Vol. 12 (3) 304-310 July 2018, ISSN 0973-8916 (Print), 2230-7303 (Online)

# The Emergence of Blockchain Technology and its Impact in Biotechnology, Pharmacy and Life Sciences

**L. N. Chavali[1], N. L. Prashanti[2], K. Sujatha[3] G. Rajasheker[1] and P.B. Kavi Kishor[1]**
[1]Department of Genetics, Osmania University, Hyderabad 500 007, India
[2]GITAM Institute of Management, GITAM University, Rushikonda, Visakhapatnam 530 045, Andhra Pradesh, India
[3]Department of Chemistry, KTR Women's College, Gudivada 521 301, Andhra Pradesh, India
*For correspondence - pbkavi@yahoo.com

**Abstract**

The emergence of blockchain technology is regarded as 4th industrial revolution i.e., the integration of cyber-physical systems since the advent of Internet with far reaching applications in Banking, Insurance and Government, may impact other sectors especially life sciences. The fourth revolution is characterized by fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. Therefore, it is vital to understand the opportunities and threats of adopting this technology in life science/ pharmaceutical research. The proprietary databases of today's institutions interact with some form of interface either human or otherwise. Integrating blockchain with life science/ pharmaceutical applications will decentralize the interface as well as the data exchange, resulting in high efficiency, greater speeds, low marginal cost, and infinite scalability.

**Keywords:** Blockchain, Agriculture, Pharmacy, Genomecoin, Cryptography, Smart contract

## Introduction

The computing paradigms underwent through many changes since the first main frame. There is a birth of a new paradigm in every decade. Personal Computer (PC) was regarded as revolutionary over mainframes and later on Internet revolutionized everything (1, 3). It can be seen that mobile phone and social networking have established their place in the computing world over the last decade and now, the current decade may be dominated by blockchain and Internet-of-Things (IoT). Over the years, the companies or institutions stored the data in the proprietary database where they have complete control over it. The structure of database of an institution is different from other institutions due to its proprietary nature. The access of data and operation of the database are localized within the institution or company with restrictions/permissions. With the advent of new technologies, data exchange between different databases has become a necessity. The inter-communication between databases was achieved through broker or intermediaries and recently by Application Programming Interface (API). Even with the best of API available today, a transaction must be coordinated among stakeholders before final delivery or closing. Regulations, selective enforcement and efficiencies are some of the key issues encountered in modern-day commerce. In centralization (10), if two databases communicate directly with some commonality, it can be regarded as merger where data are combined under a central authority. Such centralization may suffer from the fear of legislation, monopoly, inefficiencies etc. In decentralization (11), everyone can share the same database with no controls and central authority. It may be faster and cheaper but suffers from other anomalies like cheating, fraud etc. But, the blockchain technology solves the problems

Vol. 12 (3) 304-310 July 2018, ISSN 0973-8916 (Print), 2230-7303 (Online)

encountered in decentralization. Blockchain may serve as the main backbone for the future computing world in terms of connecting wearable devices, IoT sensors, smart phones, tablets, laptops etc.

***Blockchain technology enables direct interactions between users :*** Blockchain technology is a distributed, shared, encrypted, chronological, irreversible and incorruptible database and computing system (public/private) with a consensus mechanism (permissioned/ permission less), that adds value by enabling direct interactions between users (4). Or blockchain is a technology for shared databases between multiple non-trusting writers, yet can be modified and authenticated without a trusted intermediary (9). Blockchain-based authentication model allows users to truly identify and confirm each other's public keys. This eliminates the man-in-the-middle threat and any kind of manipulation attempts from the server and third parties' sides. A blockchain is a shared and secured database, which is not controlled by a single user but by the network as a whole. Schwab (2) defined blockchain as a technology that represents a "distributed database or ledger or a registry, which uses a secure protocol where a network of computers collectively verifies a transaction before it can be recorded and approved. Therefore, blockchain can be used to create trust, by enabling people who do not know each other (and thus have no underlying basis for trust) to collaborate without going through a central authority". Blockchain (the technology behind Bitcoin and other digital currencies) would permit multiple parties to share a single database with no central authority where access and controls are managed with software. Blockchains are very difficult to tamper with once the information is registered thereby making it less error prone and more efficient. Therefore, blockchain can be thought of as an application layer over Internet enabling transactions, digital currency payments (crypto currency), asset management etc.

**Listed below are some of the characteristics of blockchain technology** (5)

1. As a public ledger system, blockchain records and validates each and every transaction made, which makes it secure and reliable.
2. All the transactions made are authorized by validators, which makes the transactions immutable and prevent it from the threat of hacking.
3. Blockchain technology discards the need of any third-party or central authority for peer-to-peer transactions.
4. Decentralization of the technology.

Any new technology such as blockchain now and Internet in earlier era needs trust and ease of use for main stream adoption. In the financial world, the wallet companies such as Circle Internet Financial and Xapo developed applications for mainstream adoption of Bitcoin. Bitcoin refers to three layers in the technology stack of blockchain viz., platform (i.e. decentralized ledger), protocol (i.e. software) and Crypto currency. In blockchain technology, the user initiates the action and pushes the information to the network as opposed to pulling the information from a centrally authorized data store which may be vulnerable to thefts, attacks etc. Hence, blockchain technology operates on push model ensuring no dependency on centralized data store. Blockchain may become the "Internet of Money", connecting finances in the way that the IoT connects machines. In currency and payments (7), the blockchain adoption may reduce the transaction fee below 3% from 7 to 30% (8). A key outgrowth of the ledger is the idea of "smart contracts", which "provide security superior to traditional contract law and reduce other transaction costs associated with contracting". The decentralized computer-code can be run on a blockchain database and these pieces of computer codes are called smart contracts (6). In the absence of blockchain, if a person sends a contract over e-mail, each party would hold an identical copy that could be easily manipulated, whereas with blockchain only the receiving party would hold a valid copy.

Bitcoin and e-wallets are related to money. Trust becomes a major factor in currency exchange as well as the sensitivity to security with regards to crypto currency, digital currency backup, privacy etc. Blockchain and Bitcoin are used interchangeably though being different. Bitcoin is digital currency where as blockchain is a distributed database. Currencies that use a blockchain (and thereby these cryptographic algorithms) are referred to as Cryptocurrencies. After the introduction of blockchain technology in Bitcoin, other cryptocurrencies emerged. The flow of money transfer in blockchain is depicted in the figure 1.

Blockchain has three types of users like (1) users that read data (2) users that write data (users, transaction users), and (3) users that validate data (miners, full nodes/users, validator nodes/users). Beyond currency, blockchain applications cover various other types of transactions some of which are bonded contracts, bonds, business licenses, copyrights, death certificates, derivatives, driver's licenses, identity cards, land and property titles, marriage certificates, mutual funds, passports, patents, registrations, reservations, stocks, third-party arbitrations, trademarks, vehicle registrations, voter lists etc. There are many blockchain projects that are currently being developed. Ethereum (http://ethereum.org/) is a general-purpose crypto-currency platform which is being widely used. Some of the wallet projects are ChromaWallet, CoinSpark, Counterwallet etc., built over blockchain protocol. Wallets help to store and exchange bitcoin in secure way.

## Utility of blockchain in life sciences and pharmacy

**(*a) Blockchain and genomics :*** Blockchain is allowing to record genomics data that can combat counterfeit pharmaceuticals and protect intellectual property rights. Medicinal Genomics Corporation (https://www. medicinalgenomics. com) is a molecular information company that applies state-of-the-art life science technology to *Cannabis* plant genetics and devoted to sequencing of genomes of the patients with seizure disorders such as epilepsy, developmental and intellectual disabilities (including those on the autism spectrum), and mitochondrial diseases. It has developed novel DNA purification technologies and Next-Generation DNA Sequencing technologies which have been widely adopted by major scientific research institutions and commercial enterprises. It is using blockchain to counter claims on patents as there is no legitimate prior proof of it in the field and also using it to get strains digitally notarized by verification of blockchain technology. Blockchain is being used to fight the mistrust in genomic research by

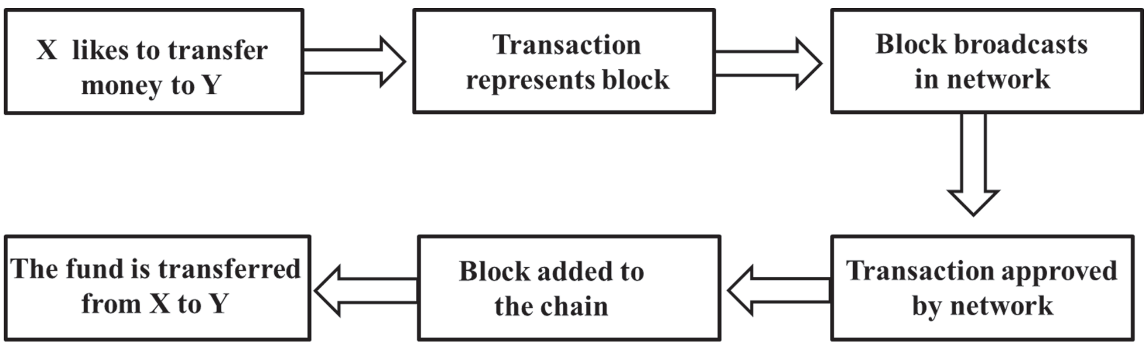


**Fig. 1.** Figure displaying flow of money transfer in blockchain

sharing data. Data silos (a repository of fixed data) and centralization is causing suspicion and mistrust in genomic research which necessitates decentralization of data like ledgers in blockchain. Global Alliance for Genomics Health (GA4GH) (https://www.ga4gh.org) is planning to use blockchain for internationally sharing genomics data. Decentralization and sharing of data through blockchain will lower the cost and enable poorer countries to access the data. Due to privacy restrictions of data, it may be possible to implement private blockchain, however, everything in private blockchain will be subjected to the supervision of an independent central authority. Private blockchain may be a necessity in some situations in genomics like when dealing with the entire genome. Of late, patients are demanding more assurances that their genomic data are being secured appropriately, accessed as per their wishes which comes into reality with blockchain. In future, patients are empowered in terms of their data access and let companies access some blocks of their data for research purpose. Therefore, it is crucial for stakeholders to understand blockchain usage in life science R&D and especially in pharma R&D and its potential disruption in near future.

The data inserts in blockchain are immutable. So, information stored on a blockchain cannot be subsequently amended or deleted. Therefore, attentions is required if the sensitive data stored in blockchain is to comply with data protection laws, which may be challenging due to specific regulations in terms of individual rights in deleting data or correcting the data. A Russian startup called Zenome.io is looking to put consumers in control of their genomic data. The blockchain-based, peer-to-peer technology will automate collection and sharing of genomic data in part by allowing individuals to upload their own DNA profiles control which researchers may access and add to each secure store of information (12). This may be a platform for buying and selling genomic data. EncrypGen, a startup from Coral Springs, Florida is getting ready to beta test a blockchain-based system to allow patients to store and share genomic data through what it calls a "gene-chain."

The right to one's own genetic information must be seen as a basic human right, and migrating the transactional organizations to decentralized blockchain is a necessity in view of protecting the personal rights. In the United States of America, prominent genomic researchers have tried to make a public case that the Food and Drug Administration is overcautious on consumer genomics (13) and established in studies that there is no detrimental effect to individuals having access to their own genomic data (14). Blockchain-based genomic services could be an idea for providing low-cost genomic sequencing to individuals, making the data available via private key.

***Genomecoin and Genomic Research Coin :*** Genecoin (www.genecoin.me) samples one's DNA, turns it into data and stores it in the Bitcoin network. Genecoin developed a tool to spread the DNA across the globe by collecting DNA sample and converting it into the data before loading the genome data into Bitcoin network. The genome data are stored and the network is used as a permanent back up of the data.

DNAnexus (https:/www.dnanexus.com), a cloud-based platform, provides a global network for sharing and management of genomic data and tools to accelerate genomics research. The DNAnexus solution is the largest current data store of human genomes and is ever expanding. As the future of human health is in genomics and only 300 worldwide preapproved genomic researchers have permission to use it, it is important to add coin functionality or blockchain functionality to DNAnexus to make it more open to public use. The Genomic Data Commons is a US-government-funded large-scale genomic research project which is accessible only to USA based researchers. This has to be expanded on large scale to be accessible to an individual worldwide by adding genomecoin. Organizing genomic data into a standard unified repository and allowing access to it at least to a limited research group/population is ideal. A further step in this direction could be using an appcoin like Genomecoin to expand its accessibility to a wider population.

***(b) Blockchain and agriculture :*** Blockchain has a potential to transform agricultural industry in the three key sectors namely (1) provenance (the place of origin) and radical transparency (2) mobile payments, credits, and decreased transaction fees (3) real-time management of supply chain transactions and financing. While agriculture is the most significant sector in rural areas and provides a livelihood for 70 per cent of the world's poor, it is also the industry that provides the biggest disconnect between supplier and retailer. Using blockchain, however, a more direct link can be established, ensuring that farmers receive fair payment for their produce and enabling retailers to verify that they are getting what they have paid for (16). Consumers are always willing to pay for organic food, and clean food if proper information is provided. Despite many regulations are in existence as of today, consumer remains in utter confusion over it. Blockchain may be useful in solving this problem by effectively monitoring the food supply chain. Practical applications of blockchain technology in the agriculture sector also include minimizing unfair pricing, product origins, and reducing multinational agricultural influence in favor of more localized economies. In the future, platforms could also help with remittances to rural regions as well as other rural farming finance solutions (17). The digital tokens based on blockchain can be exchanged for fertilizer for small farmers. Because the tokens are on a blockchain, they cannot be misused or imitated, ensuring that the government-allocated funds are creating maximum impact where intended. Blockchain can be used to create immutable land titles to prove ownership and protect farmers from widespread corruption and digitization of paper contracts into smart contracts to improve efficiency and minimize costs. Farmers always look for technologies that deliver value and solve significant problems. The future of blockchain in agriculture solely depends how it can help and take agriculture forward by connecting this technology to viable business models.

***(c) Blockchain and pharmaceuticals :*** The disruptive nature of blockchain technology caught the imagination of technologists as it makes markets more efficient and the technologists continue to fuel the hype over the possibilities. According to Gartner Hype Cycle for emerging technologies, blockchain technology started going down the trough of disillusionment after hitting the peak (19). However, the majority of leaders in the life sciences and pharmaceutical industries expect a broad adoption of blockchain in life sciences and pharmaceuticals in the next five years and most of the companies are experimenting with blockchain and the storage and all access tools may go through a rapid change as to leverage previously unavailable data sources. The creation of immutable and auditable records in clinical trials with blockchain is important in meeting regulatory requirements. The blockchain should enable the companies to collect the clinical data more securely. Clinical trial data in real-time on an immutable basis will also make it hard for subsequent manipulation of the results by researchers. Blockchain enables Food and Drug Administration (FDA) approvals faster in new drug discovery process due to diverse sampling of data, auditable trial of supply chain and minimized fraud because of consensus of different parties in the network. Supply chain security is one aspect that has recently won attention, when the Drug Supply Chain Security Act (DSCSA) has been implemented in the USA. The act has been implemented amongst other things to fight the counterfeit drug problem. Counterfeit drugs are drugs that do not contain the active ingredients that they are supposed to have and consequently can harm patients from all sectors (15). Blockchain may be seen as an answer to handle the illegitimate drug problem as the blockchain platform ensures drug identification, tracing, verification and notification, trust and transparency between parties during ownership changes in supply chain.

***Blockchain and challenges ahead :*** Some claim that in a few years' time, blockchain will no longer be a buzzword but some others believe that blockchain is all hype and it is an untested technology with huge risks and little upside. There are potential threats (18) for adopting blockchain technology in every country, some of which are listed below.

1. Powerful Incumbents
2. Ideological Pushback
3. Privacy Concerns
4. Off-Chain Transactions
5. Loss of Discretion and Arbitration Challenges
6. Distrust of the Technology Due to Lack of Adoption

The lack of widespread understanding of blockchain and the difficulty of integrating the technology into existing infrastructures and bureaucracies is blocking the adoption. However, once the value is recognized and trust is built over privacy, the threats may not be major challenges but surmountable. The adoption of blockchain technologies would limit the means and methods for illicit activities.

## Conclusions

It is the technology which drives science always forward. Blockchain technology is a kind of mechanism that needed to achieve the next orders-of magnitude progress in vital areas such as human healthcare/genome research, agriculture, pharmacy and well beyond. It is time to adopt such innovative and impending technologies which will take science forward and change the lives of common man in the society.

## References

1. McKinsey and Company (2016). Blockchain in Insurance-Opportunity or Threat. Insurance, July, 2016.

2. Schwab, K. (2017). The fourth industrial revolution. Published by Penguin, UK.

3. Schwab, K. (2015). The Fourth Industrial Revolution: what it means, how to respond. https://www.weforum.org/agenda/2016/01/the-fourth-industrialrevolution - what - it-means –and – how – to - respond. Snapshot. December, 2015.

4. Meijer, D.B. (2017). Consequences of the implementation of blockchain technology. A grounded theory study to develop a conceptual framework on the perceptions of actors on the consequences of implementing blockchain technology. Master thesis submitted to Delft University of Technology in partial fulfilment of the requirements for the degree of Master of Science Systems Engineering, Policy Analysis, Management.

5. Howard, G. (2015). Blockchain technology is our chance to rebuild the Internet in a way that benefits creators: http://www.forbes.com/sites/georgehoward/2015/08/12/blockchain-technology-is-ourchance - to-rebuild-the-internet-in-a-way-that-benefits-creators/ - 63bd3ac9610f.

6. Buterin, V. (2013). Ethereum: A next-generation smart contract and decentralized application platform [White paper]. Retrieved from (01-09-2016): https://github.com/ethereum/wiki/wiki/White-Paper.

7. Levine, A.B. and Antonopoulos, A.M. (2014). Let's Talk Bitcoin podcast, September 30, 2014. http://letstalkbitcoin.com/blog/post/lets-talk-bitcoin-149-price-and-popularity.

8. Hajdarbegovic, N. (2014). Deloitte: Media 'distracting' from Bitcoin's disruptive potential. CoinDesk, http://www.coindesk.com/deloitte-media-distractingbitcoins-disruptive-potential/Anonymous. "Remittances: Over the Sea and Far Away". The Economist, May 19, 2012. http://www.economist.com/node/21554740.

9. http://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project.

10. https://en.wikipedia.org/wiki/Centralisation.

11. https:/en.wikipedia.org/wiki/Decentralization.

12. https://www.genomeweb.com/informatics/despite - hype - blockchain – remains – mostly –theoretical – precision - medicine.

13. Green, R. and Farahany, N.A. (2014).

Vol. 12 (3) 304-310 July 2018, ISSN 0973-8916 (Print), 2230-7303 (Online)

Regulation: The FDA is overcautious on consumer genomics. Nature 505: 286-287.

14. Wright, C., MacArthur, D., Pickrell, L., Morley, K., Jostins, L., Fisher, I., Anderson, C., Conrad, D.,, Dan Vorhaus, D., and Plagnol, V. (2011). Genomes unzipped: personal public genomes. http://genomesunzipped.org/2011/03/people - have - a – right – to – access – their – own – genetic - information.php.

15. Schöner, M.M., Kourouklis, D., Sandner, P., Gonzalez, E., Förster, J. (2017). Blockchain technology in the pharmaceutical industry. Frankfurt School of Finance & Management gGmbH Sonnemannstrasse 9-11 60314 Frankfurt am Main, Germany, 1-9. https://medium.com/@philippsandner/blockchain - technology - in - the - pharmaceutical-industry - 3a3229251afd.

16. https://www.ccgrouppr.com/practical-applications-of blockchain technology / sectors / agriculture.

17. https://news.bitcoin.com/blockchain-agriculture-industry.

18. Burgess, K., and Colangelo, J. (2015). The promise of bitcoin and the blockchain. Consumers' Research 2015.

19. Yew L.K. (2018). Technology brief: Blockchain-risks and opportunities. School of Public Policy at the National University of Singapore, Pages 1-16.