Decentralized science (DeSci): Web3-mediated future of science

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The paper presents an attempt to conceptualize the features of science in the context of digital transformation mediated by distributed ledger technologies, and blockchain. The focus is on an open alternative to the current scientific system – decentralized science or DeSci, a new movement of scientists and enthusiasts, that stands for transparency, open-access scientific research and crowd-sourced peer-review funded with public and crypto, that aims to increase society engagement and collaboration across the field. In this paper, we distinguish and analyze the main issues in the modern science system, and provide an overview of opportunities of DeSci for improving the space. Then, we sketch a DeSci ecosystem landscape, listing state-of-the-art DeSci initiatives. Afterward, we discuss the main challenges of DeSci.

Key words: decentralized science, decentralization, blockchain, Web3, DLT

Introduction

The last decade has shown that distributed ledger technology (DLT) and blockchain as a part of it have incredible potential to transform and enrich finance and tech spaces. A growing number of entrepreneurs leveraged blockchain tools, cryptocurrency, smart contracts, and decentralized autonomous organizations (DAOs) in an attempt to improve the modern world. After their obvious advances, other fields and initiatives gradually began to utilize new technologies, wanting to benefit from them, and creating a broad scope of directions and use cases for DLT. One of them is the decentralized science movement also known as DeSci.

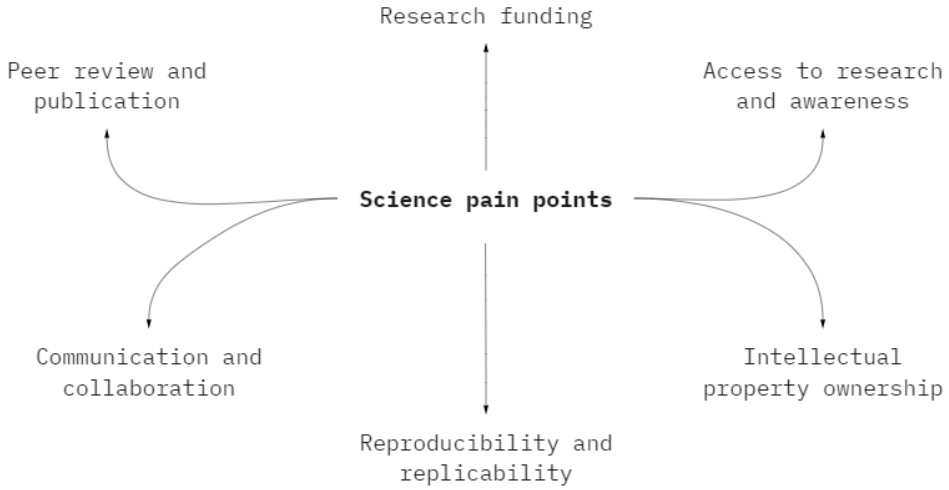
The DeSci phenomenon takes its name from the nascent finance industry innovation – decentralized finance (DeFi) – that resulted in the acceleration of transformation and flourishing of the finance industry under the crypto and Web3 influence in the last couple of years. In contrast to traditional financial services, blockchain-based DeFi projects use crypto and smart contracts to perform a variety of financial functions, remarkably enhancing the space. In parallel with DeFi, DeSci is attempting to apply the advances made in blockchain to the contemporary science system.

Part I. The existing academic system: an overview and challenges

An overly general term ‘science’ encompasses knowledge, processes, and a wide range of activities and disciplines, and can be divided into different branches based on the subject of study. According to Encyclopedia Britannica, science covers any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws.

The scientific enterprise in a broad sense, can be broken down into stages and general tasks. Mainly, the process starts with generating knowledge and securing funding. The main products of science are knowledge, publications and intellectual property. In order to apply knowledge to the world practice, the scientific idea must be verified in models or tested, and then finally brought to live.

The traditional academic system is a specific phenomenon that exists in a way that usually does not benefit enough the researchers or their community. There have been many problems in this conservative field that have been slowing it down for decades. We distinguish the main six of them as issues with: research funding, peer review and research publication, intellectual property ownership, access to research and awareness, reproducibility and replicability of research results, and communication and collaboration between researchers.



Six main science pain points, potentially addressed by DLT – the main DeSci drivers.

Research funding

First and foremost, the commercialization of science is vast and yet the space is still unprofitable. With a limited supply of capital whether sponsored by the government, venture capital, or institution, the scientific research funding seems like an untouched field, as only a few mechanisms of it exist. The one who

begins to delve into this understands that financing science is extremely challenging at any stage.

As for scientists, attracting funding is an especially acute pain point, as it is unbelievably hard, slow and bureaucratic for them to raise money in the existing system. The process is intensely specific and complex. Worth noting, it distracts scientists from focusing on the research they conduct, as they need to spend up to half of their time writing grant proposals.

On top of that, the rewards system in academia sometimes doesn't select for the best work. Success in obtaining funding is closely related to indicators that quantify the impact of a publication (like, for example, the h-index). Peer review selects for consensus rather than risk-taking, and scientists feel pressured to publish for quantity rather than quality. The resulting "publish or perish" pressure stimulates a desire for research that likely to make hype headlines rather than work that is critical for society but not so entertaining to read. Ultimately, inadequate and unreliable funding not only reduces the amount of scientific research but also influences the choice of topics that researchers choose, contributing to issues such as the replication crisis. As a result, many potentially important projects die in the early stages due to lack of funding.

Another concern is that early-career scientists are usually at a disadvantage since science is trending older and towards scientists with demonstrated experience. For instance, most NIH grant funding goes to older scientists, and the age of a Nobel Prize-winning discovery by scientists is increasing.

Peer review and research publication

Established in academia pathways of scientific papers publishing are usually biased and slow. Peer review processes are complex and problematic. As a rule, they are managed by academic publishing houses that rely upon enthusiasm and free labor and time from researchers, reviewers, and editors, who work hard without any incentives. Moreover, publication in the majority of scientific journals tends to be paid as the journals adhere to the pay-to-publish business model (for example, *Nature* charges over $11,000 per paper). Thus, scientists need to pay to publish their research, peer reviews get no rewards for their work, and after all, they may not even get access to the publication since the majority of online academic journals are paid. All that makes current peer review and publication methods inefficient and particularly exploitative. And creates a need to streamline time spent in peer review and compensate peer reviewers for their time.

Needless to say, numerous studies and systematic reviews have shown that peer review doesn't reliably prevent poor-quality science from being published. A so-called publication bias remains as well as a question of the quality of published papers, influenced by the financing pressure.

Good this is, even after a long peer review process and after an article is finally published, the peer review may not stop. There is a "post-publication" peer review phenomena on the web, due to which academics can critique and comment on articles after they've been published. Sites like PubPeer and F1000Research facilitate that kind of post-publication feedback.

Intellectual property ownership

Intellectual property (IP) is a generic legal term for patents, copyrights, and trademarks, which provide legal rights to protect ideas, the expression of ideas, and the scientists as the inventors and creators of such ideas.

Registration and management of IP is a cumbersome and archaic process, ready to fail, especially for those in the very early stages of development like academic IP. Stuck in universities and academic institutions, or unused in tech, in traditional science IP is a big problem. Furthermore, it is hard to value. Most IPs do not savvy the details and intricacies of how to properly implement registration and management requirements, usually leaving the burden on the institution's Technology Transfer Office (TTO). And TTOs are generally understaffed and underfunded. One common TTO strategy is to file provisional patents and then separately find a buyer for the IP that will cover registration and maintenance costs. Thus, IP does not often owned by scientists themselves.

There is a lot of room for improvement in IP ownership management and protection using blockchain technology.

Collaboration and communication

Scientists suffer from a lack of transparency and isolated existence within one organization with no real possibility of global cooperation due to dependence on institutions and their funding.

Communication is one of the great problems scientists face in the existing scientific system. There is a constant question of how to communicate on a regular basis with other experts in the field before the experiment is conducted or research papers are published. Traditionally, scientists communicate through scientific conferences, email, and now through social media. However, email doesn't work in real-time, and social media is primarily about the person, not about the research topic. Gathering a few people around certain topics for regular productive discussion is one of the promises that have yet to be realized on a global scale.

Similarly, another ongoing issue is the exchange of standards in every field. Sometimes groups of scientists list best practices, but due to the nature of the scientific system and a type of communication, these practices are usually lost in the amount of academic content published, or simply ignored.

Additionally, there is an issue with experience exchange. Lots of theories and methods may be difficult to learn or require expensive equipment that is unjustifiably costly for a few experiments. The problem may be solved by sending the scientist to the necessary equipped, which also takes time and have a certain level of bureaucracy.

And last but not least, science is poorly communicated to the public. An opportunity to explain academic research to a non-scientific audience is as important as publication in a reviewed journal, but currently, there is practically no place for public involvement and science literacy improvement.

Reproducibility and replicability

The inability to reproduce and replicate results is another major problem plaguing science. The indicators of quality scientific discovery, reproducible results can be achieved multiple times in a row by the same team using the same methodology while replicable results can be achieved by a different group using the same experimental setup.

Testing, validating, and retesting are all part of a slow and painful process to achieve some semblance of scientific truth. But this does not happen really often since researchers face few incentives to engage in tedious replication. Funding initiatives prefer to support researchers that find new information instead of confirming old results. Most journals also prefer publishing original and groundbreaking

results because replication studies lack novelty.

On the other hand, even when scientists try to replicate a study, they sometimes find they can't do it as a lot of studies can be difficult to replicate. Increasingly, this is referred to as the 'crisis of irreproducibility'. It happens if the original studies' methods are too opaque, or they had too few participants to produce a replicable answer. Or if the study is simply poorly designed and outright wrong.

Information access and awareness

Access to scientific information is another hot issue. Although the science is the epitome of a global public good, much scientific knowledge is hidden behind paywalls in journals and private bases with research data.

There are several initiatives on a mission to tackle this problem. For instance, making all types of data more accessible is the main goal of the Open Science movement, which emerged more than a decade ago. SciHub, a site set up by Alexandra Elbakyan, a Russia-based neuroscientist, also provides free access to millions of published academic papers, but not legally, and only after the publishers have already received their payment and encased the work under strict copyright laws. Still, there is a lot of room for improvement.

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To sum up, the main actions for improving the modern science system are as follows:

- Make the research funding process simple and transparent;
- Overhaul the academic peer-review process;
- Ensure that reproducibility and replicability are the basis of discovery;
- Increase public engagement collaboration across the science field;
- Open access to scientific research.

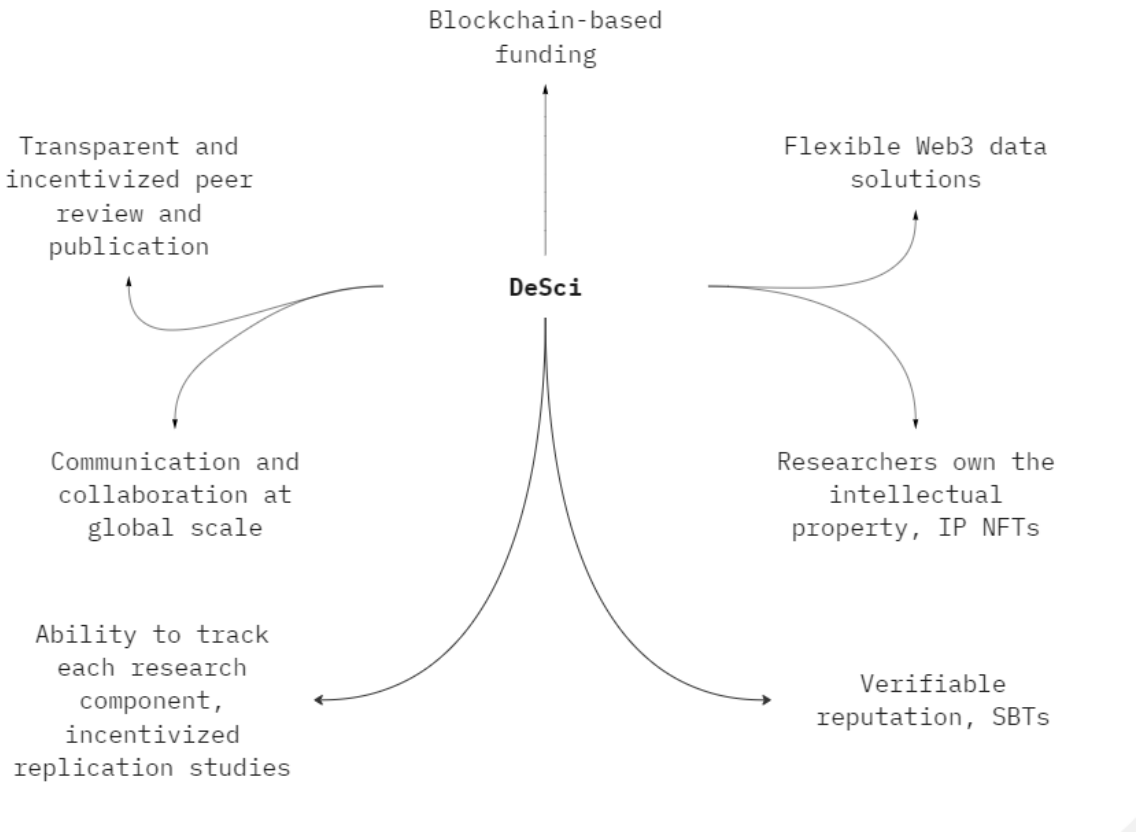
Part II. DeSci: A new paradigm for science

The DeSci movement adherents aim to create an ecosystem where scientists are motivated to conduct and share their research in an open transparent way and receive recognition for their work, making it easy for anyone to access and contribute to research. In other words, legitimize the work of practitioners while serving as a Schelling point for like-minded people, attracting more talent to the space.

Still in its infancy, the DeSci movement comes from the idea that scientific knowledge should be accessible to everyone, disseminating scientific knowledge fairly and equitably. Collaborative research, its peer review and publication process should be transparent and unsophisticated, amplifying the quality of research, so that scientists can fully pursue their curiosity and produce knowledge that finds its way into applications that benefit humanity.

Using the Web3 stack, DeSci proposes a more decentralized research and commercialization model, making it more resistant to censorship and influence and control of itstitutions and publishing houses. It creates an environment where new and unconventional ideas can flourish by decentralizing and diversifying access to funding (from DAOs, quadratic donations to crowdfunding, etc.), research data and methods, scientific tools and communication channels. DeSci fuels open science, encourages citizen science, creates incentives for scientists and public.

There are several crucial science key pain points that appears at all of the research stages (see above). They could be potentially ddressed by applying Web3 ideas and technologies to the existing system.



DeSci: Web3 tools to improve science.

Blockchain-based funding models

The current standard model for science funding is opaque, highly vulnerable to the biases, and self-interests of grant review panels. Traditionally, such panel – a small group of trusted individuals scores the applications and interviews candidates before awarding funds to a small portion of them. Aside from creating bottlenecks this scheme lead to sometimes years of waiting time between applying for and receiving a grant. Grants also usually expire after 3 or so years, which pushes scientists away from long-term projects.

Moreover, studies have shown that grant review panels do a poor job of selecting high-quality applications since the same application submitted to different committees produces wildly different results. As funding became scarcer, it became elitarian, concentrated in a smaller pool of senior researchers who sometimes create more intellectually conservative ideas. This leads to a hyper-competitive science funding landscape that stifles innovation.

Web3 tools have a potential to fix this broken funding model.

- First of all, by adapting blockchain protocols to create sustainable long-term funding for scientists that can resemble traditional tenure.

- Then, by experimenting with different incentive schemes and utilizing mechanisms developed by DAOs, governance, and blockchain-based public good funding models such as quadratic funding used by Gitcoin as the "mathematically optimal way to fund an ecosystem in a democratic way" and retroactive funding used by Optimism, the core principle behind which is: 'it's easier to agree on what was useful than what will be useful".
- By creating new Web3 platforms and protocols dedicated to science.
- And last but not least, by returning value from commercialized outputs (like IP-NFTs) to fund further research, enabling self-sustaining scientific communities.

Check out Vitalik's paper on quadratic funding. Optimism's article on retroactive funding. Karl Floersch and Vitalik discuss retroactive public goods funding and other related topics at ETHOnline 2021.

Transparent & incentivized peer review and publishing

The current scientific publishing system undermines the whole concept of scientific knowledge as a public good and generates profits only for a small group of publishers. Acting as an intermediary, the academic publishing industry profits enormously while scholars provide peer review for free. It is known, that a few free open access publishing platforms exist in the form of preprint servers like, for example, arXiv. However, these solutions lack papers' quality control, anti-sybil mechanisms, and usually do not track article-level metrics, meaning such platforms are typically only used to publish scientific papers before sending it to a traditional major publisher.

Emerging Web3 solutions are on a mission to change the situation. On the one hand, there is blockchain as a decentralized immutable public ledger that provides transparency. Exchanges around the article could be recorded on the blockchain and thus be freely accessible. On the other, due to DAOs, the choice of reviewers would no longer depend solely on the editor but could be approved collectively. Furthermore, tokens and NFTs could be used to incentivize scientific communities to share, review, and curate different types of information sources. This could enable new models of knowledge-sharing and rapid research publishing and review, vital for rapid science. For instance, the Ants Review initiative shows how smart contracts could instead of biased and profit-seeking publishers act as intermediaries between authors and reviewers, who are genuinely rewarded with tokens for their reviews.

IP ownership and development

IP is a big problem in science, from being stuck in universities to notoriously difficult to value. However, ownership of digital assets (such as scientific data or research papers) is something that Web3 does exceptionally well.

Web3 creates new models of financing and collaboration. In the DeSci ecosystem, various aspects of science, such as scientific papers peer review, intellectual property, and reputation systems, can be governed by separate decentralized specialized communities. This both reduces the risk of being dominated by a single institution, and helps future-oriented science withstand rapidly changing technologies and emerging threats. With DAOs and NFTs, DeSci enables communities to be the new shareholders of scientific knowledge (for example, through IP-NFTs that can be owned by DAOs). Furthermore, the value generated by such assets can be then used to fund the creation of

new knowledge, in an attempt to build self-sustaining scientific ecosystems.

Developed in 2021 by the Molecule team, the IP-NFTs concept is as a meeting point between intellectual property and non-fungible tokens, allowing scientific research to be tokenized. Due to this, a representation of a research project is placed on the blockchain in the form of an NFT. A legal agreement is automatically made between the investors – collectors of the NFT, and the scientist or institution conducting the research. The owners of the NFT then entitled to remuneration for licensing the intellectual property resulting from the research or creating a start-up from this IP.

In other words, researchers can present a project and raise funds from investors even before a patent is filed. In exchange, the investors have an IP-NFT that allows them to benefit from a certain percentage of the intellectual property and revenues that will potentially be generated by the innovation.

In December 2022, the team introduced the next generation of IP-NFTs: the IP-NFT V2, in closed beta. Version 2 builds on the proven components of the IP-NFT and extends it with new features. The IP-NFT V2 is built with modularity in mind to enable users and builders to tailor their own use cases. In addition, it allows developers to extend its functionality by adding to existing modules or creating completely new ones.

IP-NFTs allow natively on-chain entities such as DAOs like VitaDAO to conduct research directly on-chain.

Verifiable reputation

The advent of non-transferable soulbound tokens (SBTs) may also play an significant role in DeSci by allowing individuals to prove their experience and credentials linked to their crypto address.

A concept was proposed in May 2022 by Ethereum cofounder Vitalik Buterin, lawyer Puja Ohlhaver, and E. Glen Weyl, an economist and social technologist. The whitepaper, entitled "Decentralized Society: Finding Web3's Soul," lays out the foundation of a fully-decentralized society (DeSoc) governed by its users and how SBTs can function as the credentials people use in everyday life.

In a nutshell, SBTs refer to digital identity tokens that represent the traits, features, and achievements as the characteristics or reputation of a person or entity. SBTs are issued by "Souls," which represent blockchain accounts or wallets, and cannot be transferred.

Today the reputation of scientists—and, by extension, their ability to secure funding—is tied to diplomas and the publishing metrics such as the h-index. In Web3 scenario, scientists could earn SBTs, NFTs, and POAPs for all activities that research communities find valuable, including peer review, teaching and mentoring, as well as data sharing. Token collections can act as a verifiable digital reputation for contributions, further encouraging this behavior. In this way, scientists and groups of individuals with a shared wallet, such as a decentralized laboratory, can create a reputation for themselves.

What's more, in the times of a pandemic, academic institutions increasingly move their activities online. Keep that in mind, DeSci ecosystem can become an attractive alternative to traditional science education. In such system, students can simultaneously learn and build their digital reputation by taking part in community tasks like writing papers, literature reviews, data cleaning, and analysis. DeSci will allow people to be rewarded for their contributions to science while learning.

Information access

The permanent properties of blockchain where researchers can store data and information nearly forever, accessible from any location at any time can be leveraged to grant constant open access to scientific information as well as to guard against censorship.

Using Web3 patterns, scientific information can be made vastly more accessible, and distributed storage enables research to survive cataclysmic events. Thus, flexible Web3 data solutions can provide the foundation for truly open science, where researchers can create public goods open to public, without access permissions or fees. For instance, IPFS, Arweave and Filecoin are optimized for decentralized data storage, dClimate initiative provides universal access to climate and weather data, including from weather stations and predictive climate models, etc.

Reproducibility and replicability

Web3's new native tools can ensure that reproducibility and reproducibility of research results can become the foundation for scientific discoveries, weaving innovative technological stack, transparency, and incentivized mechanisms in the academic fabric.

Thus, a greater degree of transparency and open-source data sharing would enable replications as Web3 offers the ability to create attestations for each component of the analysis and to track every set whether it is raw data, the computational engine, and the application result. The advantage of blockchain consensus systems is that when a trusted network is created to maintain these components, each member of the network can be responsible for reproducing the calculations and validating results. Furthermore, regularly adding supplements at the end of academic papers that get into the procedural nitty-gritty, may help anyone wanting to repeat experiments.

Another key issue that needs to be addressed is incentives for scientists. It affects reproducibility because there is still little value in confirming another lab's results and trying to publish the findings. Replication studies should be publicly incentivized via blockchain funding mechanisms (quadratic funding, retroactive funding), and academic journals should not be afraid to publish ‘negative’ results studies. All scientific results matter, not just the flashy, paradigm-shifting ones.

Communication and collaboration

There are several issues considering communication: limited opportunities for researchers' collaboration, and experience exchange, and a communication gap exists between the scientific and the non-scientific communities.

In the Web3 scenario, researchers are able to communicate and collaborate with like-minded people from all over the globe in dynamic teams. Moreover, sharing laboratory sources is easy and more transparent with Web3 primitives. With Web3 solutions, miscommunication of science, divided opinions about scientific matters, and lack of informed decision-making among the public can be mitigated. Furthermore, with blockchain-based solutions and DAOs, the public gains a real opportunity to influence science, as well as the possibility of increased participation in scientific discourse.

DeSci vs TradSci

Traditional science	Decentralized science
Closed centralized groups control the distribution of funds.	Distribution of funds is determined by the public (with blockchain-based mechanisms like DAOs or quadratic donations).
Funding decisions are made with a long turnaround time and limited transparency.	Funding decisions are made in real time and transparently.
Funding organizations and home institutions limit researchers' communication and collaborations.	Researchers communicate and collaborate with like-minded people from all over the globe in dynamic teams.
Sharing laboratory equipment is slow and opaque.	Sharing laboratory sources is easy and more transparent with Web3 primitives.
Research is published through established pathways frequently acknowledged as inefficient, biased and exploitative.	New publishing models can be developed using Web3 primitives with trust, transparency, and universal access.
Researchers' peer-review work is unpaid, benefiting for-profit publishers.	Researchers can earn tokens and a reputation for peer-reviewing work.
Researchers' home institution owns intellectual property they generate.	Researchers own the intellectual property they generate and distribute it according to transparent terms.
Publication bias means that researchers are more likely to share experiments that had successful results.	Sharing all of the research, including the data from unsuccessful efforts, by having all steps on-chain.

Traditional science vs. Decentralized science.

Part III. DeSci landscape

DeSci is exploding with more than 50 projects flourishing the space. The majority of them popped up in the last year alone. Striving to improve the state of modern science, DeSci projects specialize on different directions with various goals that range from funding science, disrupting the scientific publishing industry, upholding open science, and pursuing specific research goals like longevity or space exploration. There are dozens of DeSci DAOs and philanthropy initiatives. Scientists are keeping up with the trend of NFTs which provide a new way to fundraise and own IP, on the other hand, science is a fathomless source of inspiration for artists who showcase science to the public though their NFT collections.

DeSci Landscape

DAOs
Antidote DAO
AthenaDAO
Bio DAO
Cherubs DAO
CRISPRDAO
CureDAO
DeNature DAO
DeSciWorldDAO
Frontier DAO
Future Foods DAO
Genomes DAO
HairDAO
Immortality
LabDAO
LoveHealth
MedDAO
NeuraDAO
OpenNMN
Open Science DAO
PsyDAO
Reputable DAO
Research Collective
Research Hub DAO
The Science DAO
Valley DAO
VitaDAO

Multidirectional Initiatives
Bio.xyz
The DeSci Academy
DeSci Africa
DeSci Foundation
deScier
Gridcoin
Halogen
IberoAm
The Innovation Game
SCINET

Publishing
Agora Labs
Ants Review
Atoms
Braid Science
DeSci Labs
Longevity Review
Planck
Sci2sci
TalentDAO

Funding/Philanthropy
Beaker DAO
Crowd Funded Cures
DeSci Foundation
Experiment
GainForest
Gitcoin
Giveth
Impact Finance
Medical.watch
Moon Rabbit
Science Fund
Sesame Foundation
SCINET
ViralCure

Biotech
BioDAO
Croud Funded Cures
DeBio
Fleming Protocol
Framework Bio
Innovative Bioresearch
LabDAO
Molecule
OpenNMN
Perlara PBC
Phage Directory
Recerca
Vibe Bio

Infostructure & Data
Abakhus
Bacalhau
Ceramic
Data Lake
DataUnion
DeSci Labs
Fleming Protocol
Kamu
Ocean Protocol
Protocol Labs
Weavechain

Foundations & Institutions
Arc Institute
Arcadia Institute
Astera Institute
Comvergent Research
Foresight Institute
New Science
Paradigm Research

Science NFTs
Atomic Heart NFT
DNAVERSE
Gels
GeneNFT
PlantGang
SameYou
SpinalCordNFT
UltraRare

Multidirectional projects

These initiatives encompass multiple sectors and tackle several problems at once including decentralized financing, science and scientific publishing tools, etc.

Bio.xyz is a Molecule initiative funding decentralized science and biotech projects, and providing hands-on support from legal to tech. Funded VitaDAO, LabDAO, ValleyDAO, PsyDAO and more.
The DeSci Academy is onboarding non-technical users into science to create the next generation of scientists. The team finds and trains passionate, driven and curious individuals who want to contribute to science but lack the credentials.
DeSci Africa is a non-profit aimed at supporting scientists in Africa through Decentralized Science. Through specialized meetups, travel grants, and events, among other things, the DeSci Africa community will raise awareness of decentralized science on the African continent. The team aims to reroute funds toward research conducted by African scientists and laboratories while also creating channels of outreach and knowledge for those who are new to Web3.
DeSci Foundation is an independent think tank of leading scientists and Web3 pioneers, dedicated to exploring the potential of applying Web3 technologies to the scientific ecosystem. The mission is to support high-quality science by thinking carefully about the potential opportunities and risks of applying Web3 technologies to the scientific ecosystem, bringing scientists and Web3 pioneers together, and supporting initiatives that have the potential to improve scientific progress, and creating new ways to finance and incentivize high-quality, replicable science.
deScier (Previously SciDAO, now merged with CRDAO, a contract research organization DAO) is an ecosystem to integrate and foster synergies in decentralized science actions to expand the possibilities of collaboration in the various science-related initiatives. Editorial work for publishing scientific papers with shared financial gains continues being one of the important arms in this project.
Gridcoin is a science-focused blockchain which uses minting protocols and fee-based mechanisms to incentivize computational contribution to distributed computing projects (on the BOINC network) working on various areas of scientific research, raise funds for research, and verify publication ownership.
Halogen is a platform and a set of protocols aiming to replace the journal monopoly with a self-organizing network of self-sufficient scientific communities. Publishing, review, documentation, funding is all done at the community level. This model is to solve the epistemic issues endemic to journal science and restructure the scientific epistemic engine to produce an accurate, representative, and usable knowledge base.
IberoAm is a non-profit and three-fold initiative aiming to identify, promote and support iberoamerican Web3 projects with a clear social and financial impact for the region and prioritizing minorities.
The Innovation Game a pplying a framework of crypto-economics to address the market failure related to funding and transparency around the innovation.
SCINET is is a decentralized life sciences research and investment platform that revolutionizes the way people do and support science. Powered by blockchain technologies, SCINET allows retail and institutional investors to invest directly in life sciences research and technology with security and authenticity.

DeSci DAOs

Decentralized autonomous organizations capture many ideals already held by academic communities, and in a sense provide the technology platform to truly implement ideas

around open science. They are popping up with various goals that range from funding science, disrupting the scientific publishing industry, upholding open science, and pursuing specific research goals like longevity. The ability to have anyone worldwide contribute to solving common problems is quite promising to transform the space.

Antidote DAO is an altruistic Web3 DAO dedicated to funding various cancer initiatives.
AthenaDAO is a decentralized collective to fund women's reproductive health research and drug discovery.
BioDAO aims to be a collective funding DAO for biotech startups and drug discovery.
Cherubs DAO is NFT funded, DAO governed collective investing in accelerating solutions & cures to Alzheimer's disease and advancing brain wellness and longevity. 80% of funding dedicated to investments for ROI and impact, and 20% to fund primary research grants.
CRISPR DAO is building a decentralized organization to fund cutting edge CRISPR research to advance potential therapies and Ag-tech solutions.
CrunchDAO is a DAO of scientists making use of collective intelligence to solve complex problems. Focusing on quantitative finance, it makes use of DeSci as a tool to coordinate its members.
CureDAO is an alliance of digital health innovators working to minimize suffering in the universe by accelerating clinical discovery. This is done through a community-owned rewards collaboration over competition. The end result is the discovery of how millions of factors like foods, drugs, and supplements affect human health.
DeNature DAO is a decentralized science DAO that aims to empower STEM innovators using blockchain technology.
DeSciWorldDAO aims to connect the decentralized and scientific communities to help further the mission of decentralizing science. The DAO coordinates treasury expenditure and future development goals.
FrontierDAO is a Research and Development DAO for science and engineering that looks to incubate promising innovation in their focus areas of fusion energy, space exploration, and climate solutions. The end goal is to catalyze commercialization of the most promising technologies. They raise funds through membership and their NFT collection, available on OpenSea.
Future Foods DAO is a community-owned collective funding early-stage alternative protein open-source research. The project aims to identify and fund the most promising foundational alternative protein research.
Genomes DAO strives to meet the increasing expectations of research organizations, institutions as well as customers for the security of genomic data and the quality of research workflow. In order to increase the democratization and decentralization of genomic studies, they focus on combining cutting-edge technologies such as AMD's SEV, blockchain and decentralized finance. They have partnered with Nebula Genomics to sequence your genome and then securely store the sequencing data.
HairDAO is a decentralized autonomous organization in search of a cure for hair loss. Hair loss remains one of the most pervasive medical conditions globally: 80% of men and 50% of women will experience noticeable hair loss in their lifetimes, with over 95% of cases caused by androgenic alopecia (male and female pattern baldness).
Immortality is a cryptocurrency designed to bring scientifically proven, peer reviewed age prevention and reversal into reality. Envisioning the treatment of aging in a world-class clinic using proven and novel therapies such as working with TensorFlow machine learning for prediction, improved diagnostics and imaging analysis, in vivo gene therapy, stem cells and in vivo partial reprogramming.
LabDAO is an open, community-run network of laboratories accelerating progress in the biomedical and life sciences.

Love Health and the Love DAO represent the decentralized approach to people-powered pharma. Through the Love DAO, members of the community can submit clinical trial proposals, and share in the upside when treatments are launched.

MedDAO creates new incentives and systems for a global, distributed medical knowledge network leveraging a highly-engaged community of public health stakeholders who are co-owners of the organization.

NeuraDAO is a community-governed, decentralized platform for neurotech research and intellectual property.

OpenNMN is a DAO formed to make the supplement NMN accessible with community based biotech.

Open Science DAO is a community-owned open science ecosystem that unlocks data silos, revolutionizes collaboration, and democratizes funding.

PsyDAO is a decentralised organisation with the goal of funding research at the intersection of psychedelics and mental health.

Reputable DAO is a biohacking and personalized wellness community that allows members to sell their data to third parties over places like the Ocean marketplace.

Research Collective is a DAO performing decentralized trials and 'adversarial research', often going against the status quo. It acts as a bridge between the 'biohackers' and crypto community.

ResearchHub DAO's mission is to accelerate the pace of scientific research. ResearchHub provides an open forum where users can port in scientific publications, upload preprints through our notebook feature, generate scientific bounties and discuss science (like Reddit) incentivised by ResearchCoin. As an alternative to scientific journals, ResearchHub contains hubs of all genres of scientific research.

The Science DAO is a decentralized think tank to foster growth and incubate scientific ideas. DeFi community and DAO to fund scientific research, primarily biomedical. The goal is to serve as a Venture Fund to allow the public access to pre-IPO science. They plan to offer fund-raising for projects via NFT sales, with 90% of the money raised by the NFT launch going to the project (10% to the DAO). The NFT valuation is expected to track the valuation of the company, which provides stable NFT floor prices, and increases in value as the company succeeds.

ValleyDAO' s vision is to support the transition to a sustainable bioeconomy by funding democratically elected academic research and collectively govern the generated IP.

VitaDAO is a DAO collective for funding longevity research. VitaDAO's core mission is the acceleration of research and development in the longevity space and the extension of human life and healthspan. To achieve this, VitaDAO collectively funds early-stage research projects and spins out startups to commercialize them. It also aims to improve longevity awareness through both scientific and general audience publishing initiatives.

Decentralized financing and philanthropy

These DeSci initiatives and DAOs experiment with crypto, NFT, crowdfunding, and other mechanisms to fund research and reward scientists.

Beaker DAO is a DAO, co-initiated by Tribute Labs that supports the expansion of decentralized science. Through research funding and IP management, the DAO aims to promote open accessibility & create decentralized market liquidity across the DeSci space.

Experiment is the crowdfunding platform for science. Launched in 2012.

GainForest / LabDAO Rainforest Monitoring Lab is bringing together young engineers, students and scientists to contribute to an open and reproducible machine learning repository for rainforest monitoring. The models will then be used to transparently analyze carbon

offset projects around the world and assess nature's contribution for ReFi.
Gitcoin is a funding mechanism for Web3 focused on public goods. Gitcoin had its first DeSci funding round from 9/7-9/22, 2022.
Giveth is building a culture and economy that rewards and empowers those who give. The goal is to use Web3 to radically transform how public goods are funded by helping nonprofits evolve out of systems that depend on sacrifice into ones that create win-win situations for everyone involved. Beginning with a free and direct crypto donation platform on Ethereum, Giveth onboards for-good projects and support them so that they can eventually blossom into DAOs with their own regenerative economies, with Giveth itself becoming an impact investment hub for public goods.
Impact Finance builds Web3 tools with the aim of increasing the impact that citizen scientists can have on the scientific research process and the development of new technologies. It is a a community-governed platform that enables science-based digital asset creators to cultivate their professional networks, track reputation, fund research, and unlock new opportunities for collaboration and cooperation.
Medical.watch is building a medical knowledge base for the world. Imagine a medical version of Wikipedia + UpToDate, updated by doctors in real-time. With Medical.watch, doctors will have the latest medical knowledge to treat patients.
Moon Rabbit is a distributed crypto-conglomerate constituting a system of systems (Jurisdictions), uniting distributed ledgers and cryptocurrencies in the ultimate cross-chain protocol – a Metachain. Moon Rabbit is focused on building scalable incentive models and Web3 infrastructure to accelerate Longevity R&D. They are constantly integrating new chains and recently partnered with the world's leading Longevity research institution, Foresight Institute.
Science Fund is an initiative to create funding pools for science through NFTs.
Sesame Foundation provides a platform for creating and contributing to decentralized prizes for science enthusiasts and philanthropists who want to support research in computational mathematics. Sesame Prizes use smart contracts to ensure that prizes are awarded only once a given problem is actually solved.
ViralCure is an impact-first DeSci platform that helps fund healthcare-oriented research and development in alternative ways. Part of the Sthorm Web3 project ecosystem with a long trajectory working with alt-funding for scientific projects.

Decentralized scientific publishing

These initiatives try to improve the way how and where scientific research gets published. Some ways are incentivized peer review, micro-publications, platforms where scientists can receive donations for their contributions, etc.

Agora Labs is a platform where scientific publications and their researchers can be 'invested in'.
Ants Review is a privacy-oriented protocol of smart contracts that incentivizes peer review. Ants-review allows authors to offer bounties for anonymous peer review using the ERC-20 token ANTS. This incentivizes academics to provide reviews, accelerates the time for peer review, and reduces redundancy in peer review. To reduce the capacity for abuse, peer review quality is assessed by the community.
Atoms intends to improve incentives in science by developing smart research contracts mediated by peer-to-peer review networks. These will collectively reward scientific contributions, including proposals, papers, replications, datasets, analyses, annotations, editorials, and more. Long term, these smart contracts help accelerate research by minimizing science friction, ensuring science quality, and maximizing science variance.
DeSci Labs is working on new technologies to improve the accessibility, reliability,

transparency, and value sharing of scientific publications.

Longevity Review by VitaDAO is a platform that provides funding for researchers to review each other's work. It addresses critical issues with academic journals.

Planck is an incentive system aimed at bettering the incentives around open innovation, antifragile tinkering, and the scientific production of knowledge. The team do this by helping to create and organize digital manuscripts on a blockchain. Original manuscripts of important works have long been uniquely valuable, and by programming around such digitally scarce, non-fungible manuscripts (called Glyphs) they have developed an incentive system to reward thinkers, innovators, and creators. This incentive system can be thought of as alt-IP.

Sci2sci develops a 'scientist-to-scientist' platform to conveniently store, share and search for research data. An electronic lab notebook conveniently paired with a publishing platform allows to easily release research data into open access - whenever it's ready - in one click. Additionally, the search engine tailored specifically for datasets allows for advanced search options, such as finding datasets that contain the same information using search by structural similarity. It indexes data found both on the sci2sci platform and on external services such as Zenodo and FigShare.

TalentDAO is a community of organizational scientists, strategists and researchers building the world's first decentralized community-reviewed publication protocol for the social sciences and applying what we learn to help the DAO ecosystem thrive.

Infostructure, data storage and management

These blockchain projects build the infrastructure for decentralized science and offer tools for the Web3 data economy.

Abakhus is a set of decentralized and interconnected privacy-preserving health and life sciences data and services that leverage the full capabilities of private smart contracts on Secret Network and IBC from the Cosmos Ecosystem. By making extensive use of private metadata, Abakhus protocol to bring together in one place clinical/veterinary laboratory specialists, multi-omics, bioinformatics and systems biology specialists, software developers in the health and life sciences space, physicians and veterinarians and end-users in need of clinical/veterinary/multiomics/systems biology services.

Bacalhau's goal is to give researchers and data engineers the ability to publicly reproduce data pipelines, thereby making their research more transparent and reusable.

Ceramic is a decentralized network where people can collaborate on open data sets while being in control over their data. ComposeDB is a graph database built on top of Ceramic that enables developers to create public knowledge graphs, social applications, DAO coordination tooling, etc. Ceramic works with most existing Web3 wallets and enables a seamless experience for users interacting with data in the system.

Data Lake is an EU-funded start-up creating a global medical data donation system, based on Web3 technologies. Just like donating blood, people can donate their medical records to researchers around the globe who need medical data to cure diseases, develop new treatments, and improve diagnostics and patient outcomes. Consents are recorded on the Polygon blockchain, which ensures researchers have a guarantee that they have a legal right to access the donor's data. The entire process respects patient privacy, and consent can be revoked at any time. To incentivize stakeholder participation, the project is tokenized and uses the LAKE token to reward data donors, as well as other market participants.

DataUnion is a powerful way for science communities to collaborate. They offer

opportunities to mobilize and reward groups to product and valorise data sets (beyond the scientific re-use). All participants benefit from the value creation within these DataUnions, which could provide additional funding opportunities for research projects and help develop inclusive datasets.

DeSci Labs is building the infrastructure for decentralized science. DeSci Nodes, the first product from DeSci Labs enables a radically transparent ledger of scientific record that is secure, permanent, interoperable and resistant to cross-national censorship.

Fleming Protocol is on a mission to create a data economy where patients capture the value of their data. Through incentivization and innovative data monetization mechanisms, they enable patients and biomedical innovators to collaborate and create value in a privacy preserving way.

Kamu is a decentralized data supply network created to address the ongoing reproducibility crisis in science. Think of it as 'Git for Data' that lets you easily share both static and highly dynamic data without losing ownership, collaborate with others on building data processing pipelines that continuously clean, combine, and enrich data from other sources, and effortlessly maintain 100% reproducibility, verifiability, and detailed provenance of data for your analysis and ML projects.

Ocean Protocol creates tools for the Web3 data economy. Data owners and consumers use Ocean Market app to publish, discover, and consume data in a secure, privacy-preserving fashion. OCEAN holders stake liquidity to data pools. Developers use Ocean libraries to build their own data wallets, data marketplaces, and more. Ocean datatokens wrap data services as industry-standard ERC-20 tokens. This enables data wallets, data exchanges, and data co-ops by leveraging crypto wallets, exchanges, and other decentralized finance tools.

Weavechain offers a solution for both public and private datasets, with immutable blockchain properties guaranteeing data lineage and advanced role-based permissioning to the table level guaranteeing security. Researchers can share and access secure and tamper-proof data instantly, without any need to download updates, since additions are reflected in real-time.

Decentralized biotech and biopharma

These projects are specialized in improving biotech and biopharma science fields through decentralized technologies.

BioDAO aims to be a collective funding DAO for biotech startups and drug discovery. The goal is to own biotech assets developed by DAO-funded projects.

Crowd Funded Cures is on a mission to a create pay-for-success model bring certain off-patent treatments and repurposed generic drugs to the forefront and into patient hands without patents.

LabDAO is to to build an on-chain marketplace for wet and dry lab services to enable scientific progress. They aim to connect scientists with the specialized resources and expertise needed to advance their own work. This would be a way of connecting scientists with Contract Research Organizations (CROs), and enabling individual labs to serve as CROs. To start, they are tackling challenges in standardizing computational biology.

Molecule was inspired by the open science movement and open drug development that was happening in certain patient communities. The idea was to utilize blockchain tools to help advance and fund early stage drug development. To that end, the company has made several savvy decisions that have advanced the DeSci space, including ideating IP-NFTs, NFTs tied to intellectual property, and launching the VitaDAO community to fund longevity research. They continue to seed new DAOs and help advance the funding of early stage drug development. Their marketplace currently boasts around 60 research projects available for funding.

Perlara PBC employs consultants that write work plans and perform project management for the development of therapies for families and nonprofit foundations seeking cures for rare diseases. It is a distributed biotech in the sense that it employs scientists around the world to work together to build 'cure roadmaps' for identifying new treatments for patients and foundations.
Phage Directory was started from the observation that clinicians and scientists were seeking cures to antibiotic-resistant infections. It was formed with a simple solution: building out a more concrete network of the people who might have the tools to help. To date, the group has helped with three different cures. Great model and simple template for decentralized cure discovery.
Recerca is a tokenizing research initiative. The team won 2nd prize in the Hedera X Filecoin Grant, for an application centered around solving data integrity problems, crowdfunding research, and NFT based participant rewards.
Vibe Bio hopes to bring power and agency to patient communities by building out a DAO toolbox of sorts so that a given patient community could organize via a DAO, co-own and co-develop therapeutics to treat the illness they are suffering from.
Virtual Drug Development or Clinical Trial Platforms is a mRNA Swap for offsetting risk in clinical trial efficacy studies.

Decentralized spacetech and exploration

These initiatives apply decentralized technologies to refine space development, research and exploration.

LunCo is a permissionless collaborative space missions design tool powered by Web3. With the help of LunCo it's possible to run complex projects like planning civic CO2 tracking constellations, Lunar colony etc. Their mission is to make humanity multiplanetary species by providing a collaborative tool to plan missions together.
SpaceChain offers space-as-a-service for modern businesses, enabling companies to innovate new use cases using space products and take their blockchain tech to space. The startup is less about space exploration and more about using the existing infrastructure to improve the blockchain experience, although outer space is also involved in this case. Basically, SpaceChain is building the world's first open-source satellite network that runs on blockchain nodes.
TruSat is a blockchain-based database that will monitor orbital positions of satellites — something that could be all the more crucial as large fleets of satellites launch under companies such as SpaceX and Amazon.

Science NFTs

Science is keeping up with the trend of NFTs which provide a new way for scientists to fundraise and inspiration for artists, as well as an incentive to showcase science to the public.

AtomicHeartNFT is a Web3 collective showcasing images produced using electron microscopy and other advanced microscopy techniques.
DNAverse is an NFT project collection customized with real DNA data. The long term mission is the geneticizing of avatars in the metaverse and the replication of life in the digital world with a self-sustainable decentralized model.
Frontier DAO is a science investment DAO with an art gallery.
Gels are a science-inspired generative pieces. Their algorithm simulates gel electrophoresis. The DNA band patterns in this work derive from combinations of a simulated experimental data and real-world data, including DNA sequences that encode several variants of the SARS-CoV-2 spike protein, and the corresponding mRNA vaccines.

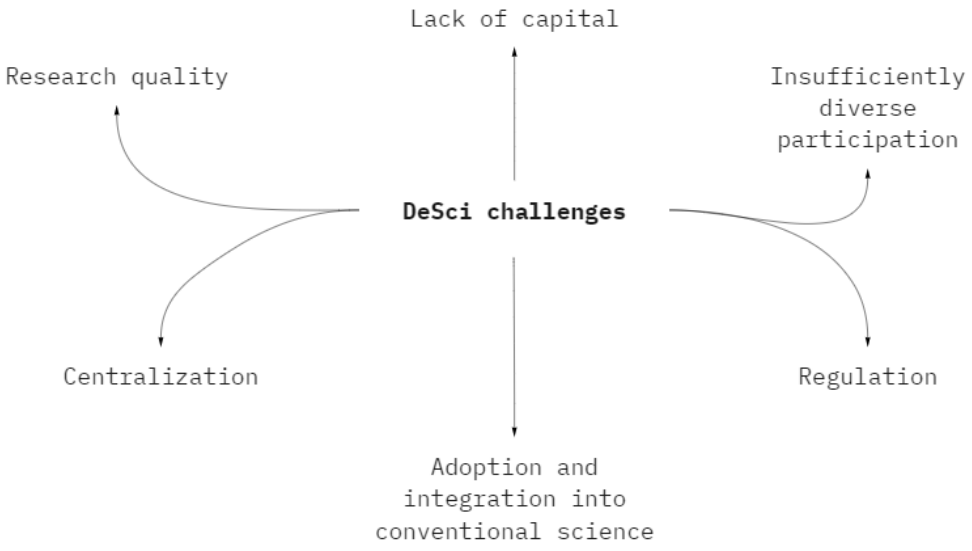
Gene NFT is an experiment at the intersection of art, science, and technology. Its foundational collection is HUMAN - a unique NFT for each protein-encoding human gene. The building blocks of The Human Machine.
PLANT GANG is a community building the herbarium of the metaverse, producing scientific 3D model NFT plant specimens, with associated metadata and physical counterparts.

SameYou is an NFT collection to raise money for treatments for brain injury or stroke.
UltraRare is a Web3 collective exploring the intersection of art and science. The team includes scientists, developers, and artists. They care about communicating science through audio and visual means, and produce the UltraRare The Podcast to help onboard people to the Web3 space.

Part IV. DeSci challenges

Despite the apparent disrupting opportunities of DeSci, it is still difficult not to pay attention to its several potential problems. We distinguish six of them: lack of investment in science through Web3 mechanisms, research quality and lack of scientific qualification in the crypto space, insufficiently diverse participation, centralization of the majority of blockchain networks, regulatory risks, and DeSci adoption, acknowledgment and painless integration into conventional science.

The problems in DeSci are presented in the scheme below.



Lack of capital

Science research funding is one of the crucial issues in the traditional scientific system. So it is no surprise, that it passes to DeSci. On the one hand, blockchain-based DeSci has the potential to greatly solve science funding problems. On the other hand, it suffers from a lack of capital available through Web3 mechanisms. Currently, DeSci funds can not compete with those of traditional science financing initiatives and venture capital. If

DeSci successfully reached adoption, the space will attract additional investment.

Research quality

Ultimately, scientists are judged by the research they publish, and there is always a question of quality, even in traditional academia. Bad-designed studies, hastily done experiments, chasing spectacular results and big headlines, and as a result founding and an opportunity to publish research in prestigious journals – the scientific space is no saint.

In the Web3 scenario, it becomes even more difficult to understand the quality of scientific research. DeSci has the potential which is also a risk for opening the gates to unqualified mass science.

What's more, decentralization and equality – main Web3 principles mean that everyone in the network and DAO gets the right to vote, regardless of his scientific background or even the lack of it. The active crypto community is not comprehensive, although global. It is full of non-scientists, who often are not specialized in particular scientific fields, and hence are not able to distinguish quality projects from bad ones. Bridges between DeSci and conventional science can help in assessing quality. A robust peer review, reputation (via for instance SBTs) and management systems are vital.

Insufficiently diverse participation

It is important for groups making decisions about science to represent society. DeSci communities still remain a fairly narrow segment. Until it is overcome with future adoption, DeSci space will be having an obvious imbalance as a consequence.

Moreover, since DeSci is largely made up of people who are involved in crypto and science – two spaces where women are still underrepresented, there is a potential risk of under-researched scientific directions.

Centralization

Although one of the main features of blockchain is decentralization, the current state of blockchains shows that it is halfway true. Currently, the two best-known types of crypto networks dominate in the space – Proof of work (PoW) and Proof of stake (PoS). PoW systems are known for their dependency on the power of mining cartels while PoS networks are controlled by the capital accumulated in hands of the largest validators.

A few alternatives exist. For instance, the Proof-of-Personhood (PoP) protocols that bring equality and Sybil resistance to the system, guaranteeing every individual the same amount of voting power and rewards creating a democratic and fair peer-to-peer network. Such networks may be a good option for designing future DeSci projects, where it is crucial for groups responsible for making decisions to represent society.

Regulation

DeSci regulation is another essential issue. In different countries, crypto is regulated by different government bodies and lacks one unifying framework. There is an ongoing risk that regulators may quickly change laws and cripple DeSci projects. It may affect NFTs that represent IP, SBTs as well as DAOs. Furthermore, the legal structure of DAOs is a problem since DAOs are treated as a general partnership, which means that all token holders are partners, and all partners are responsible for any legal action brought against the DAO they are part of.

Integration into conventional science

Efforts to improve science have been underway for many years. The DeSci movement is experimenting with a set of new tools in an attempt to perfect the current state of the science. Alongside conventional science, DeSci should focus on empowering scientists to do good research. To succeed, DeSci tools must be invisible and easily integrated into the scientists' daily work.

Conclusion

As a dextrous way for improving the current state of science, DeSci has great potential. Addressing the main pain points the scientific system has, blockchain-based solutions are already working tirelessly on a mission to transform peer review schemes, change scientific funding mechanisms, unleash scientific knowledge, eliminate researchers suffocating dependence on institutions and profit-hungry intermediaries like publisher conglomerates, and enhance cooperation.

Now DeSci is exploding with more than 50 initiatives flourishing the space, many of which are still in very early form. There are many opportunities to get involved, not just for scientists, but for developers, researchers, legal, community, etc. With all these powers and a pinch of enthusiasm, the DeSci movement is to effortlessly solve the problems it faces now and overcome the challenges to-be. The future of science will be nothing else but bright.

References

- Davis P.M, Walters W.H. The impact of free access to the scientific literature: a review of recent research. J Med Libr Assoc. 2011 Jul;99(3):208-17. doi: 10.3163/1536-5050.99.3.008. PMID: 21753913; PMCID: PMC3133904.
- DeSci Wiki by Jocelynn Pearl and Ultrarare. Curated by Jocelynn Pearl.
- Ding, Wenwen & Hou, Jiachen & Li, Juanjuan & Guo, Chao & Qin, Jirong & Kozma, Robert & Wang, Fei-Yue. (2022). DeSci Based on Web3 and DAO: A Comprehensive Overview and Reference Model. IEEE Transactions on Computational Social Systems. 9. 1563-1573. 10.1109/TCSS.2022.3204745.
- Ducrée, Jens & Codyre, Martin & Walshe, Ray & Barting, Sönke. (2022). DeSci-Decentralized Science. 10.20944/preprints202205.0223.v1.
- Pearl, Jocelynn (2022) A Guide to Decentralized Biotech. Published in Future (a16z).
- Wang, Fei-Yue & Ding, Wenwen & Wang, Xiao & Garibaldi, Jon & Teng, Siyu & Imre, Rudas & Olaverri-Monreal, Cristina. (2022). The DAO to DeSci: AI for Free, Fair, and Responsibility Sensitive Sciences. IEEE Intelligent Systems. 37. 16-22. 10.1109/MIS.2022.3167070.
- Wang, Fei-Yue. (2022). The Metaverse of Mind: Perspectives on DeSci for DeEco and DeSoc. IEEE/CAA Journal of Automatica Sinica. 9. 2043-2046. 10.1109/JAS.2022.106106.