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Views & Comments

Revolutionizing the Life Sciences by Developing a Holographic Digital Mannequin

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1. The need to develop a holographic digital mannequin

Life processes, including high intelligence, self-organization, and homeostasis, are characterized by the biological organism in the form of self-renewal, self-replication and self-regulation, metabolism, self-repair, and self-reproduction, which are all processes of multisystem coordinated movement [1]. Research in the field of life sciences is not limited to the use of advanced observational methods to reveal microscopic structures at the subcellular or molecular level. Discoveries based on these methods alone cannot characterize the dynamic processes of life at the microscopic and molecular level [2]. In the field of life sciences, the United States has successively launched the global Human Genome Project [3], the Global Human Proteome Project [4], the Human Microbiome Project [5], and the Human Cell Atlas [6]. The implementation of these projects has enabled the United States to occupy the world's leading scientific and technological research space. These projects, however, may not systematically reveal the fundamental laws of human life activities from the macroscopic to microscopic levels [2,7], nor do they systematically reveal the specific biological functions characterized by the regulation of biomolecular networks, such as proteins and their processes of temporal dynamic changes. The exploration of human life has reached the molecular level, including DNA and protein, according to central dogma [8]. It remains difficult, however, to reveal the natural laws of life activities systematically and completely, such as the molecular regulation network, or to describe the specific biological functions in a temporally dynamic manner. Therefore, biomedical research has been seeking a substantial breakthrough in our understanding of the basic rules of human life [9], which might advance our understanding of the exact pathological mechanisms, effective interventions, and rehabilitation measures needed to address a variety of diseases that affect humans

[10–12]. The concept of systems biology has provided a more widely accepted view at the system level to evaluate biological processes [13]. As a result of this development, the overall level of medical research has evolved toward holistic integrative medicine [14]. For example, evidence is growing in the knowledge and treatment of chronic diseases, including tumors [15,16], cardiovascular diseases [17,18], metabolic diseases [19,20], respiratory diseases [21], and autoimmune diseases [22,23] at the level of holistic theory, rather than following the “one drug, one target” strategy. We are still short on systematic research from the macro to micro perspectives, however, which would better reveal requirements for human life, health, and disease [24–27].

Advances in high-throughput methodologies in life science and technology represented by systems biology, such as genomics [28], proteomics [29], metabolomics [30], and transcriptomics [31], have opened a window for analysis of the network connections among the components in molecules, subcellular components, cells, intercellular links and tissues, organs, systems, and the whole organism following a modern biomedical perspective [32–34]. Innovative algorithms have empowered us to convert the representation of dynamic changes in the organs, tissue, and cells during life activities, which have produced a significant amount of data [35]. These data allow for simulating and reproducing the networked process of life activities through information technology, such as digital twins, to decode the essence of life activities and benefit medical treatment [36]. In this way, deep integration of life science and information science has provided optimal options to transform the research paradigm and fundamentally progress medical science [37]. Therefore, it is necessary to establish a new scientific research paradigm [38] that focuses on three basic scientific questions in the field of life science: ① to analyze the microstructure of the human body, ② to reveal the correlation between these structures, and ③ to explore the temporal change laws of these structures and their function. This work makes it possible to reveal the law of panoramic life activity at the cellular

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level; explore the regional life activity network mechanism of vital organs [39–41]; elucidate the cutting-edge deconstruction research on the human body, such as the complex network regulation process of the central nervous system [42] and the peripheral organs [43–50]; and reconstruct research of the holographic digital mannequin.

A “holographic digital mannequin” is a digital model that represents the physiological and pathological processes of life system activities of humans in real time based on the reconstruction of the human body’s micro-, meso-, and macro-networked dynamic life information dataset using digital twin, computer simulation, and other technologies. It includes dynamic networks of biomolecules within cells of different clusters, an organ-specific intercellular dynamic network, and dynamic networks among organs, such as the network between the brain and peripheral organs or the network among peripheral organs. This holographic digital mannequin works in an Internet of Things (IoT) operational pattern that is self-organizing, automated, and self-coupling [51]. The main application objectives of a holographic digital mannequin are as follows: ① to reveal the structural network of the tissues and organs of the human body and the law of time-phase changes on the network of human body structures; ② to evaluate the status of an individual’s health, subhealth, or disease based on physiological and biochemical data, imaging, electrophysiology, and magnetic change data, which are calculated with a holographic digital human body and are characterized according to the microstructure and functional alterations; ③ to identify precise treatment strategies for different patients according to personalized medical data; ④ to develop novel treatments based on multi-target integrative regulation and systematic interventions; ⑤ to reveal the principle of traditional Chinese medicine (TCM) in the diagnosis and treatment of diseases; ⑥ to establish a permanent and precise digital human body for future archaeological and anthropological research; ⑦ to promote the development of advanced biomimetic manufacturing; ⑧ to develop information science and other natural sciences; and ⑨ to support the cultivation of Chinese talents and the construction of scientific and technological world highland.

Specifically, the overall research idea is to categorize, integrate, and digitize the theoretical models through the existing relevant scientific research results; to decode the complex life activity process of human beings through advanced scientific and technological means; to drive life science research into the era of data-intensive scientific discovery; to comprehensively recognize the essence of life activities from the macro to micro level [41,52]; to analyze the human holographic life system; and to crack the health code of human life according to a mutual regulation mechanism among multiple systems [53]. In this way, we may reveal the exact causes and dynamic pathological mechanisms of many diseases and also create accurate and effective intervention and rehabilitation measures to treat these diseases [54,55].

2. Progress to reveal the mechanisms of human information and energy networks

The 696th Xiangshan Science Conference on the theme of “Revealing Three Major Scientific Problems in the Field of Life and Analyzing the Mechanism of Human Information and Energy Network” was initiated by Academician Cong Bin and was held in Beijing on April 10–11, 2021. More than 40 multidisciplinary experts and scholars from medicine, biology, life science, TCM, mathematics, physics, artificial intelligence, and information technology attended this conference. The attendants reached a consensus and proposed to launch a significant research program on “digital life and holographic human body.” The main research con-

tent of the program will be as follows: ① to reveal the law of life activity at the cellular level; ② to characterize the regional life activity network model of vital organs; ③ to analyze the complex network regulation mechanism of the central and the peripheral system; ④ to develop a “holographic digital human body;” and ⑤ to establish a new Talent Cultivation System.

Scientists and experts in attendance developed a series of plans to achieve the goals of the project during the conference. Specifically, to run the project, it will be necessary to establish a centralized data center with the $(1 + N)$ model, where N represents different organism systems, such as the digital connectome among different organs, for the holographic mannequin. Some key research progress has been made, including whole-brain mesoscale mapping in primates [56], whole-brain single-neuron projectome analysis on specific brain regions that may participate in critical functions [57], and a systemic neural and metabolic connectivity framework using whole-body imaging [50,58–60]. In addition, Bigmath (Shenzhen) Technology Co., Ltd. has developed an innovative computation appliance “memory machine” to meet the significant demands of this program in computing infrastructure. The company is striving to build a unified data platform (called “BigInsights”) to create a holographic model for big data in life activities.

This project will propel development in China and globally across various fields, including life sciences, medicine, and information technology. It will establish an international, cutting-edge technological and scientific research hub, attracting exceptional talent. Obviously, this program is a mammoth undertaking and requires the collective efforts of scientists worldwide to establish a global unified framework for international cooperation and to set research and development (R&D) standards.

3. The outlook to develop a holographic digital mannequin

The development of a holographic digital mannequin is a major global research project. This effort will promote the deep integration of medicine, life science, information science, chemistry, physics, and mathematics for joint innovation and development. The holographic mannequin was proposed and established based on the structural features of TCM’s ontology and holistic theory. For example, according to the human holography, a certain part of the body may carry the overall information about the body. In TCM diagnostic methods, the face and tongue and internal organs have a subordinate relationship, both of which can reflect the overall condition of the body to a certain extent. This relationship is one of the embodiments of holographic theory in TCM consultation. Furthermore, a holographic digital mannequin can provide a critical toolset for the study of body functions as well as the study of TCM ontology, holistic, and systems theory. Undoubtedly, TCM’s ontology and holistic theory remains an integral part of modern systematic medicine and will continue to play an important role in contemporary medical practice, especially in the field of complementary and alternative medicine [61,62]. TCM may take advantage of this holographic digital mannequin to decipher the theory of internal organs and meridians as they apply to Chinese medicine [63–66].

This major research project draws on the epistemology and methodology of TCM’s ontological and holistic views. It also analyzes the four-dimensional spatial operation law of the evolution of living matter in the body; establishes a cross-fusion platform in the fields of information science, brain science, physics, modern medicine, life science, and TCM; and constructs a holographic digital mannequin [67,68]. Undoubtedly, this is a major global research program that will promote the deep integration of medicine, life sciences, information science, chemistry, physics, and mathemat-

ics. It jointly innovates and develops science in multiple disciplines [69] while turning great research into great products [70,71]. This project represents an international research frontier to establish a new model that combines original innovation, technology R&D, talent training, technology application, and industrial aggregation to collectively represent five-in-one integrated development and establish a new industrial format.

The goal of this project is to decipher the code of human life and health from a mutual regulation mechanism among multiple life systems. The process of deciphering the code of human life and health will rely on the achievements and engineering practices of all scientific and technological progress. This effort will mark the culmination in the achievements of existing scientific and technological progress [72–75]. The layer-by-layer decryption of the human holographic life system may inspire many novel questions and opportunities, which will further promote the comprehensive development of science and technology.

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