



Blockchain Explained

GUIDE TO BLOCKCHAIN ▾

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What Is a Blockchain?

A blockchain is a distributed database that is shared among the nodes of a computer network. As a database, a blockchain stores information electronically in digital format. Blockchains are best known for their crucial role in cryptocurrency systems, such as [Bitcoin](#), for maintaining a secure and decentralized record of transactions. The innovation with a blockchain is that it guarantees the fidelity and security of a record of data and generates trust without the need for a trusted third party.

One key difference between a typical database and a blockchain is how the data is structured. A blockchain collects information together in groups, known as [blocks](#), that hold sets of information. Blocks have certain storage capacities and, when filled, are closed and linked to the previously filled block, forming a chain of data known as the blockchain. All new information that follows that freshly added block is compiled into a newly formed block that will then also be added to the chain once filled.

A database usually structures its data into tables, whereas a blockchain, like its name implies, structures its data into chunks (blocks) that are strung together. This data structure inherently makes an irreversible time line of data when implemented in a decentralized nature. When a block is filled, it is set in stone and becomes a part of this time line. Each block in the chain is given an exact time stamp when it is added to the chain.

KEY TAKEAWAYS

- Blockchain is a type of shared database that differs from a typical database in the way that it stores information; blockchains store data in blocks that are then linked together via cryptography.
- As new data comes in, it is entered into a fresh block. Once the block is filled with data, it is chained onto the previous block, which makes the data chained together in chronological order.
- Different types of information can be stored on a blockchain, but the most common use so far has been as a ledger for transactions.
- In Bitcoin's case, blockchain is used in a decentralized way so that no single person or group has control—rather, all users collectively retain control.
- Decentralized blockchains are immutable, which means that the data entered is irreversible. For Bitcoin, this means that transactions are permanently recorded and viewable to anyone.

How Does a Blockchain Work?

The goal of blockchain is to allow digital information to be recorded and distributed, but not edited. In this way, a blockchain is the foundation for immutable ledgers, or records of transactions that cannot be altered, deleted, or destroyed. This is why blockchains are also known as a [distributed ledger technology \(DLT\)](#).

First proposed as a research project in 1991, the blockchain concept predated its first widespread application in use: Bitcoin, in 2009. In the years since, the use of blockchains has exploded via the creation of various [cryptocurrencies](#), [decentralized finance \(DeFi\)](#) applications, [non-fungible tokens \(NFTs\)](#), and [smart contracts](#).

Transaction Process

 Blockchain

Attributes of Cryptocurrency

 Blockchain

Blockchain Decentralization

Imagine that a company owns a server farm with 10,000 computers used to maintain a database holding all of its client's account information. This company owns a warehouse building that contains all of these computers under one roof and has full control of each of these computers and all of the information contained within them. This, however, provides a single point of failure. What happens if the electricity at that location goes out? What if its Internet connection is severed? What if it burns to the ground? What if a bad actor erases everything with a single keystroke? In any case, the data is lost or corrupted.

What a blockchain does is to allow the data held in that database to be spread out among several network nodes at various locations. This not only creates redundancy but also maintains the fidelity of the data stored therein—if somebody tries to alter a record at one instance of the database, the other nodes would not be altered and thus would prevent a bad actor from doing so. If one user tampers with Bitcoin's record of transactions, all other nodes would cross-reference each other and easily pinpoint the node with the incorrect information. This system helps to establish an exact and transparent order of events. This way, no single node within the network can alter information held within it.

Because of this, the information and history (such as of transactions of a cryptocurrency) are irreversible. Such a record could be a list of transactions (such as with a cryptocurrency), but it also is possible for a blockchain to hold a variety of other information like legal contracts, state identifications, or a company's product inventory.

Important: To validate new entries or records to a block, a majority of the decentralized network's computing power would need to agree to it. To prevent bad actors from validating bad transactions or [double spends](#), blockchains are secured by a consensus mechanism such as [proof of work \(PoW\)](#) or [proof of stake \(PoS\)](#). These mechanisms allow for agreement even when no single node is in charge.

Transparency

Because of the decentralized nature of Bitcoin's blockchain, all transactions can be transparently viewed by either having a personal node or using [blockchain explorers](#) that allow anyone to see transactions occurring live. Each node has its own copy of the chain that gets updated as fresh blocks are confirmed and added. This means that if you wanted to, you could track Bitcoin wherever it goes.

For example, exchanges have been hacked in the past, where those who kept Bitcoin on the exchange lost everything. While the hacker may be entirely anonymous, the Bitcoins that they extracted are easily traceable. If the Bitcoins stolen in some of these hacks were to be moved or spent somewhere, it would be known.

is means that only the owner of a record can
s can remain anonymous while preserving

transparency.

Is Blockchain Secure?

Blockchain technology achieves decentralized security and trust in several ways. To begin with, new blocks are always stored linearly and chronologically. That is, they are always added to the “end” of the blockchain. After a block has been added to the end of the blockchain, it is extremely difficult to go back and alter the contents of the block unless a majority of the network has reached a consensus to do so. That’s because each block contains its own [hash](#), along with the hash of the block before it, as well as the previously mentioned time stamp. Hash codes are created by a [mathematical function](#) that turns digital information into a string of numbers and letters. If that information is edited in any way, then the hash code changes as well.

Let’s say that a hacker, who also runs a node on a blockchain network, wants to alter a blockchain and steal cryptocurrency from everyone else. If they were to alter their own single copy, it would no longer align with everyone else’s copy. When everyone else cross-references their copies against each other, they would see this one copy stand out, and that hacker’s version of the chain would be cast away as illegitimate.

Succeeding with such a hack would require that the hacker simultaneously control and alter 51% or more of the copies of the blockchain so that their new copy becomes the majority copy and, thus, the agreed-upon chain. Such an attack would also require an immense amount of money and resources, as they would need to redo all of the blocks because they would now have different time stamps and hash codes.

Due to the size of many cryptocurrency networks and how fast they are growing, the cost to pull off such a feat probably would be insurmountable. This would be not only extremely expensive but also likely fruitless. Doing such a thing would not go unnoticed, as network members would see such drastic alterations to the blockchain. The network members would then [hard fork](#) off to a new version of the chain that has not been affected. This would cause the attacked version of the token to plummet in value, making the attack ultimately pointless, as the bad actor has control of a worthless asset. The same would occur if the bad actor were to attack the new fork of Bitcoin. It is built this way so that taking part in the network is far more economically incentivized than attacking it.

Bitcoin vs. Blockchain

Blockchain technology was first outlined in 1991 by Stuart Haber and W. Scott Stornetta, two researchers who wanted to implement a system where document time stamps could not be tampered with. But it wasn’t until almost two decades later, with the launch of Bitcoin in January 2009, that blockchain had its first real-world application.^[1]

The Bitcoin protocol is built on a blockchain. In a research paper introducing the digital currency, Bitcoin’s pseudonymous creator, [Satoshi Nakamoto](#), referred to it as “a new electronic cash system that’s fully peer-to-peer, with no trusted third party.”^[2]

The key thing to understand here is that Bitcoin merely uses blockchain as a means to transparently record a ledger of payments, but blockchain can, in theory, be used to immutably record any number of data points. As discussed above, this could be in the form of transactions, votes in an election, product inventories, state identifications, deeds to homes, and much more.

Currently, tens of thousands of projects are looking to implement blockchains in a variety of ways to help society other than just recording transactions—for example, as a way to vote securely in democratic elections. The nature of blockchain’s immutability means that fraudulent voting would become far more difficult to occur. For example, a voting system could work such that each citizen of a country would be issued a single cryptocurrency or token. Each candidate would then be given a specific wallet address, and the voters would send their token or crypto to the address of whichever candidate for whom they wish to vote. The transparent and traceable nature of blockchain would eliminate both the need for human vote counting and the ability of bad actors to tamper with physical ballots.

Blockchain vs. Banks

Blockchains have been heralded as being a disruptive force to the finance sector, and especially with the functions of payments and banking. However, banks and decentralized blockchains are vastly different.

To see how a bank differs from blockchain, let’s compare the banking system to Bitcoin’s implementation of blockchain.

How Are Blockchains Used?

As we now know, blocks on Bitcoin's blockchain store data about monetary transactions. Today, there are more than 10,000 other cryptocurrency systems running on blockchain. But it turns out that blockchain is actually a reliable way of storing data about other types of transactions as well.

Some companies that have already incorporated blockchain include Walmart, Pfizer, AIG, Siemens, Unilever, and a host of others. For example, IBM has created its Food Trust blockchain to trace the journey that food products take to get to their locations.^[3]

Why do this? The food industry has seen countless outbreaks of E. coli, salmonella, and listeria, as well as hazardous materials being accidentally introduced to foods. In the past, it has taken weeks to find the source of these outbreaks or the cause of sickness from what people are eating. Using blockchain gives brands the ability to track a food product's route from its origin, through each stop it makes, and finally, its delivery. If a food is found to be contaminated, then it can be traced all the way back through each stop to its origin. Not only that, but these companies can also now see everything else it may have come in contact with, allowing the identification of the problem to occur far sooner and potentially saving lives. This is one example of blockchain in practice, but there are many other forms of blockchain implementation.

Banking and Finance

Perhaps no industry stands to benefit from integrating blockchain into its business operations more than banking. Financial institutions only operate during business hours, usually five days a week. That means if you try to deposit a check on Friday at 6 p.m., you will likely have to wait until Monday morning to see that money hit your account. Even if you do make your deposit during business hours, the transaction can still take one to three days to verify due to the sheer volume of transactions that banks need to settle. Blockchain, on the other hand, never sleeps.

By integrating blockchain into banks, consumers can see their transactions processed in as little as 10 minutes—basically the time it takes to add a block to the blockchain, regardless of holidays or the time of day or week. With blockchain, banks also have the opportunity to exchange funds between institutions more quickly and securely. In the stock trading business, for example, the settlement and clearing process can take up to three days (or longer, if trading internationally), meaning that the money and shares are frozen for that period of time.

Given the size of the sums involved, even the few days that the money is in transit can carry significant costs and risks for banks.

Currency

Blockchain forms the bedrock for cryptocurrencies like Bitcoin. The U.S. dollar is controlled by the Federal Reserve. Under this central authority system, a user's data and currency are technically at the whim of their bank or government. If a user's bank is hacked, the client's private information is at risk. If the client's bank collapses or the client lives in a country with an unstable government, the value of their currency may be at risk. In 2008, several failing banks were bailed out—partially using taxpayer money. These are the worries out of which Bitcoin was first conceived and developed.

By spreading its operations across a network of computers, blockchain allows Bitcoin and other cryptocurrencies to operate without the need for a central authority. This not only reduces risk but also eliminates many of the processing and transaction fees. It can also give those in

applications and a wider network of ally.

Using [cryptocurrency wallets](#) for savings accounts or as a means of payment is especially profound for those who have no state identification. Some countries may be war-torn or have governments that lack any real infrastructure to provide identification. Citizens of such countries may not have access to savings or brokerage accounts—and, therefore, no way to safely store wealth.

Healthcare

Healthcare providers can leverage blockchain to securely store their patients' medical records. When a medical record is generated and signed, it can be written into the blockchain, which provides patients with the proof and confidence that the record cannot be changed. These personal health records could be encoded and stored on the blockchain with a private key, so that they are only accessible by certain individuals, thereby ensuring privacy.

Property Records

If you have ever spent time in your local Recorder's Office, you will know that the process of recording property rights is both burdensome and inefficient. Today, a physical deed must be delivered to a government employee at the local recording office, where it is manually entered into the county's central database and public index. In the case of a property dispute, claims to the property must be reconciled with the public index.

This process is not just costly and time-consuming—it is also prone to human error, where each inaccuracy makes tracking property ownership less efficient. Blockchain has the potential to eliminate the need for scanning documents and tracking down physical files in a local recording office. If property ownership is stored and verified on the blockchain, owners can trust that their deed is accurate and permanently recorded.

In war-torn countries or areas that have little to no government or financial infrastructure, and certainly no Recorder's Office, it can be nearly impossible to prove ownership of a property. If a group of people living in such an area is able to leverage blockchain, then transparent and clear time lines of property ownership could be established.

Smart Contracts

A smart contract is a computer code that can be built into the blockchain to facilitate, verify, or negotiate a contract agreement. Smart contracts operate under a set of conditions to which users agree. When those conditions are met, the terms of the agreement are automatically carried out.

Say, for example, that a potential tenant would like to lease an apartment using a smart contract. The landlord agrees to give the tenant the door code to the apartment as soon as the tenant pays the security deposit. Both the tenant and the landlord would send their respective portions of the deal to the smart contract, which would hold onto and automatically exchange the door code for the security deposit on the date when the lease begins. If the landlord doesn't supply the door code by the lease date, then the smart contract refunds the security deposit. This would eliminate the fees and processes typically associated with the use of a notary, a third-party mediator, or attorneys.

Supply Chains

As in the IBM Food Trust example, suppliers can use blockchain to record the origins of materials that they have purchased. This would allow companies to verify the authenticity of not only their products but also common labels such as "Organic," "Local," and "Fair Trade."

As reported by Forbes, the food industry is increasingly adopting the use of blockchain to track the path and safety of food throughout the farm-to-user journey.^[4]

Voting

As mentioned above, blockchain could be used to facilitate a modern voting system. Voting with blockchain carries the potential to eliminate election fraud and boost voter turnout, as was tested in the November 2018 midterm elections in West Virginia.^[5] Using blockchain in this way would make votes nearly impossible to tamper with. The blockchain protocol would also maintain transparency in the electoral process, reducing the personnel needed to conduct an election and providing officials with nearly instant results. This would eliminate the need for recounts or any real concern that fraud might threaten the election.

For all its complexity, blockchain's potential as a decentralized form of record-keeping is almost without limit. From greater user privacy and heightened security to lower processing fees and fewer errors, blockchain technology may very well see applications beyond those outlined above. But there are also some disadvantages.

Pros

- Improved accuracy by removing human involvement in verification
- Cost reductions by eliminating third-party verification
- Decentralization makes it harder to tamper with
- Transactions are secure, private, and efficient
- Transparent technology
- Provides a banking alternative and a way to secure personal information for citizens of countries with unstable or underdeveloped governments

Cons

- Significant technology cost associated with mining bitcoin
- Low transactions per second
- History of use in illicit activities, such as on the dark web
- Regulation varies by jurisdiction and remains uncertain
- Data storage limitations

Benefits of Blockchains

Accuracy of the Chain

Transactions on the blockchain network are approved by a network of thousands of computers. This removes almost all human involvement in the verification process, resulting in less human error and an accurate record of information. Even if a computer on the network were to make a computational mistake, the error would only be made to one copy of the blockchain. For that error to spread to the rest of the blockchain, it would need to be made by at least 51% of the network's computers—a near impossibility for a large and growing network the size of Bitcoin's.

[6]

Cost Reductions

Typically, consumers pay a bank to verify a transaction, a notary to sign a document, or a minister to perform a marriage. Blockchain eliminates the need for third-party verification—and, with it, their associated costs. For example, business owners incur a small fee whenever they accept payments using credit cards, because banks and payment-processing companies have to process those transactions. Bitcoin, on the other hand, does not have a central authority and has limited transaction fees.

Decentralization

Blockchain does not store any of its information in a central location. Instead, the blockchain is copied and spread across a network of computers. Whenever a new block is added to the blockchain, every computer on the network updates its blockchain to reflect the change. By spreading that information across a network, rather than storing it in one central database, blockchain becomes more difficult to tamper with. If a copy of the blockchain fell into the hands of a hacker, only a single copy of the information, rather than the entire network, would be compromised.

Efficient Transactions

Transactions placed through a central authority can take up to a few days to settle. If you attempt to deposit a check on Friday evening, for example, you may not actually see funds in your account until Monday morning. Whereas financial institutions operate during business hours, usually five days a week, blockchain is working 24 hours a day, seven days a week, and 365 days a year. Transactions can be completed in as little as 10 minutes and can be considered secure after just a few hours. This is particularly useful for [cross-border](#) trades, which usually take much longer because of time zone issues and the fact that all parties must confirm payment processing.

Many blockchain networks operate as public databases, meaning that anyone with an internet connection can view a list of the network's transaction history. Although users can access details about transactions, they cannot access identifying information about the users making those transactions. It is a common misperception that blockchain networks like bitcoin are anonymous, when in fact they are only confidential.

When a user makes a public transaction, their unique code—called a public key, as mentioned earlier—is recorded on the blockchain. Their personal information is not. If a person has made a Bitcoin purchase on an exchange that requires identification, then the person's identity is still linked to their blockchain address—but a transaction, even when tied to a person's name, does not reveal any personal information.

Secure Transactions

Once a transaction is recorded, its authenticity must be verified by the blockchain network. Thousands of computers on the blockchain rush to confirm that the details of the purchase are correct. After a computer has validated the transaction, it is added to the blockchain block. Each block on the blockchain contains its own unique hash, along with the unique hash of the block before it. When the information on a block is edited in any way, that block's hash code changes—however, the hash code on the block after it would not. This discrepancy makes it extremely difficult for information on the blockchain to be changed without notice.

Transparency

Most blockchains are entirely open-source software. This means that anyone and everyone can view its code. This gives auditors the ability to review cryptocurrencies like Bitcoin for security. This also means that there is no real authority on who controls Bitcoin's code or how it is edited. Because of this, anyone can suggest changes or upgrades to the system. If a majority of the network users agree that the new version of the code with the upgrade is sound and worthwhile, then Bitcoin can be updated.

Banking the Unbanked

Perhaps the most profound facet of blockchain and Bitcoin is the ability for anyone, regardless of ethnicity, gender, or cultural background, to use it. According to The World Bank, an estimated 1.7 billion adults do not have bank accounts or any means of storing their money or wealth.

^[7] Nearly all of these individuals live in developing countries, where the economy is in its infancy and entirely dependent on cash.

These people often earn a little money that is paid in physical cash. They then need to store this physical cash in hidden locations in their homes or other places of living, leaving them subject to robbery or unnecessary violence. Keys to a bitcoin wallet can be stored on a piece of paper, a cheap cell phone, or even memorized if necessary. For most people, it is likely that these options are more easily hidden than a small pile of cash under a mattress.

Blockchains of the future are also looking for solutions to not only be a unit of account for wealth storage but also to store medical records, property rights, and a variety of other legal contracts.

Drawbacks of Blockchains

Technology Cost

Although blockchain can save users money on transaction fees, the technology is far from free. For example, the PoW system which the bitcoin network uses to validate transactions, consumes vast amounts of computational power. In the real world, the power from the millions of computers on the bitcoin network is close to what Norway and Ukraine consume annually.^[8]

Despite the costs of mining bitcoin, users continue to drive up their electricity bills to validate transactions on the blockchain. That's because when [miners](#) add a block to the bitcoin blockchain, they are rewarded with enough bitcoin to make their time and energy worthwhile. When it comes to blockchains that do not use cryptocurrency, however, miners will need to be paid or otherwise incentivized to validate transactions.

Some solutions to these issues are beginning to arise. For example, bitcoin-mining farms have been set up to use solar power, excess natural gas from fracking sites, or power from wind farms.

Speed and Data Inefficiency

Bitcoin is a perfect case study for the possible inefficiencies of blockchain. Bitcoin's PoW system takes about 10 minutes to add a new block to the blockchain.^[9] At that rate, it's estimated that the blockchain network can only manage about seven transactions per second (TPS).

Solutions to this issue have been in development for years. There are currently blockchains that are boasting more than 30,000 TPS. ^[11]

The other issue is that each block can only hold so much data. The [block size debate](#) has been, and continues to be, one of the most pressing issues for the scalability of blockchains going forward.

Illegal Activity

While confidentiality on the blockchain network protects users from hacks and preserves privacy, it also allows for illegal trading and activity on the blockchain network. The most cited example of blockchain being used for illicit transactions is probably the [Silk Road](#), an online dark web illegal-drug and money laundering marketplace operating from February 2011 until October 2013, when it was shut down by the FBI. ^[12]

The [dark web](#) allows users to buy and sell illegal goods without being tracked by using the [Tor Browser](#) and make illegal purchases in Bitcoin or other cryptocurrencies. Current U.S. regulations require financial service providers to obtain information about their customers when they open an account, verify the identity of each customer, and confirm that customers do not appear on any list of known or suspected terrorist organizations. ^[13] This system can be seen as both a pro and a con. It gives anyone access to financial accounts but also allows criminals to more easily transact. Many have argued that the good uses of crypto, like banking the unbanked world, outweigh the bad uses of cryptocurrency, especially when most illegal activity is still accomplished through untraceable cash.

While Bitcoin had been used early on for such purposes, its transparent nature and maturity as a financial asset has actually seen illegal activity migrate to other cryptocurrencies such as Monero and Dash. ^[14] Today, illegal activity accounts for only a very small fraction of all Bitcoin transactions. ^[15]

Regulation

Many in the crypto space have expressed concerns about government regulation over cryptocurrencies. While it is getting increasingly difficult and near impossible to end something like Bitcoin as its decentralized network grows, governments could theoretically make it illegal to own cryptocurrencies or participate in their networks.

This concern has grown smaller over time, as large companies like PayPal begin to allow the ownership and use of cryptocurrencies on its platform.

What Is a Blockchain Platform?

A blockchain platform allows users and developers to create novel uses of an existing blockchain infrastructure. One example is [Ethereum](#), which has a native cryptocurrency known as ether ([ETH](#)). ^[16] But the Ethereum blockchain also allows the creation of smart contracts and programmable tokens used in [initial coin offerings \(ICOs\)](#), and non-fungible tokens (NFTs). These are all built up around the Ethereum infrastructure and secured by nodes on the Ethereum network.

How Many Blockchains Are There?

The number of live blockchains is growing every day at an ever-increasing pace. As of 2022, there are more than 10,000 active cryptocurrencies based on blockchain, with several hundred more non-cryptocurrency blockchains. ^[17]

What's the Difference Between a Private Blockchain and a Public Blockchain?

A public blockchain, also known as an open or permissionless blockchain, is one where anybody can join the network freely and establish a node. Because of its open nature, these blockchains must be secured with cryptography and a consensus system like proof of work (PoW).

A private or permissioned blockchain, on the other hand, requires each node to be approved before joining. Because nodes are considered to be trusted, the layers of security do not need to be as robust.

Who Invented Blockchain?

hematians who wanted to implement a
nk [Nick Szabo](#) proposed using a blockchain to
secure a digital payments system, known as [bit gold](#) (which was never implemented).^[18]

What's Next for Blockchain?

With many practical applications for the technology already being implemented and explored, blockchain is finally making a name for itself in no small part because of bitcoin and cryptocurrency. As a buzzword on the tongue of every investor in the nation, blockchain stands to make business and government operations more accurate, efficient, secure, and cheap, with fewer middlemen.

As we prepare to head into the third decade of blockchain, it's no longer a question of if legacy companies will catch on to the technology—it's a question of when. Today, we see a proliferation of NFTs and the tokenization of assets. The next decades will prove to be an important period of growth for blockchain.

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[Chainlink \(LINK\) Definition](#)

Chainlink (LINK) is a both cryptocurrency and technology platform that enables blockchain platforms to securely interact with external data. Learn more about Chainlink. [more](#)

[Algorand \(ALGO\) Definition](#)

Algorand (ALGO) is a cryptocurrency and blockchain platform that can finalize transactions immediately. Learn more about ALGO and Algorand. [more](#)

[Block \(Bitcoin Block\)](#)

What Is Double-Spending in a Blockchain?

Double-spending is a potential flaw in cryptocurrency systems that refers to the possibility of a digital currency being spent more than once. [more](#)

What Is Cryptocurrency Block Time?

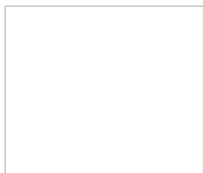
Block time, in the context of cryptocurrency, is the average amount of time it takes for a new block to be added to a blockchain. [more](#)

What Is Ethereum?

Ethereum is a blockchain-based software platform with the native coin ether. Ethereum smart contracts support a variety of distributed apps across the crypto ecosystem. [more](#)

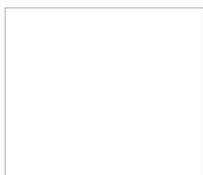
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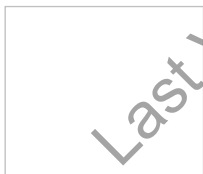
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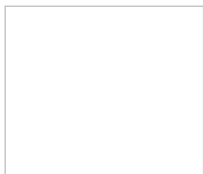
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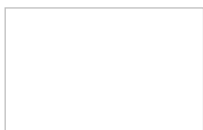
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