, particularly when used to study electron-based properties within the drug-receptor microenvironment. Quantum mechanical (QM) methods increase the accuracy of predictions providing much more relevant models of biological and chemical objects and their interactions. But QM methods are extremely costly for computation. The emergence of density functional theory (DFT) have increased in the computation power and the distributed cloud-based computational infrastructures [5].

Quantum tools for drug discovery

Over 7 decades of digital (classical) computer development have accelerated the creation of drug discovery applications. Companies, like Silicon Therapeutics and Atomwise race to cure diseases like cancer and malaria through high-volume computation. Drug discovery applications quickly adopt increases in computing power. For instance, IBM's Q System and D-Wave's 2048 qbit Quantum Annealer has solved various quantum chemistry challenges by determining minimum energy states of atoms in molecular structures. QuantumSimulations accelerate drug discovery**.** Assuming to double computational bits every 2 years, a 100,000+ qbit Quantum Annealer will be created in the next decade. The author contends that future quantum computers can build atomically accurate models of large-scale matter. These simulations can be accessed through intuitive virtual reality (VR) interfaces — providing information to users at optimum speed and ease. Today, drug researchers evaluate tools for accessibility and communicabilityand canbe addressed at the interface level. Users can exchange information with a program via interfaces. Drug discovery is inherently collaborative, and insights need to be shared. Interfacial thinking is key driver for the usage of quantum tools in drug discovery applications. User friendly interfaces expand the accessibility and usefulness of information. User interfaces are a form of translation. Quantum computing makes simulation engines more robust. Molecular simulation can be widely accessible via intuitive VR and unlocks the full potential of human – computer interaction [6].

Quantum Intelligence in the Drug Discovery Process

Quantum computing uses factorials and exponentials in algorithms and is based on the use of qubits instead of bits. The author has introduced and coined the term "Quantum Intelligence ", composed of quantum computing and artificial intelligence technologies based platform that will revolutionize the sharing of research work in preclinical life science research and has the potential to use data in ways never thought before. AI using innovative techniques such as in silico (on a computer) drug design for the mapping of drug structures and targets, can allow the

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development of more successful drugs without the costly scientific development. Quantum intelligence technologies are expected to make the hunt for new drug discovery quicker, cheaper and more effective [7].

Application of QGI to personalized and precision medicine, as shown in figure 2.
Scientists have already demonstrated how a quantum processor could be used as a predictive tool to assess a fundamental process in biology - the binding of gene regulatory proteins to the genome.

Quantum computing will ultimately have a significant impact across the global economy, with many applications, specifically rapid drug design and testing, early disease detection and prevention. Researchers made breakthroughs in the field of spin qubits recently building a powerful quantum computer cramming hundreds of millions of qubits on a square-inch chip. Scientists have developed algorithms on a silicon-based computer is making silicon qubits interact with light allowing silicon qubits eventually to communicate from opposite sides of a chip — an important step in realizing future networks of many quantum bits and necessity for scaling the computers up. Scaling up these quantum circuits is of paramount importance to increasing the complexity applications, and computational power of modern quantum information processing technologies. The silicon photonics method to quantum technologies facilitates a concise path to scaling up to the many millions of components that are ultimately required for large-scale quantum computing applications.

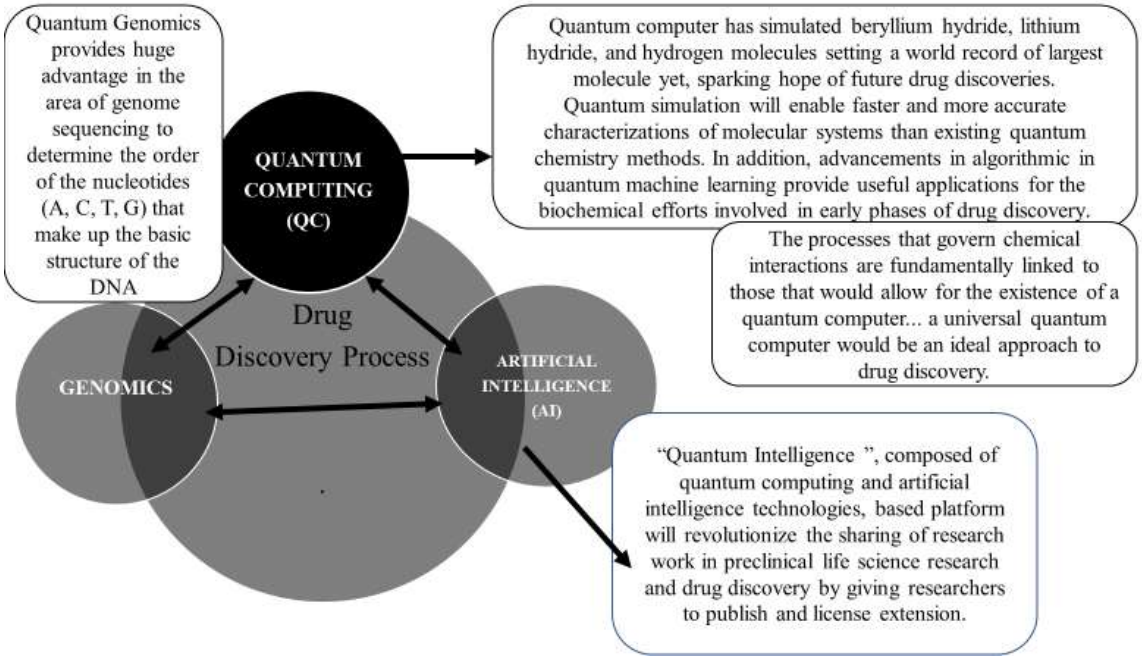

Fig. 2 Application of QGI to Drug Discovery Process

PRINCIPAL CONSTITUENTS DRIVING QVCC

The pace and scale of scientific innovation is transforming the biopharma industry. A fundamental differentiation is the generation of extensive insights and evidence from multiple data sources. Consequently, quantum transformation is a strategic imperative. Artificial intelligence empowers quantum technologies to impact the biopharma value chain and accelerate biopharma's quantum transformation.

Quantum transformation is the use of quantum technologies to reimagine an organization and drive change management. Quantum organizations are committed to transformative strategies that encourage collaboration and new ways of thinking as well as working to access the resources that need to develop quantum skills and know-how.

The building blocks of a successful quantum transformation include supportive leadership and a quantum culture of collaboration. However, the main drivers behind quantum transformation are the emerging quantum technologies that give a company a quantum foundation and quantum competitive advantage in data analytics. The fundamental

role of these quantum technologies is to improve the quality of data and information flow and the robustness of insights derived from this data

As shown in the figure 3 , the literature review also focuses on the following nine principal constituents that are co-related to each other to drive QVCC attainment: (i)quantum culture, (ii) creativity, (iii) leadership, (iv) quantum innovative thinking, , (v) quantum business model (vi) quantum value proposition, (vii) strategy for quantum ready workforce, (viii) quantum ecosystem, (ix) quantum competitive advantage (QCA):

Quantum culture is a non-judgmental, practical method which helps companies to create dynamic, inclusive, respectful, flexible to build uniqueness by connecting around the innovative ideas and practices focusing on achieving formidable goals to create quantum value. Quantum Culture applies to private and public institutions including ventures, associations, community initiatives, and larger businesses, and non-profit organizations. Diversity among people and the differences attain opportunities is at the core of quantum culture.

Culture is symbolic communication. A culture is a way of life - the values, symbols, behaviors, beliefs a team accept. Founding and endowing a culture of innovation is one thing but sustaining that culture is another. Technology companies can sustain a creative culture is by recognizing and rewarding the stakeholders, specifically employees. To create a quantum culture of innovation in a company, the following steps are essential: (i) Define the mission around quantum innovation, (ii) Create a flexible structure allowing employees to experiment with new ideas in unstructured time, (iii) Recognize stakeholder ‘s, specifically employees, contribution to the innovation process, (iv) Be intentional with concise innovation intent, (v) Measure what ‘s meaningful, (vi) Provide freedom and free time to think and innovate, (vii) Give your employees the freedom and "free time" to think and innovate, (viii) Lead with the right example.

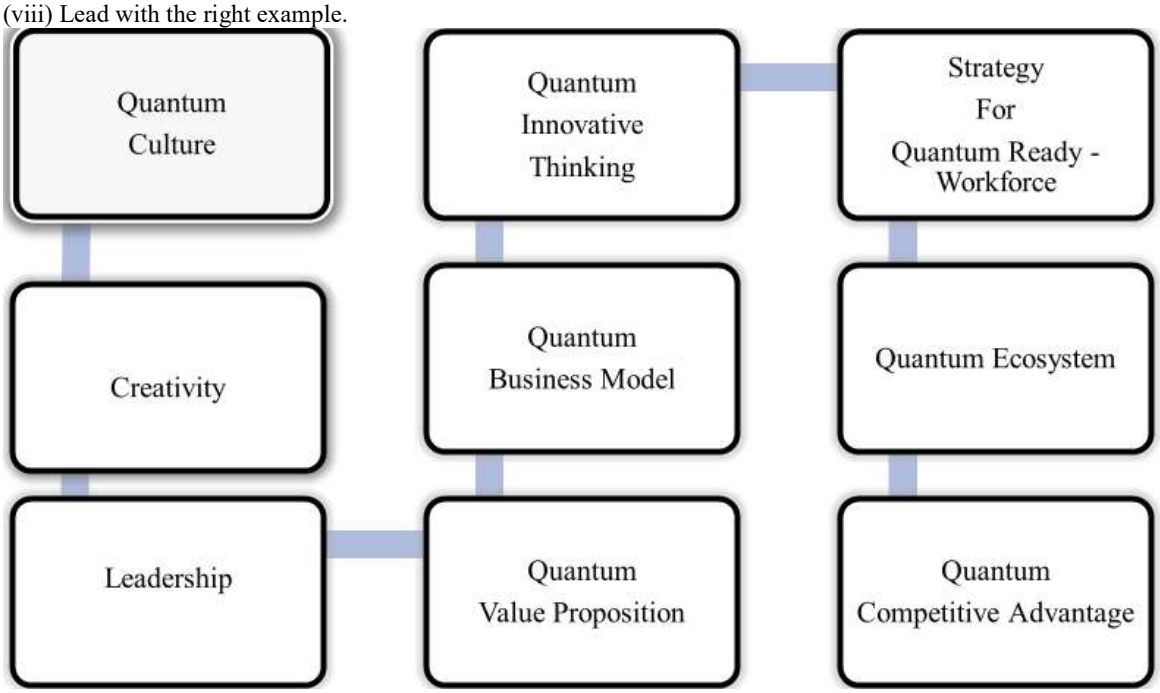

Fig. 3 Nine Constituents of QVCC

Creativity is the thinking and innovation is the execution. Creativity is not innovation, but one needs both. Business leaders frequently interchange innovation and creativity. Innovation is not a mysterious black box. Leaders need to understand the difference between innovation and creativity to pursue inspiring work to build a culture of innovation. While business leaders can promote innovation, firms need to support innovation through the design and development process and cultural makeup.

Leadership shape adaptable leaders who succeed through disruption. An enterprise with an innovation culture doesn't just happen. Developing an innovation strategy that aligns with organization ‘s goals allows creating various

aspects of success including identifying a leader and developing a vision. The following distinctive behaviors are essential from an innovation leader: (i) excellent strategic vision, (ii) a compelling customer focus, (iii) creating an environment of reciprocal trust, (iv) loyalty to do what‘s right for the organization and customer, (v) belief in a culture that amplifies upward communication, (vi) persuasive nature, (vii) excel at setting realistic goals, (viii) emphasizing speed with candid communication, (ix) inspire through action.

Quantum Innovative Thinking: The old mantra, ―differentiate or die, is not enough and no longer relevant. The author argues, nowadays, there’s too much emphasis on differentiation. So, instead of ―differentiate or die, the real mantra ought to focus on who to create an innovative solution to disrupt the market that surprises the market with excitement.

An unconventional strategy leaves competitor scrambling to catch up to compete and takes an industry into its next generation. It’s what the author calls quantum innovative thinking. The integration of technologies (quantum computing, genomics and artificial intelligence) share a unique symbiotic relationship. Information technology (quantum computing) and artificial intelligence integration are about quantum intelligent systems applications in order to increase availability both on-premises and in the cloud. Integration should be viewed as a key data management system component and helps cross-pollinate across systems to broaden and scale-up organizational outreach. In addition to offering systems application, the integration (symbiotic) relationship is about merging corporate data—or providing data integration to deliver mission-critical information enabling disruptive

value proposition. No one thing is responsible for making a brand become more innovative. Most of the time a combination of vital ingredients delivers innovative thinking and behavior. The following ingredients are essential for continuous innovation: (i)Learn to celebrate- What one celebrates plays a vital part in defining a company‘s culture by encouraging stakeholders to explore their passions, specifically give employees the opportunity to showcase their innovative work and celebrate their accomplishments. (ii)Reframe problems – People need to reflect on problems to open the opportunity space to spring to mind a solution. (iii)Co-develop with market dynamics - Think about the balance between technical and market development making sure growth should always be at a similar stage for both. (iv)Flexibility - Can the technology be executed in other ways to produce the product for other useful applications.

Quantum Business Model (QBM): The culture and methodologies of enterprise structures undergoing a fundamental shift and entering an unprecedented time in human history. All systems will evolve and elevate to new levels. QBM is a new paradigm of unified field operating with transparency, integrity, responsibility, and coherence incorporating a platform for growth drivers. In the future, companies ultimately thrive must have a coherence to recreate their business model to adapt to a new elevated value system to capitalize new understanding of how the world works. In the QC world, this includes providing the quantum computer, access to the quantum computer over the cloud, programming software, documentation, training classes, a partner program to enable third parties to support end-users and other tools. Examples: Amazon: The World's first QBM is driven by more than cost savings from market efficiencies of scale and the company's reaction time to changes in consumer demand and preference. At present, D-Wave and IBM are using the QBM with Rigetti, Google, Microsoft, IonQ, and others. https://medium.com/embracing-mastery/the-quantum-business-model-a-new-paradigm-6795bc248d56

Quantum Value Proposition (QVP): Offering value propositions in the age of disruption with new approaches and solutions is key to driving clients' business forward. To be disruptive is not about being critical; it's all about helping to take customers businesses to a higher level. Smart businesspersons welcome "quantum disruptions" that ensures business to become productive, creating a barrier to competition, efficient, and prosperous. Customers want to do business with people who are forward-looking. Every problem presents with the opportunity to come up with a "quantum disruptive" solution. Even though it maybe one ‘s idea, offering customers' ownership of the endeavor simply speeds up the journey to success. "Quantum Innovation" drives to attain ―quantum value proposition‖ and creates new markets with enormous opportunity.

Strategy for a quantum ready workforce: Companies regularly define their overall business strategy specific to supporting various functions, namely marketing, operations, finance, and R&D. Based on the author‘s four decades of experience in technology business, firms rarely articulate strategies to align innovation efforts with business strategies. A strategy is a commitment to a set of coherent, mutually reinforcing policies or behaviors aimed at attaining relevant competitive goals. Quantum computing is showing signs of early benefits today. Companies need

to train and develop the next generation of talent, expertise, and skills in the quantum workforce. Also, quantum computer developers need to continually innovate breaking down barriers to achieve affordability, flexibility to cloud access and user-friendly software and tools.

Quantum Ecosystem: Technology is viewed as one of the major dimensions of ecosystems. For the integrant market ecosystems, human emotion factors become an integral part of the creation and design approach in products and a pivotal determinant for communication with the stakeholders. Encircling QC ecosystems design thinkingwith design tools are a path to generate systems value creation. The introduction of ecosystems originates from the social sphere in the analysis of the system 's organization dynamics and to introduce a system view on value creation. An ecosystem can be explored from a macro-standpoint to generate value creation and new knowledge that continuously implement enhanced points of view. The ecosystem is created by a collaboration between brand ecosystem owners and other stakeholders.

If one wants to build real ecosystems, then one needs to focus on: generation of the context where intercommunication and consanguinity can quirk. Combining intercommunications with the products and services one provides, in specific moments. Companies that have invested to integrate quantum computing into the workflow will capitalize on the immense opportunity.

The salient features of ecosystems are (i) institutions; (ii) value propositions; (iii) resource integration. The two perspectives emphasize the need to interpret ecosystems as (i) systems composed of people and organization actively engaged in resource integration, and (ii) sharing information through digital technologies producing new social rules to enhance value creation and innovation.

Quantum Competitive Advantage: Customer care and trendsetting is at the core of the quantum competitive advantage. Maintaining quality is also one of the fundamental differentiations to attain quantum competitive

advantage (QCA) in the quantum intelligence (QI) creation and design. So, in line with the QVCC framework described in this study, ecosystems can be the creation of technology promoted experiences for improving competitiveness to acquire a quantum competitive advantage. To place companies in the vanguard of transformation, one should consider joining a quantum computing ecosystem that is already taking shape. Joining the appropriate quantum ecosystem today could give organizations a quantum competitive advantage tomorrow. Quantum Advantage refers to quantum applications delivering significant advantages and quantum volume is determined by the number of qubits, and coherence time, and compiler efficiency.

METHODOLOGY

In this study, the research methodology includes the following four segments [8]:

1. Exhaustive literature review.
2. Quantum systems thinking (QST) perspective and modeling on QGI software development.
3. KLAS (Kanban, Lean, Agile, Scrum) methodologies, a term coined by the author, is used to structure, plan, and control the process of developing quantum software development system.
4. Perpetual Product, Process, Service Innovation (P^3SI) for drug discovery process**.**

Segment 1: The comprehensive literature review explores various terms broadly the keywords and includes explanation on the sections mentioned above: (a)introduction, (b)research background that includes drug discovery paradigm, quantum theory for drug discovery, quantum intelligence in the drug discovery process, drug discovery challenges, quantum tools for drug discovery, (c) analysis on the applications of QGI to the personalized and precision medicine process, and (d) principal constituents of QVCC.

Segment 2: Quantum systems thinking (QST) perspective and modeling on QGI software development. Quantum thinking is an integral part of "Quantum Being" that includes six elements: quantum thinking, quantum feeling, quantum knowing, quantum seeing, quantum trusting, and quantum acting. The six constituents are interlinked to each other, as shown in figure 4.

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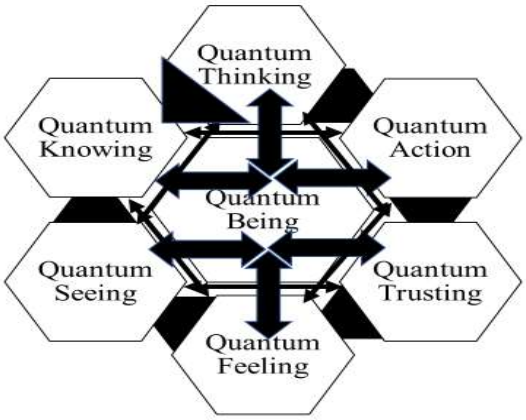

Fig.4 Illustration of "Quantum Thinking" is an element of "Quantum Being"

Systems thinking - has evolved as an alternative to the old paradigms. Many methodologies are derived from the systems thinking. With systems thinking, designers learn how their organization interact. Systems Thinking was originally proposed as an analytical paradigm to different scientific disciplines like life science, biology, psychology, the social sciences, etc. Nowadays systems thinking has become an established perspective on the management process. One of the goal of systems thinking in management is conceptual understanding of the structure and behavior of complex organizations and the benefits.

Quantum system thinking (QST) - is an exceptional exercise of quantum leadership, humility and empowerment. In the quantum systems thinking process the inconceivable starts to thrive and wildest dreams are possible. When one recognizes the magnitude of being all-inclusive thinkers, everyone faces the humility that represents the awe-inspiring reality of quantum system thought. Quantum system thinking is big picture thinking that extrapolates responsibility to self, others and the world. It's an amazing tool that have the power to transform the modesty of attainments because everyone is tiny piece of the intellectual fabric of the universe. To embrace quantum system thinking, everyone needs to fully comprehend the effect of a positive choice.

The author introduces the quantum systems thinking and modeling methodology as a conceptual and analytical method relevant to the drug discovery process. This approach is based on the system dynamics methodology developed for the theory of information feedback systems to understand the decision-making process and for the development of stimulating mathematical models in quantum computing. The development of quantum systems thinking, and modeling methodology involves the following six distinct phases and can be used separately or individually, for value added purpose, as shown in figure 5:

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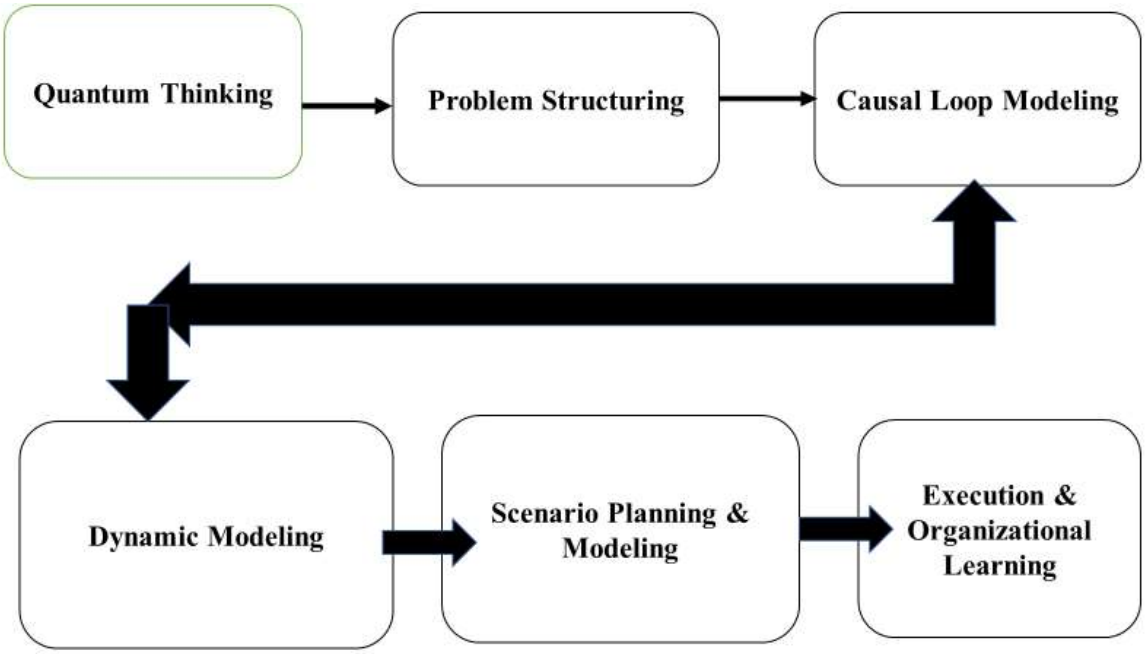

Fig. 5 Quantum systems thinking & modeling methodology

(i)Quantum thinking – a new mental superpower involving a paradigm shift from linear thinking to holistic thinking and the ability of the mind to function at a higher level of creativity and innovation that allows one to envision the next generation products, process and services. Quantum thinking is also the fuel to fire those creativity-innovation cylinders. Quantum mechanics fueled quantum computing, quantum internet, and semiconductors revolutionized pretty much everything from smartphones, laptops, and communications. Quantum thought hold two opposing thoughts at the same time and the key to creating quantum value co-creation (QVCC).

(ii)Problem structuring involves scope and boundaries consisting of (a) problem areas concerning to stakeholders, (b) collection of information and data, (c) conducting group sessions for creative problem structuring.

(iii)Causal loop modeling – conceptual models of the problem is created through (a) key variables identification, (b) behavior for the key variables, (c)developing influence among the key variables, (d) discussing dynamics of the behavior, (e)identification of system archetypes, (f) identification of leverage points, (g) developing strategies to intervene.

(iv)Dynamic modeling involves the following phases: (a) development of a high-level systems map of a potential simulation model, (b)defining variable types , (c)collecting detailed and relevant information and data , (d)construction of a computer simulation model, (v)producing graphical and output of the model, (e) verifying model equations and validate the model's behavior, (f) performing sensitivity tests , (g) test and design policies/procedures with the model to address management concerns, (h)developing test strategies.

(v)Scenario planning and modeling includes strategies and policies for all stakeholders: (a) developing general scope, and timeframe, (b) identification of key drivers that could have a significant impact on the decisions, (c) constructing pro/con scenarios, (d) simulating the scenarios with the model, (e) evaluation of the performance of the strategies with the model for each scenario.

(vi)Implementation and organizational learning, most beneficial and enduring outcomes of systems thinking and modeling, includes (a) preparing a report for all the stakeholders, (b)communicate outcomes and insights to all stakeholders, (c)developing a detail picture for the simulation model, (iv)develop and use the learning lab process to facilitate learning for stakeholders.

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Software development projects and pharmaceutical industry have quite a bit in common. Both are highly complex and rely on multidisciplinary teams. They are also often judged based on safety, reliability, and efficiency. Both software and drug development teams aim to produce efficacious, compliant, effective, safe, and commercially viable products. But they take very different approaches to development.

As shown in figure 6, a common systems perspective on design and development process consists of three subsystems, namely sensors/controller system, software development system, and customer System. Software development environment requires often change during the design and development lifecycle to meet business needs, minimizing headaches for development teams. The software development system has requirements and resources as inputs, and software as output. The inputs and outputs are flow of information. Ex: the customer system has software (e.g. information about the software's actual functionality) as one input, and it produces requirements (e.g. information about the software's desired functionality) as one output. The outputs of such a system are not only dependent on the inputs, but they also depend on the system's state. This create dynamics that result in time delays between input changes and corresponding output changes of a system. Delays can cause two effects: (i)the system needs more time to respond to changes, (ii) delayed flows of information result in outdated information.

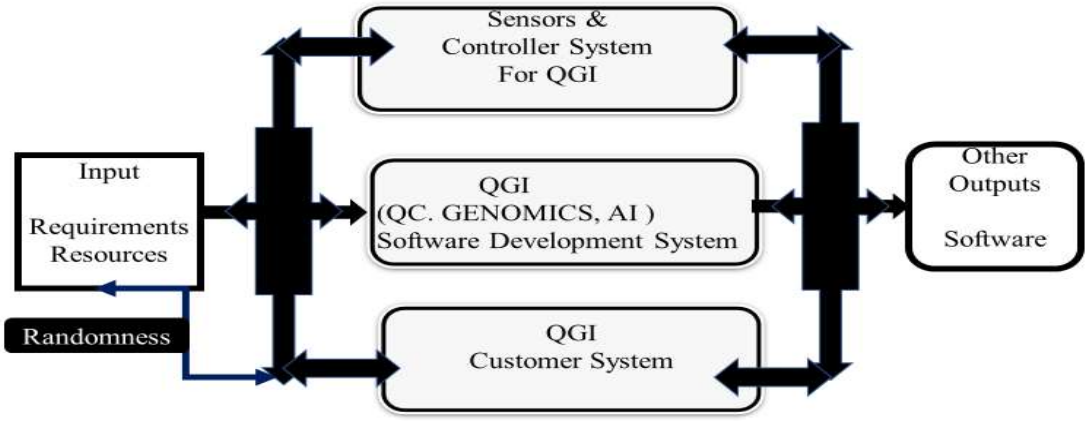

Fig. 6 A systems perspective of QGI software development

Genomics Suite® is a statistical analysis software is fast, agile, memory efficient with a user-friendly interface, analyzes microarray, and guided workflows for common genomics assays. Genomics software suite gives biologists, bio informaticists, and statisticians a single, integrated solution for trustworthy results. http://www.nature.com/nature/DNA50).
The quantum computing software solutions pioneered by Accenture and partners, is breaking new grounds to accelerate advanced molecular design and result in faster drug discovery for treatment of complex (computationally this is a very difficult problem) neurological conditions. This process should lead to novel therapies for patients with different neurological conditions.

Given the complexity of the conditions and the variety of candidate molecules, only quantum computing can process the complex data in a reasonably fast time frame. http://www.digitaljournal.com/tech-and-science/technology/quantum-computing-initiative-advances-drug-discovery/article/496462#ixzz61mtg4Wd1

Segment 3: Quantum Systems thinking approach with KLAS Methodology - To understand how systems thinking in drug discovery management works, the author has introduced a novel holistic - interdisciplinary approach, as shown in figure 7 & 8, for enhancing organizational performance through KLAS (Kanban, Lean, Agile, Scrum) methodologies, a term coined by the author.

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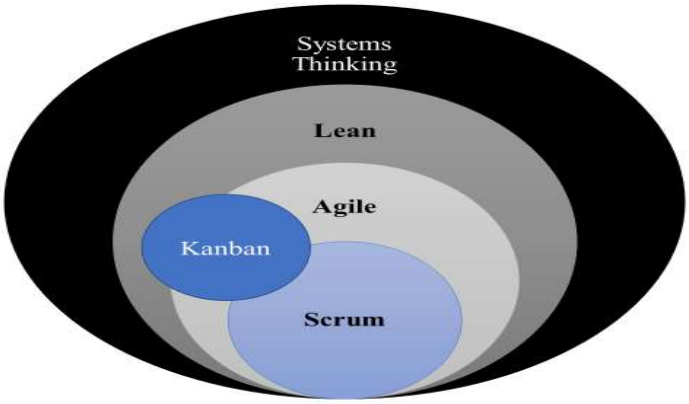

Fig. 7 "Systems Thinking" composed of KLAS Methodologies

Software development methodology is a framework that is used to structure, plan, and control the process of developing an information system. Although systems thinking and KLAS methodologies operate at two different levels, the author has learned from personal experience that an understanding of system thinking dramatically improves the learning curve of KLAS techniques and practices.

Over the past two decades KLAS methodologies have been steadily gaining popularity in various business fields. Although many companies are currently executing or leaning towards these methodologies, only a few understand the entire process to capture value for project management. Lack of knowledge among the staff of an organization leads to lower motivation and poor performance. Hence methodology basics must be learned and shared by every employee involved. Considering the above, the following are the reasons the author has chosen "systems thinking" in this study: https://realtimeboard.com/blog/choose-between-agile-lean-scrum-kanban/

(i) Being lean is essential to adapt and survive the cutthroat competition.
(ii) Due to rapid growth of technology market, particularly software sector introduces other industries to adopt lean and scrum mindsets.
(iii) Trend toward perfection makes everyone proud designing and developing products to offer the best price and best quality.
(iv) Proper management reduces stress, increases welfare and satisfaction.

The literature on using KLAS methodologies in distributed development software projects has steadily been growing. However, to date, there is little effort made to systematically select, review, and synthesize the literature on this topic.

Kanban

Kanban is a scheduling system of visual management aimed at just-in-time delivery. Many companies have tried Kanban scheduling and implementing Kanban without a clear idea of the goal is doomed to fail. Hence, most of them go back to conventional approach applying enterprise resource planning (ERP) systems. Kanban is about taking all ambiguity out of the information flow throughout the supply chain eliminating the individual judgments and is a great tool for revealing the real leverage points for improvement in delivery systems.

Blockbuster status of a drug is both a scientific and business success. The largesse of the successful drug also leads to complacency and inefficiencies in the drug discovery process making the pharma companies a prime candidate for Kanban project management enabling to streamline the business process and minimize expenses. Kanban method also applied to maintaining drug inventory.

Lean

Lean movement was born in manufacturing industry (automotive industry) aiming at loss reduction and sustainable production. Later, adapted for software development with relevant lean principles. A lean company follows a learn – measure – build cycle, conducts many tests, continuously connects with customers to understand, and improve the value creation process. Lean methodology helps launch software products far more quickly and cheaper than conventional methods. So far, the lean methodology hasn't spread quickly through most industries. Many have

tried, only few achieved successes. Very few companies are lean yet, because most still have trouble understanding the fundamental link between information and production. Based on extensive experience of the author, the "Systems Thinking" contributes significantly by providing an overall framework to lean methodology. Lean systems thinking is a methodology aims at creating unique lean enterprise that sustains growth by aligning customer satisfaction and organizing human activities to deliver higher productivity to the society. The tenants of lean efficiency and operation in life cycle manufacturing still have applications in pharma industry, specifically as blockbuster drugs lose their intellectual property (patent) right protections impacting on pharma drug pipelines to produce new drugs.

Although pharma has recently started to adopt and execute Lean Six Sigma, their potential is already being realized. Pharma companies pursuing to integrate the tools and culture of Lean Six Sigma into their infrastructure and operations are recognizing the benefits that includes increased capacity, higher throughputs, increased capacity and fewer errors, productivity, and better utilization of personnel, and resources.
Why Lean Six Sigma works for Pharma?

(i) Pharma products are new molecules, instruments, or reagents. Lean Six Sigma principles is applied to these continuous processes.
(ii) Research and Development is not a process. The output of R & D is new knowledge and the flow of knowledge can be monitored and tracked.
(iii) Data based approach of Lean Six Sigma complements FDA's process analytical technology initiative.
(iv) Lean Six Sigma implements various statistical techniques to minimize the number of experiments and prototypes. https://hyper38.com/kanban-drug-discovery/

Agile

Agile was born to improve productivity in software development and expanded into other disciplines such as Marketing. When a team follows the relevant value principles that can be considered 'agile', then time-focused, iterative philosophy allows to build a product incrementally. One of its primary benefits is the ability to adapt and change at any step to supply relevant products to the market.

Among information communication technology professionals, agile methodology is the primary approach. "Agile Development" is an umbrella term for a set of methodologies and apply time-boxed iterative and evolutionary development, adaptive planning, evolutionary delivery, and other values. Given the current struggles to shrink the product development life cycle in drug development, a more responsive, adaptive, and agile model is needed. To sum up, agile methodology is showing itself a promising way of working and moving beyond software development projects and soon will find its place in other industries like pharmaceuticals.

Scrum

Scrum is the art of getting things done. Efficiency and agility are not associated with the highly regulated pharma industry. Since drug pricing under intense scrutiny, the pharma business model is changing, and companies are embracing various ways to enhance their operational efficiency. Most of pharma companies still uses a traditional waterfall approach for drug discovery.

Waterfall method work best when the requirements of a project is not evolving. But the drug discovery process is complex, lengthy, and undoubtedly things (market demands, patient needs, industry regulations) evolve throughout the drug discovery process. The author contends that pharma needs to leave its traditional waterfall approach and pursue a more agile and efficient model. All pharma companies have a common goal to develop the best quality drug in the shortest span of time. Furthermore, the intellectual property (patent) expiration clock is always pulsating. Hence, scrum is a method that allows flexibility, and maintains a level of urgency by providing constant deadlines. https://www.pharmamanufacturing.com/articles/2016/scrum-the-art-of-getting-stuff-done/

Scrum is a software development methodology for managing knowledge work and addresses complex adaptive problems while creatively delivering products with highest value creation. Scrum assumes that the systems development process is an unpredictable, complicated process, enhancement of the commonly used iterative object-oriented development cycle, and workable techniques that a development team build systems.
Scrum is a special way for a team to work together to develop a product, as it occurs in small pieces. Scrum can also be thought of as a simple framework for effective teamwork in complex projects which provides a small set of

rules aimed to create just enough structure for teams to be able to focus.The aim of Scrum is to be able to respond

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fast and have flexibility in the development process without sacrificing quality, cost control, motivation or customer needs. In preference to orientation upon high-level and extensive planning and heavily documentation, it emphasizes the need for customer interaction during incremental and focused development cycles. The goal of Scrum, responding fast and flexibly to changes in requirements during the project, without sacrificing quality, cost control, motivation or especially user requirements, is a best fit for product development life cycle in drug development

Both (Scrum and Kanban) methodologies follow the principles of Agile and Lean. They track processes via scheduling system to ensure transparency. Scrum limits them by time units — iterations, Kanban limits work in progress per workflow state.

Segment 4: As shown in figure 8, the author introduces the "Perpetual Product, Process & Service Innovation (P^3SI)", - a holistic-interdisciplinary approach that is synergetic with systems thinking to create unique product, process, service, management, and strategy for sustainable development of pharma products that truly works in practice [8].

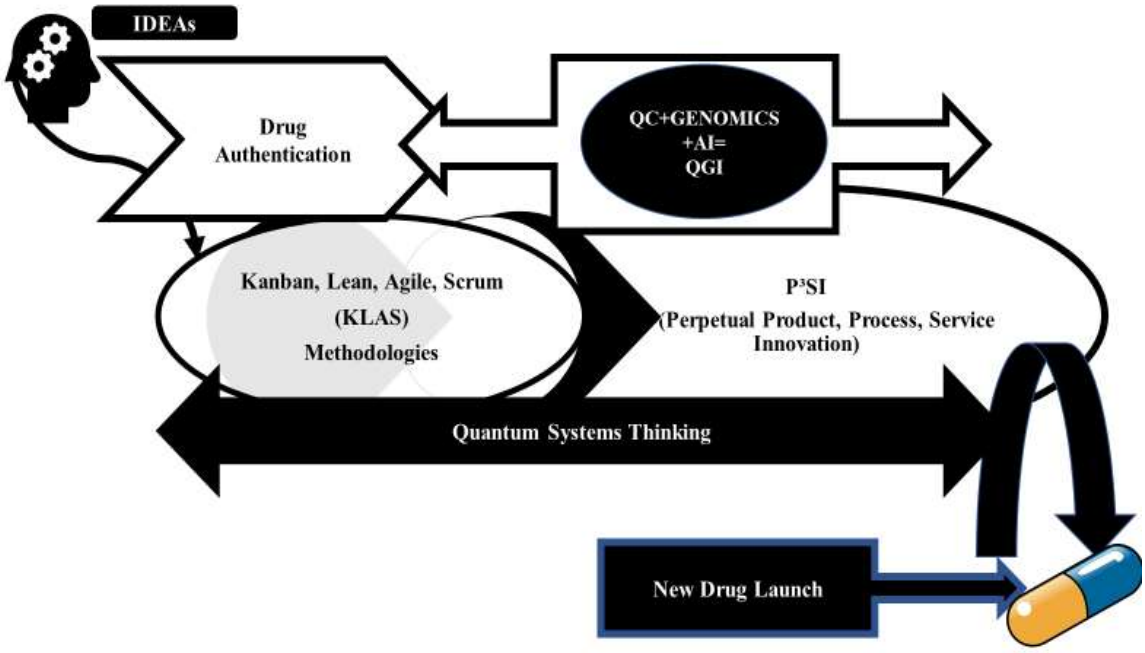

Fig.8 Quantum Systems thinking approach with KLAS Methodology and P^3SI for drug discovery process

Pharma companies that compete based on technology innovation strategy need to contend with how their products, process and service delivers value. Pharma enterprises need better systems thinking in their strategic delivery actions. The success of the pharma firm depends on all stakeholders to interact to co-create value. Literature shows the application of systems thinking help to maximize the return on innovation investment that drives profitability, sustained growth, and competitive advantage. Technology leaders responsible for delivering technology solutions in complex systems markets also need to develop their employees to think in terms of systems, adopt systems practices, and apply relevant strategic tools to leverage systems thinking. Innovation systems are considered a key factor to enterprises' long-term success.

Considering the important role of innovation to the firm, an innovation systems model should be designed using systems thinking approach. The aim of the model is to enhance innovation activity in the firms of manufacturing industrial sectors. Systems thinking methodology has been used to uncover the complexity of the innovation systems framework and reveal the underling structures which generate change.

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QUANTUM VALUE CO-CREATION (QVCC) USING QGI APPLICATIONS

Genomics bring significant benefits by accelerating clinical research and drug development, personalizing medicines, and reducing the cost of care. Genomic data, the most personal of all human data is enabled by the growth in quantum computing power and the commercialization of quantum wearable technologies. Genomic data can now be shared with healthcare professionals and disparate partners. The cornerstone for genomic data leadership is a robust data strategy meeting tough regulations and preserve ethical standards. This, along with the use of the emerging quantum technologies — to process large data volumes and generate insights — can enable Life Sciences companies help in discovering and taking forward new drugs.

Co-creation of value in marketing is a business strategy promotes and encourages active involvement from the customer to create on-demand products. Quantum value co-creation (QVCC) - a business strategy focused on QGI applications inscribing economic, socio-cultural and environmental issues by recognizing sustainable competitive advantage that brings community quantum benefit. In this study, the author has coined the term QVCC and the definition is as follows:

(i)Quantum term refers to scale and scope where effects become important.

(ii)Value is described in two ways. From an economic point of view, value is defined as the utility of goods and services as well as the benefits arising from ownership. In the ethical sense, value denotes something of significance and contribution to society to make a positive difference in humanity.

(iii)Co-creation is a form of economic strategy or management initiative, that brings different stakeholders together to jointly produce a mutually valued outcome. Co-creation is getting other people to do the work and love the brand for it. Nowadays, most businesses are learning to listen, consult, co-operate to work with stakeholders. Furthermore, co-creation is a management dynamism, contemporary business thinking and a new frame of reference that brings the stakeholders together to jointlyproduce a mutually value-added result. While most people think of co-creation to innovate to transform the competitiveness, it is also a way of cutting cost. With co-creation, consumers get exactly what they want and have a hand in making it happen.

(iv) Co-creation of value brings the unique blend of ideas to innovative ideas for the brand to provide unique experiences for the stakeholders with continual learning and enhanced market performance drivers. Co-creation of value is not new, but new disruptive technologies create new possibilities and opportunities.

Still, to date, the top leadership team of most pharmaceutical firms consider drug discovery process as a one-dimensional opportunity. Such a one-dimensional approach provides pharmaceutical enterprises shortcomings to deal with the challenges in a strategic way. Quantum value co-creation (QVCC) requires a multi-dimensional approach by pharmaceutical firms to achieve optimum performance. Multi-dimensional approach comprises of assessing and implementing methods, tactics, strategies that consists of more than one feature and/or design to address a complex situation. In this study, the development of a QGI framework through quantum systems thinking is focused on the quantum value co-creation framework that involves the synergistic relationship of quantum computing, genomics and artificial intelligence (QGI) applications and the relevant value chain in a multidimensional opportunity involving all stakeholder's participation.

The building blocks of the quantum value co-creation (QVCC), as shown in figure 9, are: (i) QGI applications, (ii) quantum systems thinking among the stakeholders, (iii) stakeholders' participation in the entire value chain of the drug company, and (iv) products, process and services interactive actions with the application of QGI.Quantum value with information communication technology business is to achieve measurable high-performance results.

Future of pharmaceutical quantum value co-creation depends on the following: (i) advances in quantum science and technology, (ii) genomics and personalized medicine can help treat diseases previously out of reach, (iii) quantum technology and metrics can help quantify pharmaceutical value , (iv) policy-makers and pharma can collaborate to incentivize R&D and create revenue security in areas of public concern, (v) create a more transparent, systematic method for pricing based on value, (vi) transparency can benefit both consumers and pharma companies, (vii) reduce existing physician uncertainty regarding the value of drugs, (viii) expand existing treatments to new populations or diseases, and (ix) develop & distribute highly effective and groundbreaking treatments

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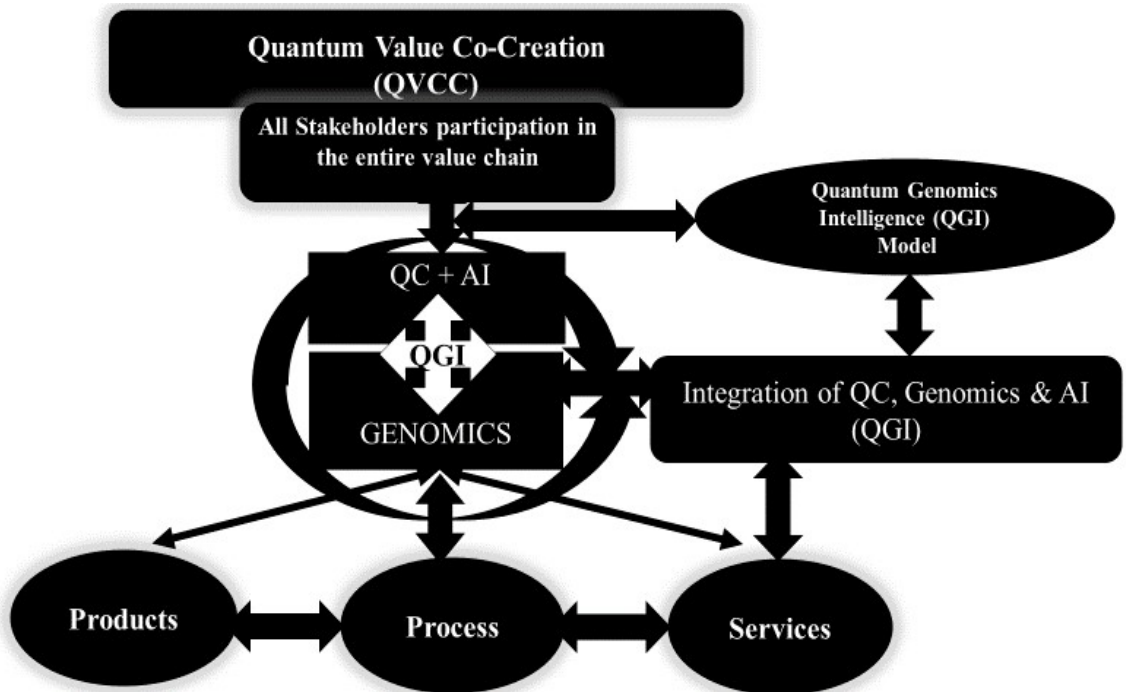

Fig. 9Quantum value co-creation using QGI applications

CONTRIBUTION

The contribution of this research provides quantum systems thinking approach to the QGI applications for the drug discovery process to attain quantum value co-creation. Finding reveals that drug discovery designers ought to use the quantum systems thinking as "holistic and interdisciplinary" approach for the transformation of value chain to attain transcendence and stakeholder satisfaction. This study provides precept to pharmaceutical enterprises, drug designers, academia, entrepreneurs, industry practitioners, investors, and policymakers to assuage socio-economic benefit for the contemporary society.

CONCLUSION

Drug discovery often takes more than a decade and billions of dollars investment before a molecule can be recognized as a drug and the process has been so complex that it cannot be contained within the confines of the pharmaceutical industry. Therefore, it requires a flexible and diversified quantum biotechnological industrial base.

99% of new molecules fail to deliver drug discovery. More than 95% of all Pharma scientists are unfamiliar with quantum genomics intelligence (QGI) applications for drug discovery. Research shows that lack of knowledge and lack of talent pool is the biggest barrier in the integrated application of QC, genomics and AI to drug discovery process.

The QGI integrated concept as a system is still largely undiscovered discipline in the drug discovery process. The convergence of QGI applications has not received its fair share of scholarly attention yet in the drug discovery literature. Projects in practice devoted to this groundbreaking symbiotic integration of QGI applications is not pursued by the pharmaceutical companies yet.

Developing the future therapeutic agents involve the quantum biotechnological science disciplines that have always been at the core of drug discovery. Taking drug discovery to the next level will require an entirely new systems thinking approach with the application of QGI. Quantum systems thinking requires new mindset to integrate quantum computing, artificial intelligence, genomics, and bioinformatics with appropriate methodology into the development process to pursue the next stage of advances in drug discovery.

QGI transformative value is five to ten years away for the drug discovery process. The fundamental question one

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should ask- why should drug enterprises consider investment now in QGI applications? The simple answer - QGI is a new biotechnological science paradigm that presents formidable ramp-up challenges, even for firms with advanced technological capabilities. Early adopters will gain expertise, visibility into knowledge, and even intellectual property ownership that will put them at quantum advantage as QGI gains commercial traction. Now is the time for the pharma industry stakeholders to implement the seamless integration of QC, genomics, and AI because it will give immense benefits with regards to productivity, performance and cost savings with quantum value creation.

So far, the current literature does not provide any comprehensive information on the quantum systems thinking and the holistic perspective of QGI applications to the drug discovery process. The objective of this research has been to analyze the literature to-date and apply quantum systems thinking approach with KLAS methodology and perpetual innovation to understand the applications of QGI for the drug discovery process. Thus, this study fills the vacuum with new knowledge to the literature.

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BIOGRAPHY

Prafulla Kumar Padhi, a serial entrepreneur and techno-market futurist, has over 43 years of global business experience and held the Founder, CEO and Chairman of the Board positions for more than 25years and managed up to US$1.2 Billion revenue operations. His education qualification includes a Master of Science degree from the prestigious Massachusetts Institute of Technology (MIT), Cambridge, USA and a graduate of the Ivy League Wharton School of Business, University of Pennsylvania (USA) and holds seven diploma certificates from the Ivy League Columbia University (USA), the Ivy League Dartmouth College (USA), and Kellogg School of Management (USA). For more than 40 years, as a pioneer, Mr. Padhi has been involved in entrepreneurial venture endeavors in disruptive technologies and smart fashion wearable ventures globally. So far, he has done business in 46 countries and travelled to 142 countries. He is an author, freelance writer, independent researcher, teacher, innovator, pioneer, product marketing architect (patent/copyright holder) in the creation, design, marketing disruptive technologies and products.