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# Cryptocurrency 201: What Is Ethereum?

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If Cryptocurrency 101 is about Bitcoin, Cryptocurrency 201 is about Ethereum. As such, learning about it is a key part of Morgan Stanley Wealth Management's call to "get educated" on crypto. In this primer, we discuss what Ethereum is, how it works and how it differs from Bitcoin. We also explore use cases, including decentralized finance (DeFi) and non-fungible tokens (NFTs), and detail its risks.

**For additional information about the risks of cryptocurrencies, see Important Information in the Disclosure section of this report.**

# Introduction

Cryptocurrency is a fast-growing and complicated marketplace. Most investors encounter concepts such as the blockchain, coins and tokens, private keys and mining as they learn about Bitcoin, the first and largest cryptocurrency. But Bitcoin represents less than half of all the value in cryptocurrencies. Ether, linked to the blockchain protocol Ethereum, is the second-largest and frequently the second stop for cryptocurrency investors. While Bitcoin is a complicated system that solves a simple problem—how to store and send value—Ethereum repurposes the Bitcoin design to enable blockchains to meet many other challenges. As developers launch countless new software programs using blockchain design concepts, more of them now operate on the Ethereum network than any other platform.

We make no recommendation whether to buy or sell Ether. Bulls like its large addressable market, decelerating supply growth and declining float (the number of ether available for trading). Bears point to emerging competition, scalability issues and risk of government regulation. No matter which side one takes, it's vital to become informed about this part of the crypto ecosystem. Regarding both Ethereum and cryptocurrency in general, there are new terms to learn and new risks and opportunities to appreciate. Importantly, we do not see this asset class disappearing. The faster we can get educated, the faster we can understand how cryptocurrency may fit into some, though not all, portfolios.

**Key Points**

- Ethereum is a blockchain protocol that uses its native cryptocurrency, Ether, to pay transaction fees and reward computers for running Ethereum software and processing transactions.
- Ether is the second-largest cryptocurrency and represents approximately 20% of total cryptocurrency market capitalization, as of Jan. 21, 2022.
- Ether is less scarce than Bitcoin (there are 118 million ether outstanding and 18.9 million bitcoins) and has higher inflation (there is no cap on the amount that can be issued), and its holders are less decentralized.
- The Ethereum platform acts like a decentralized app store that third parties can use to upload software applications called "smart contracts," which any user with compatible software can access.
- Thus far, the most widely used Ethereum apps are either focused on financial applications (DeFi) or storage of art or collectibles (NFTs).
- Due in part to its more ambitious addressable market, Ethereum faces more competitive threats, scalability issues and complexity challenges than Bitcoin. Furthermore, Ether is more volatile than Bitcoin.

## The Basics of Crypto

For information on additional concepts and for more details on the topics below, see our April 2021 primer, "Investing in Cryptocurrency."

**What are cryptocurrencies?** Cryptocurrencies are purely digital currencies with no physical form. No central party, such as a government or company, controls them. Bitcoin, the first cryptocurrency, was launched in 2009. After its success, thousands of others were created. Often, developers of these newer cryptocurrencies copied the Bitcoin code and made small adjustments. When someone owns cryptocurrency they do not possess anything tangible.

Ownership of a cryptocurrency means that an owner has a password linked to an address or account on a public blockchain. This password allows the owner to send instructions to the network, such as "Send my bitcoins from account 1 to account 2." Encryption allows the instructions and the password to be broadcast over the internet in a manner that is readable only to the software. Encryption, an important part of the technology, is a form of cryptography—thus the term cryptocurrency.

**What is a blockchain?** Most cryptocurrencies use a blockchain to store transaction data and account balances. Periodically (every 10 minutes, on average, for Bitcoin), all the transactions are grouped together into a "block" of transactions. By employing a cryptographic technique called a hash, these blocks are connected, or "chained," to each other. This ensures the blocks are always in the same order. Computers running cryptocurrency software keep a copy of the latest version of the blockchain, listen for new versions of the blockchain broadcast by other computers and continually broadcast the latest copy to other computers in the network.

Some computers process transactions and attempt to add new blocks to the blockchain. They then broadcast the new blockchain to the broader network. Blockchains are especially useful because they are redundant and tamper-resistant. Instead of a master file and a few backups, as is the case for most centralized systems, blockchains enable thousands of computers to maintain backups. Any copies that don't match everyone else's are assumed to have incorrect data. Blockchains allow users to trust the group consensus rather than rely on one particular entity, such as a company with a "master version" of the data.

**What is innovative about cryptocurrencies?** Cryptocurrencies are innovative in two main ways. First, they enable digital scarcity, the concept that something digital can be scarce. Previously, digital items like pictures, videos and music were never scarce because they could easily be copied, and it was prohibitively expensive to separate the copies from the original. Blockchains made it very easy and cheap to distinguish between legitimate and fake digital items. The second innovation relates to the manner in which enabling digital scarcity was achieved—through a decentralized autonomous organization (DAO).

With no person or entity functioning as the Bitcoin network's leader or administrator, it was maintained through well-designed economic incentives utilizing the new digital currency, Bitcoin. The network is famously permissionless: Anyone can use it, it's censorship-resistant and no one can technologically block a transaction (though they can be made illegal). These innovations have been applied to many areas beyond sending and receiving digital currencies.

**What is a smart contract platform?** After Bitcoin became established as a currency between 2010 and 2013, enthusiasts began to envision solving other problems using a decentralized organization and blockchain. While Bitcoin could only execute simple commands, such as "send," in theory a similar system could execute all kinds of complicated programs. These programs are known as smart contracts. A system that hosts smart contracts is known as a smart contract platform.

In the same way that Bitcoin is like a decentralized bank, a smart contract platform is like a decentralized app store. Like mobile phone app store platforms, which host software apps developed by third parties, a smart contract platform can host applications (lines of code) built by third parties that are uploaded to the blockchain. Anyone can access and run these apps without asking permission. Unlike centralized app stores, developers do not need approval to upload their programs. Once deployed, the apps cannot be forcibly removed or censored. Ethereum is the leading smart contract platform.

## What Is Ethereum?

Ethereum was conceived in 2013, funded in a crowd sale in 2014 and launched in 2015. Vitalik Buterin, a young Bitcoin enthusiast, is the most prominent founder of Ethereum. Six years after its launch, Ethereum, as of January 21, has a market capitalization of $332 billion. It is the second-largest cryptocurrency by market cap and the most valuable smart contract platform (see Exhibit 1). There are roughly 118 million ether outstanding, and each ether is worth approximately $2,400. For more details on how it began, see the Appendix .

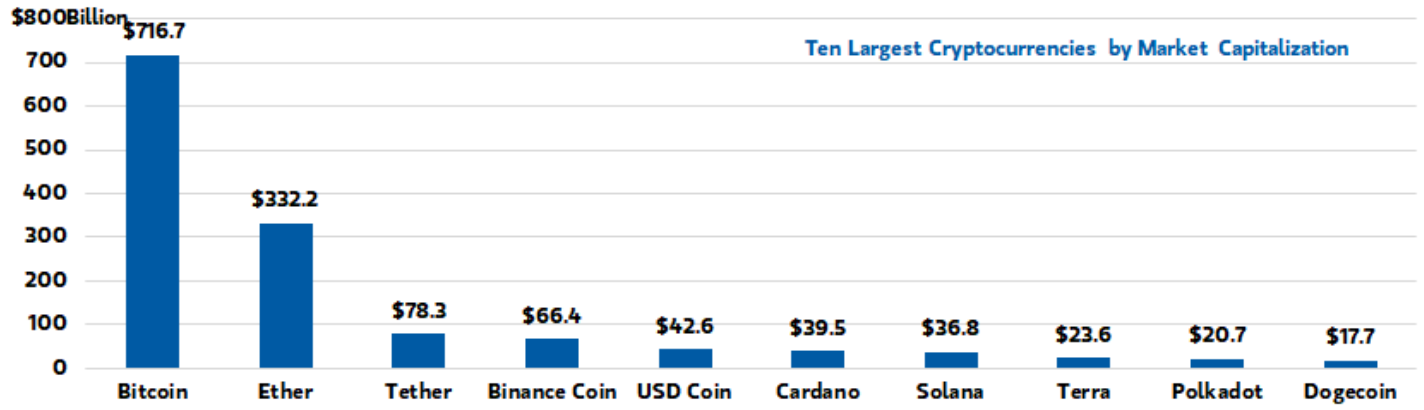
Among other things, Ethereum is a programmable blockchain, built using the concepts introduced by Bitcoin, but designed differently. Rather than seeking to create a decentralized savings account, like Bitcoin, Ethereum developers aspire to create a decentralized open-source app store. Like Bitcoin, Ethereum utilizes a blockchain. A blockchain is a chain of blocks of data that are connected using cryptographic techniques. Like instructions listed in an assembly manual, the blocks must remain in a specific order relative to one another.

Changing the order of the blocks will cause a failure.

Bitcoin's blockchain contains a record of all historical transactions. Transactions are bitcoins moving from one address to another. Ethereum's blockchain contains transactions, lines of code and data. The lines of code and the data can be combined to write programs called smart contracts. One of the first analogies Ethereum developers used to describe the network likened it to a "world computer." Anyone can log on to the computer, upload programs or run somebody else's programs. Another useful analogy compares Ethereum to a decentralized app store. To use the apps, customers pay a fee for each transaction in the cryptocurrency Ether. These fees pay for the computer-processing power and memory required to run the software program.

**Differences between Ethereum and Bitcoin.** Ethereum uses different hardware, employs a different programming language and has a different fundamental design. Its programming language, Solidity, is more flexible than Bitcoin's language, Script. Because app stores need to handle more transactions than savings accounts, Ethereum's blocks are produced every 15 seconds—much faster than Bitcoin's blocks, which are produced every 10 minutes. If Bitcoin's demand is driven by users' desire to hold Bitcoin, a large portion of Ether's demand is driven by users who want to spend it on transactions. Given these dynamics, if Bitcoin can be viewed as digital gold for holding, Ether can be viewed as digital oil for burning. Exhibit 2 illustrates the differences in goals, market leadership, competitive factors and network effects among currencies, smart contract platforms and decentralized applications.

## Exhibit 1: Bitcoin and Ethereum Have Significantly Larger Market Caps Than the Next Eight Largest Cryptocurrencies




Source: Coinmarketcap.com, Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

## Exhibit 2: Differences Between Currencies, Smart Contract Platforms and Decentralized Applications

| | Currencies | Smart Contract Platforms | Decentralized Applications |
|---|---|---|---|
| **Goal** | Serve as a unit of account, medium of exchange and store of value | Provide settings for running decentralized applications | Provide trustless, decentralized software solutions |
| **Competes on** | 1. Adoption<br>2. Liquidity<br>3. Store of value | 1. Users<br>2. Transaction cost<br>3. Decentralization | 1. Fees<br>2. User Interface<br>3. Brand |
| **Network Effects** | Strong | Medium | Weak |
| **Market Share Leader** | Bitcoin (BTC) | Ethereum (ETH) | Uniswap (UNI) |

Source: Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

## How Does Ethereum Work?

Ethereum's goal—to become a decentralized app store—makes it different from most of the earlier cryptocurrencies that merely attempted to improve Bitcoin. Ethereum was designed as a platform to upload and run smart contracts. While many of the details of how Ethereum works are beyond the scope of this paper, a simplified explanation, visualizing its four most important "layers," can be helpful.

**First layer – the physical network.** This is a distributed collection of computers, called nodes, running Ethereum software. Some of the nodes mine the cryptocurrency and some broadcast the blockchain and transactions around the world.

**Second layer – the Ethereum Virtual Machine**. This code allows developers to upload smart contracts to the blockchain and allows external accounts (users) to interact with the smart contracts. External accounts are controlled by a private key (password). Smart contracts are simply computer programs. By design, all the programs are stored on every node in the Ethereum network—a very redundant, but resilient design.

**Third layer – the smart contract.** Smart contracts are programs that receive instructions and can send messages or instructions to other accounts or other smart contracts. A smart contract might do something like change a variable or send a cryptocurrency to another address.

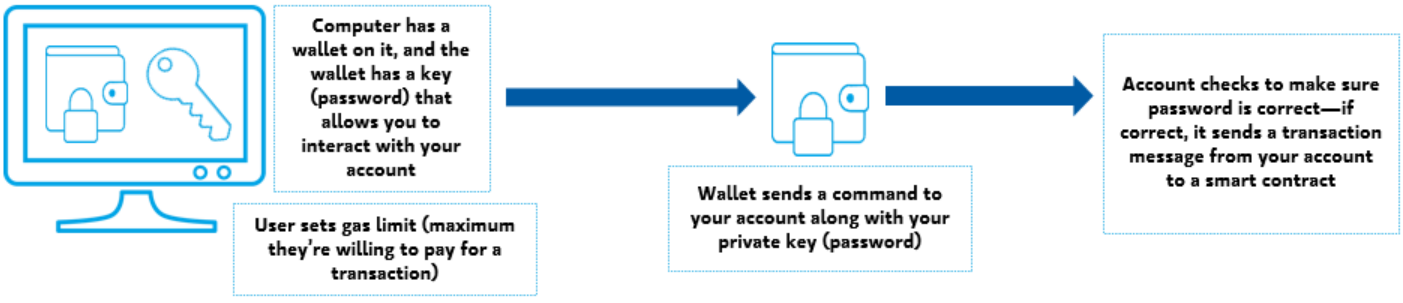
**Fourth layer – the decentralized application (dapp).** Dapps are collections of smart contracts that perform complicated tasks, such as exchanging one token for another or lending a token using another token as collateral. They are accessed through websites that allow users to connect their "Web 3" wallets to the Ethereum network. Web 3 wallets hold passwords associated with cryptocurrency addresses. A wallet can broadcast instructions (lines of code) to the Ethereum blockchain. These wallets approve transactions by electronically signing them with passwords and sending the approval to the Ethereum network.

**What is an Ethereum transaction?** Ethereum transactions are messages sent across the network. Using wallet software, a user can send a message from his or her address to another user or to a smart contract. A message might be as simple as "Send Ether from address 1 to address 2," or it could be more complicated, such as a command to run a specific piece of code or to save data to the blockchain.

Most users typically rely on websites to write and send the code to the Ethereum network. The ability to send more complicated code makes Ethereum more advanced than Bitcoin, which can only process simple transactions. Ethereum can run complicated smart contracts.

As illustrated in Exhibit 3, once an instruction is written, it is "signed" using a user's private key then broadcast to the network. When a message is sent, users include a transaction fee denominated in Ether with their message. Nodes on the network running Ethereum software listen for messages and rebroadcast them to the broader network. Miners then organize all the messages into blocks, process them and add them to the blockchain. In return, miners receive a block reward (currently two ether per block) and transaction fees. Transaction fees are called "gas." Much like with cars, gas is the fuel that allows the Ethereum network to run. Some messages require more gas than others. When the network is congested, gas prices go up, and when relatively few are using the network, gas prices go down. Transaction fees keep the network secure by preventing spam (low value transactions) and infinite loops, which would cause a smart contract to run out of gas.

### Exhibit 3: There Are Three Key Steps of an Ethereum Transaction




Source: Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

**Who controls the Ethereum network?** Like Bitcoin, no one person controls the Ethereum network. It is controlled by thousands of computers called nodes. Miners, developers, exchanges and crypto businesses might all run nodes. If changes to the network are needed, these nodes must coordinate in a decentralized way. Unlike a tech company that might require users to upgrade software, the node operators do *not* have to upgrade to the newer versions of software. Each node owner decides which version of Ethereum software to run. Node owners generally prefer to run versions compatible with most other nodes so that their software will work with everyone else's. Thus, node operators try to come to a consensus on the best software updates.

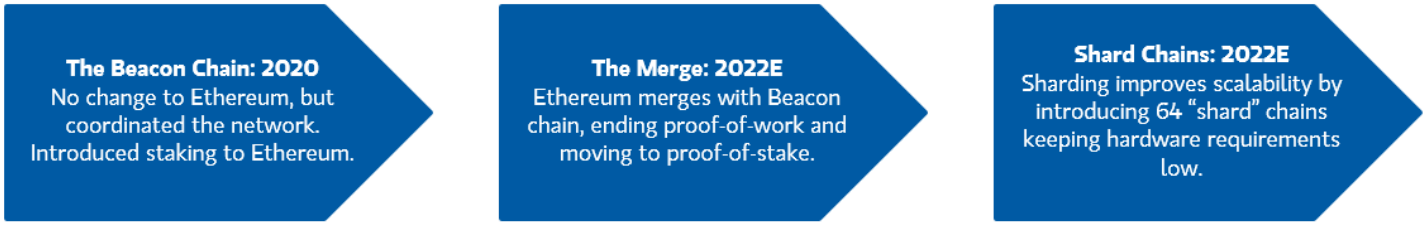
Consensus sounds attractive, but what if the stakeholders don't agree on software upgrades? If there were two incompatible versions of code, with both attracting many node operators, the code would "fork" into two networks, each with its own version of the code. This happened to Ethereum in the summer of 2016 when one Ethereum chain became Ethereum Classic, and one kept the name Ethereum. Most forks do not lead to two networks. Typically, the smaller fork dies off—as no one maintains that blockchain and no one wants to use the cryptocurrency stored on it—and usually only the more popular blockchain survives. Through this adversarial process, consensus is formed on topics such as which is the best version of the code.

**Code changes.** Ethereum's more expansive vision has led to many more forks than experienced by Bitcoin. Most of these forks have not been contentious, with almost every node operator agreeing on the upgrade and the old code abandoned, leaving only one chain remaining. However, every code change increases the potential for a software bug—one of the five major risks of cryptocurrency. Bitcoin's more conservative node operators tend to avoid hard forks to ensure older, battle-tested versions of the code still work.

Ethereum node operators, on the other hand, embrace forks, and the Ethereum protocol even has a feature that encourages them. Ethereum has undergone 16 hard forks since its launch in 2015. The Ethereum software upgrade roadmap, shown in Exhibit 4, illustrates how the software is constantly changing. Changes, however, are made known to users in advance of their implementation. In 2022, Ethereum developers hope to "do a hard fork" by changing the code from proof-of-work to proof-of-stake, a very significant adjustment.

**Bitcoin vs. Ethereum.** Although Ethereum relies on many of the same concepts as Bitcoin, there are some key differences, as illustrated in Exhibit 5.

## Exhibit 4: The Ethereum Roadmap Calls for Significant Changes




Source: Ethereum.org, Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

## Exhibit 5: Key Differences Between Bitcoin and Ethereum

| Key Difference | Bitcoin | Ethereum |
|---|---|---|
| **Goal** | Decentralized savings account | Decentralized app store |
| **Structure** | Unspent transaction outputs | Account based system |
| **Consensus** | Proof-of-work | Proof-of-work using Ethash hash function but changing to proof-of-stake |
| **Scalability** | Seven transactions per second | 30 transactions per second |
| **Size of the Blockchain** | 381 gigabytes | 1,126 gigabytes (Geth Default) |

Source: Bitcoin.org, Bitnodes.io, Ethereum.org, Etherscan.io, Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

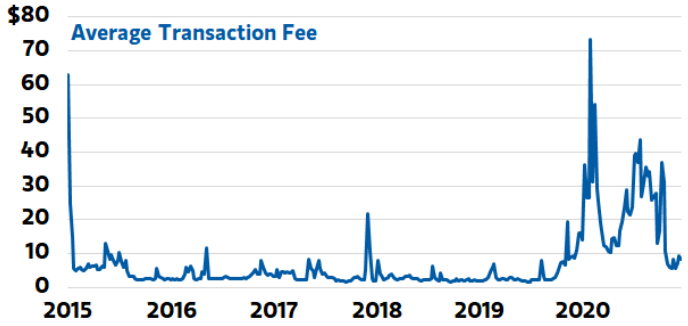
## What Is Ethereum Used For?

Technologists and various Ethereum advocates have proposed using it in a number of different ways. Recommended applications include social media, gaming, supply chain management, network coordination, art and collectibles, and voting and governance. Thus far, DeFi and NFTs have gained the most traction. But before exploring those two trends, it's important to understand the new capabilities that Ethereum offers.

Ethereum, among other attributes, shares two important capabilities with Bitcoin—digital scarcity and decentralized organization—the two key innovations that have enabled Bitcoin to compete with national currencies. These capabilities allow Ethereum to reimagine the concept of an app store. Smart contract use cases that do not require one or both of these innovations have been slower to gain traction because blockchains are so much more expensive than traditional designs. Instead of a few computers processing transactions, many computers compete to process them.

This redundant design drives up the cost to run the network and requires high transaction fees. Thus far, only applications that need digital scarcity or decentralized organization have attracted users willing to pay those high fees. The average Ethereum fee, which has recently ranged from $40 to $50, has risen by more than 2,600% since 2019. In May 2021 it reached $70, as shown in Exhibit 6 below.

**Exhibit 6: Ethereum Transaction Fees Have Been Volatile**




Source: Intotheblock.com, Morgan Stanley Wealth Management Global Investment Office as of Jan. 22, 2022

## Decentralized Finance

Decentralized finance (DeFi) is the decentralization of traditional elements of financial systems in order to facilitate or create new forms of fundraising, banks, exchanges, payments, insurance and derivatives on the blockchain. DeFi proponents point to the 1990s as a time when media and commerce were disrupted by the ability of anyone to participate in blogs, user-generated videos and online stores. This time, they say, it's financial institutions that will be disrupted by new technology allowing anyone to participate in finance. While DeFi has expanded quickly, it is experiencing growing pains.

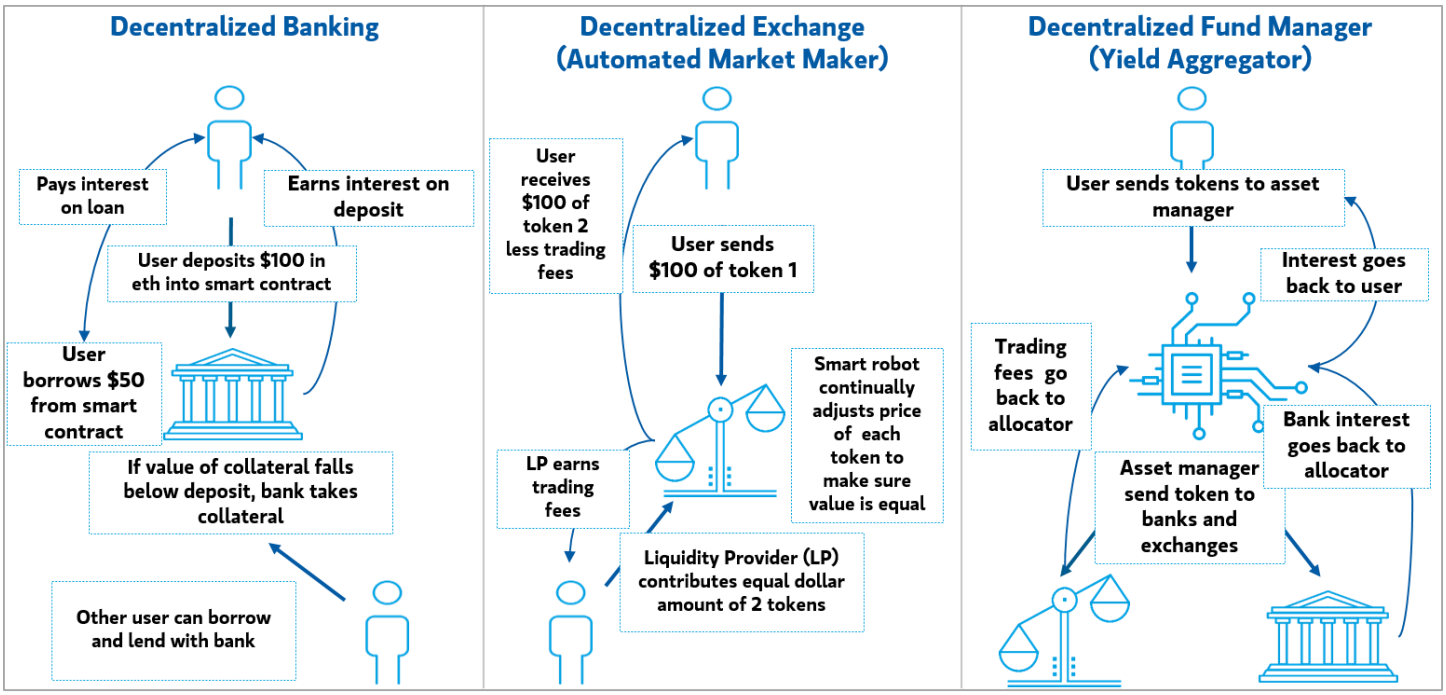
**How are DeFi and Ethereum related?** Most DeFi apps are built on the Ethereum platform for public smart contracts. DeFi apps use smart contracts to run code and transferrable tokens to store information. Often, control of a token allows the token holder to interact with dapps in different ways than users who don't control a token. Tokens can allow owners to withdraw Ether or other tokens from a dapp, receive targeted rewards, borrow tokens from a dapp or vote on various governance proposals (similar to how shares allow equity holders to vote on a board of directors). Each transaction requires the user to pay a fee in Ether to the Ethereum miners.

Since the DeFi code is often open source, independently verifiable and executed automatically, it sometimes eliminates or reduces the need for trusted third parties. Ethereum has been the leading smart contract platform for DeFi dapps because it has the leading share of a multi-sided network. It has the leading share of users, deposits and developers. One side is users who are the potential customers of the DeFi applications. However, the most valuable users are those who control significant value in cryptocurrency tokens. Because most cryptocurrency tokens are Ethereum tokens held on the Ethereum blockchain, Ethereum's users hold the most valuable digital assets. These assets are the potential deposits of the DeFi system.

Finally, Ethereum has the most developers. Ethereum developers often use DeFi applications to fund their startups, to reward customers and to provide liquidity to startup-related tokens. They also build tools that help users employ other parts of the Ethereum DeFi ecosystem. Like a three-legged stool, each of these networks—users, deposits and developers—make Ethereum a good platform for DeFi dapps. Competitors have been unable to recreate each of the three legs.

**How is DeFi innovative?** DeFi derives its most innovative features from the concept of decentralized organizations. Decentralized organizations can be permissionless (anyone can participate), trustless (no counterparty risk) and censorship-resistant (no third party can block a user from interacting with the software). However, with the system open to all actors—good or bad—permissionless also means there are fewer investor protections. Further, more incompetently designed products may be available. These may have bugs and/or may be exploited by bad actors. At this point it is unclear whether decentralization, on balance, is positive or negative.

Exhibit 7: There Are Three Groups of Decentralized Finance Projects




Source: Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

**Decentralized Exchanges (DEXs).** The DeFi sector includes many types of financial organizations, as shown in Exhibit 7, but the most popular are DEXs, decentralized banks and decentralized asset managers. DEXs are online exchanges that provide buyers and sellers liquidity 24 hours a day. Unlike centralized exchanges, users maintain custody of their tokens until the trade is completed, eliminating counterparty risk. In April 2021, the leading DEX had more than $10 billion in weekly trading volume; it has recently been generating daily volume of $1.7 billion to $2.5 billion, according to tokenterminal.com.

**Decentralized banks** are a collection of smart contracts allowing users to deposit cryptocurrency and borrow other cryptocurrency using their deposits as collateral. The top four decentralized banks have $50 billion in assets locked in their smart contracts, as of January 2022, according to DeFi Pulse.

**Decentralized asset managers,** also known as yield aggregators, programmatically manage portfolios of assets. According to DeFi Pulse, the largest yield aggregator has $3 billion to $4 billion in assets under management, as of January 2022.

## Non-Fungible Tokens

The second big trend driving Ethereum usage in 2021 was the rise of non-fungible tokens. Just as DeFi has built on Bitcoin's innovation around decentralized organization, NFTs have built on the other major facet of Bitcoin innovation—digital scarcity. Even among those who understand Bitcoin, NFTs are a difficult mental leap. Digital items have never been valuable because they were so easy to copy, and it was too expensive to separate the original from the copies. NFTs provide a cheap way to make an authentic digital item scarce. With this new capability, there has been rapid experimentation with many types of digital items.

NFTs are tokens that are unique and indivisible. Like other cryptoassets, they are issued by smart contracts and can be traded through centralized or decentralized exchanges and transferred from one crypto wallet to another. NFTs have most often been used to represent the control of digital items, functioning similarly to a deed or a certificate of authenticity. Rather than relying on the court system to enforce or signal control, NFTs rely on the underlying blockchain, a less expensive solution. Thus far, NFTs are primarily used to signify control or ownership of digital art and other collectibles on the blockchain. They have been used to cheaply track and prove ownership of digitized assets such as pictures, music and videos.

NFTs signifying control of digital assets have been sold for much higher amounts than copies of items that are not connected to an NFT. In the same way an original of a song is more valuable than a later copy because it is more scarce and the chain of custody can easily be tracked from creator to buyer, an NFT referencing a digital object (image, song, etc.) is

also more valuable than a copy. This is similar to how two Picasso paintings, one original and one copy, might look identical, but the one with believable records tracing its lineage to the painter himself is more valuable than the painting with no record of its history. Because the blockchain has made the task of verifying originals so easy and so cheap, it can be applied to digital items such as pictures that would not have been cost-effective to track via the traditional legal and property rights systems. Most valuable NFTs are stored in smart contracts on the Ethereum blockchain, though other blockchains have started NFT markets as well.

While NFTs can be used to record ownership of virtually any digital item, only three use cases have gained traction: digital art, gaming items and collectibles.

**Digital art.** NFTs made headlines when the artist Beeple sold a digital collage called *Everydays: The First 5000 Days* in March 2021 for $69 million in a Christie's auction.[1] Painters, musicians and other artists have been selling art on digital NFT platforms. Natively digital art (art that doesn't exist anywhere else) has also been sold. Like many collectors, crypto art collectors use rare pieces to show off their status.

**Gaming items.** CryptoKitties was the first popular blockchain game, released in 2017. Players adopt, raise and trade virtual cats. The cat's "DNA" is stored in an Ethereum NFT token.[2] The DNA is composed of multiple variables known as traits (eye color, fur, eye shape, etc.) and their values. Other games like Axie Infinity feature players battling Axies (digital pet NFTs that can be battled, bought and traded to earn in-game tokens).[3] Gaming items, such as weapons and "skills," are routinely sold for use in traditional games.

**Collectibles.** Collectibles might be the most widely used application of NFT technology. More affordable than exclusive digital art and reliant on fewer transactions than games, collectibles sit at a sweet spot where their value, as perceived by some, is above the transaction fee but not out of reach of most cryptocurrency holders. Thus far, NFT-related collectibles have fit into three categories: cryptocurrency memorabilia, sports clips and avatars, which are used as profile pictures.

The first NFT collectible to achieve renown was a June 2017 project called CryptoPunks. It created unique characters on the Ethereum blockchain that could be claimed for free, and a secondary marketplace sprung up to trade them.[4] As some of the first examples of an Ethereum NFT, collectors desire them for their memorabilia status, just as they would value the earliest baseball cards.

The NBA Top Shot blockchain platform sells officially licensed player video highlights as NFTs, and their sales have generated millions of dollars.[5] Just as one can buy a pack of baseball cards, users can buy a "pack" of NBA clips. Each digital sports clip has a limited supply, and individual clips can be traded on the secondary market. Before blockchain, digital clips could not be scarce.

Avatars are images used on social media to represent a person's online presence. "Profile pic" NFTs are like jewelry, handbags or cars for the digital world. A popular and scarce NFT can show wealth and status in the digital world in a similar manner in which physical items do in the real world. Buying a popular NFT can also be like joining an exclusive online country club. CryptoPunks and Bored Ape Yacht Club NFTs are also popular profile pic NFTs.

## Can Ethereum Fit in a Portfolio?

We take no position on whether investors should buy, sell or hold Ether. That being said, it's likely they will hear a variety of cases for and against it. To help investors understand the pros and cons, we detail several below.

### Bull Case

**Bigger market.** Ethereum has a much bigger addressable market than Bitcoin and can therefore be worth more than Bitcoin, which is simply the market for store of value products like savings accounts and gold.

**Supply dropping.** The switch to burning Ether for transactions from paying transaction fees to miners reduces supply, and if demand for transactions is high enough it could lead to less supply growth for Ethereum than Bitcoin.

**Lower float.** The move from proof-of-work to proof-of-stake replaces miners with stakers. The stakers deposit Ether to create a node that can validate Ethereum transactions. If they make a mistake some of their deposited Ether is burned. Staking reduces the float (Ether available to be sold) in two ways. First, when someone becomes a validator they must collect 32 ether and deposit them in a contract, reducing the amount available to be purchased in the open market. Second, if a staker reinvests Ether rewards to start a new Ethereum node to increase their staking reward, there may be less Ether outstanding for others to buy. Compared to proof-of-work miners, Ethereum stakers in the new system will have more upfront costs (Ether) and fewer variable costs like electricity. Unlike miners, Ethereum stakers will have little reason to sell any of the Ether they receive for validating the network because their operating costs are very low. By contrast, Bitcoin miners must sell enough of their rewards to pay for new chips and electricity.

### Bear Case

**Competition.** Ethereum faces more competition in the smart contract market than Bitcoin faces in the store-of-value market. Ethereum may lose smart contract platform market share to faster or cheaper alternatives.

**Not scalable.** Fewer transactions per user are needed to "use" Bitcoin, which is akin to a decentralized savings account. Ethereum demand is tied more closely to transactions. Therefore, similar scaling constraints hurt Ethereum demand more than they suppress Bitcoin demand, as Bitcoin users do not need many transactions. It may be that no blockchain is scalable enough for smart contract applications.

**Regulatory demand pressure.** Ethereum's regulatory landscape is still evolving, and many applications on Ethereum could face regulatory risk. DeFi apps or NFTs used to raise money to attempt to buy original copies of the US Constitution, for instance, could be scrutinized. Some DeFi activities may conflict with securities laws. If regulation or legislation reduces demand for these transactions, demand for Ether could drop.

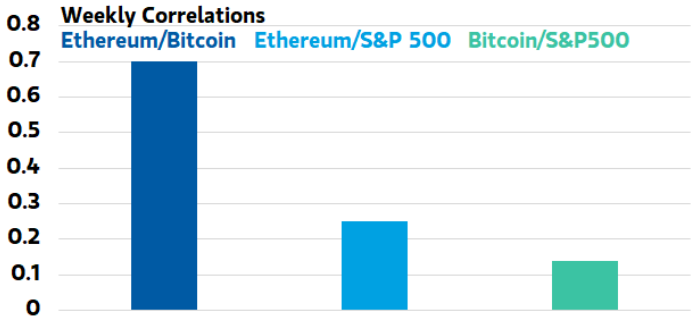
## Valuation

Our "Investing in Cryptocurrency" primer elaborates on five ways to value Bitcoin and other cryptocurrencies and includes details on relative value, price-to-operating metrics, replacement value and cyclical/technical methods. All these valuation methods work with Ethereum; additionally, its nature as a smart contract platform makes a sixth method—discounted cash flow—applicable as well. While further details are beyond the scope of this report, an analyst could model the "revenue" of Ethereum by estimating the number of transactions and the value of each transaction at some future date. He or she could then forecast the supply of Ether by estimating how many ether would be printed and how much would be burned. Finally, the future valuation could be discounted back to today, applying a cost of capital.

**Ethereum as a diversifier.** Our earlier primer discusses the argument that Bitcoin's low correlation with other asset classes may make it an acceptable holding in a diversified portfolio. Historically, Bitcoin's correlation to major asset classes has been very low, though we do not know what the future will hold. This argument is weaker for Ethereum. As shown in Exhibit 8, while Ethereum and Bitcoin have had a 0.70 correlation to one another since December 2018, Ethereum has been nearly twice as correlated to the S&P 500, at 0.26, versus 0.14 for Bitcoin.

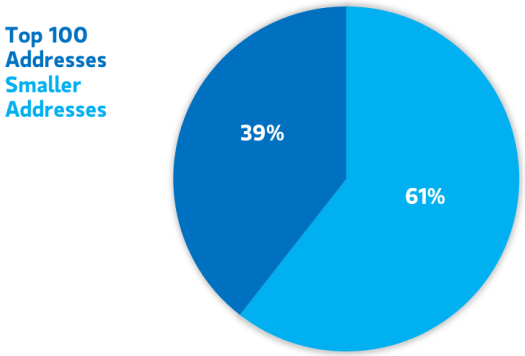
If these correlations hold, replacing some Bitcoin exposure with Ether might actually make a portfolio *more* correlated to equities. Ethereum has produced higher returns than Bitcoin since 2018 but with more volatility, though past is no indication of the future. In a period when equities declined, Ethereum might have performed worse than Bitcoin.

**Exhibit 8: Ethereum Prices Typically Move in the Same Direction as Bitcoin**




Source: Morgan Stanley Wealth Management Global Investment Office as of Dec. 21, 2021

**Exhibit 9: The Largest Addresses Control Nearly 40% of Ethereum**




Source: Morgan Stanley Wealth Management Global Investment Office as of Dec. 21, 2021

## Risks of Ethereum

Cryptocurrency risks can generally be categorized in three ways: 1) traditional risks; 2) cryptocurrency asset class risks; and 3) cryptocurrency-specific risks. **For additional information about the risks of cryptocurrencies, see Important Information in the Disclosure section of this report.**

**Traditional risks** include concentration of holders and volatility.

Concentration risk is significant for Ethereum given that most Ether is held by a relatively small number of accounts. It is less decentralized than Bitcoin, with the top 100 addresses holding 39% of Ether, which compares to 14% for Bitcoin (see Exhibit 9).

Volatility risk is critical given that cryptocurrencies are among the world's most volatile assets. As shown in Exhibit 10, since 2018, Ethereum's 60-day volatility has been approximately four to five times greater than that of the S&P 500. Notably,

Ethereum has been approximately 30% more volatile than Bitcoin since 2018. In 2021, its 60-day volatility has averaged around 86%, roughly seven times more than the S&P 500.

**Cryptocurrency asset class risks,** another category that we describe in our earlier primer, pertain to Ethereum in multiple ways.

Encryption risk is the risk that encryption techniques will break and that an attacker will subsequently divert a transaction and related assets to the attacker's own account. If this were to occur, it would likely affect many or all cryptocurrencies and engender lost funds and excessive volatility until the identification and implementation of a solution. Ethereum's encryption risk is slightly lower than Bitcoin's, as it uses SHA-3, a more recent technique than Bitcoin, which uses an SHA-2 encryption technique.[6]

Software risks may manifest themselves in a number of ways, including via bugs, as all cryptocurrencies are based on software. Severe software bugs have caused inflation (more coins being "printed" than expected) and other issues in the past. These risks depend on the individual cryptocurrency, and most of the time a bug in one cryptocurrency does not mean the same bug is exploitable in another. Ethereum's software risk is higher than Bitcoin's because 1) its code changes more frequently (16 hard forks, as opposed to three for Bitcoin); 2) it's more complicated, consistent with its ability to solve more problems and its greater propensity for glitches; and 3) it's due to undergo substantial change when it moves from proof-of-work to proof-of-stake. Further details can be found in our April 2021 primer.

Government action risks pertain to potential for government actions to reduce demand or force nodes in relevant jurisdictions to run malicious codes. This could make a blockchain splinter into less valuable regional blockchains and could cause demand to drop for certain versions of the code.

**Cryptocurrency-specific risks** to Ethereum and its blockchain stem from its strategic goals, design and position in an entirely new market.

Ethereum has created an entirely new market for smart contract platforms. Today, there are two established use cases—DeFi and art and collectibles—and many experimental use cases. It is unclear what capabilities (speed, price, decentralization, programming language, operating requirements, etc.) dapp developers will require of smart contract platforms as they pursue these and new, unproven use cases. Optimal tradeoffs between capabilities are poorly understood, and Ethereum might lose market share to other smart contract platform competitors with different design tradeoffs for some or all use cases.

Today, Ethereum clearly has dominant market share leads in value, liquidity and number of developers and users, but its shares could decrease over time. Network effects—the tendency for networks to become more valuable as more participants join them—constitute a wide moat for Ethereum, but even wide moats are sometimes overcome. Among several others, prominent Ethereum competitors include Binance, Solana and Cardano. Chinese smart contract platform Binance is affiliated with the largest cryptocurrency exchange. Solana, the fifth largest cryptocurrency, is designed to allow faster, cheaper smart contract transactions. Cardano, the fourth largest cryptocurrency, was developed by one of Ethereum's cofounders.

**Exhibit 10: Ethereum Is Even More Volatile Than Bitcoin**

| March 15, 2018-Dec. 21, 2021 | High (%) | Low (%) | Average (%) |
|---|---|---|---|
| S&P 500 Index | 65.2 | 6.7 | 18.1 |
| Ethereum | 134.1 | 37.4 | 80.7 |
| Bitcoin | 109.2 | 23.6 | 61.8 |
| Ethereum/Bitcoin | 1.2 | 1.6 | 1.3 |
| Ethereum/S&P 500 | 2.1 | 5.6 | 4.4 |

| Jan. 1, 2021-Dec. 21, 2021 | High (%) | Low (%) | Average (%) |
|---|---|---|---|
| S&P 500 Index | 16.4 | 9.2 | 12.9 |
| Ethereum | 134.1 | 58.3 | 85.8 |
| Bitcoin | 89.8 | 47.0 | 66.8 |
| Ethereum/Bitcoin | 1.5 | 1.2 | 1.3 |
| Ethereum/S&P 500 | 8.2 | 6.3 | 6.7 |

Note: This table measures historical volatility. Historical volatility is a statistical measure of the dispersion of returns for a given security or market index over a period of time.
Source: Morgan Stanley Wealth Management Global Investment Office as of Jan. 21, 2022

The second major Ethereum-specific risk is blockchain bloat and scalability. Blockchains are fundamentally expensive technologies because they have built-in redundancy. In order to be a global smart contract platform, Ethereum needs to store a very large amount of data (primarily variables for each smart contract), and it needs to be faster and less expensive to use per transaction than potential alternatives. Ethereum's blockchain, measured in gigabytes, is growing faster than Bitcoin's, and its memory requirements have surpassed Bitcoin's in half the time. Over time, Ethereum's storage demand, unless changed, will likely outstrip its resources. Decentralized storage systems comprise peer-to-peer networks of computers that need to be able to hold entire blockchains of data. As of December 2021, two versions of Ethereum full node software required 551 gigabytes and 1,121 gigabytes of memory, respectively.[7] The smaller version more aggressively removes old data from the blockchain. If memory requirements for each node were to expand to multiple terabytes, it wouldn't be plausible for all nodes to store the entire blockchain. It would also increase the cost of deploying new data.

High transaction fees create scalability problems and threaten user demand. High costs make Ethereum too expensive for small-value transactions. Layer 2 platforms—separate blockchains that synchronize with Ethereum—ease congestion on the main Ethereum chain but also divert activity from Ethereum to their own platforms.[8]

The changing regulatory landscape poses another big risk. Much of the activity on Ethereum is in DeFi and NFTs—two areas with rapidly evolving regulations. Regulations that restrict or eliminate certain market segments, such as finance, from using Ethereum could reduce demand for Ethereum transactions.

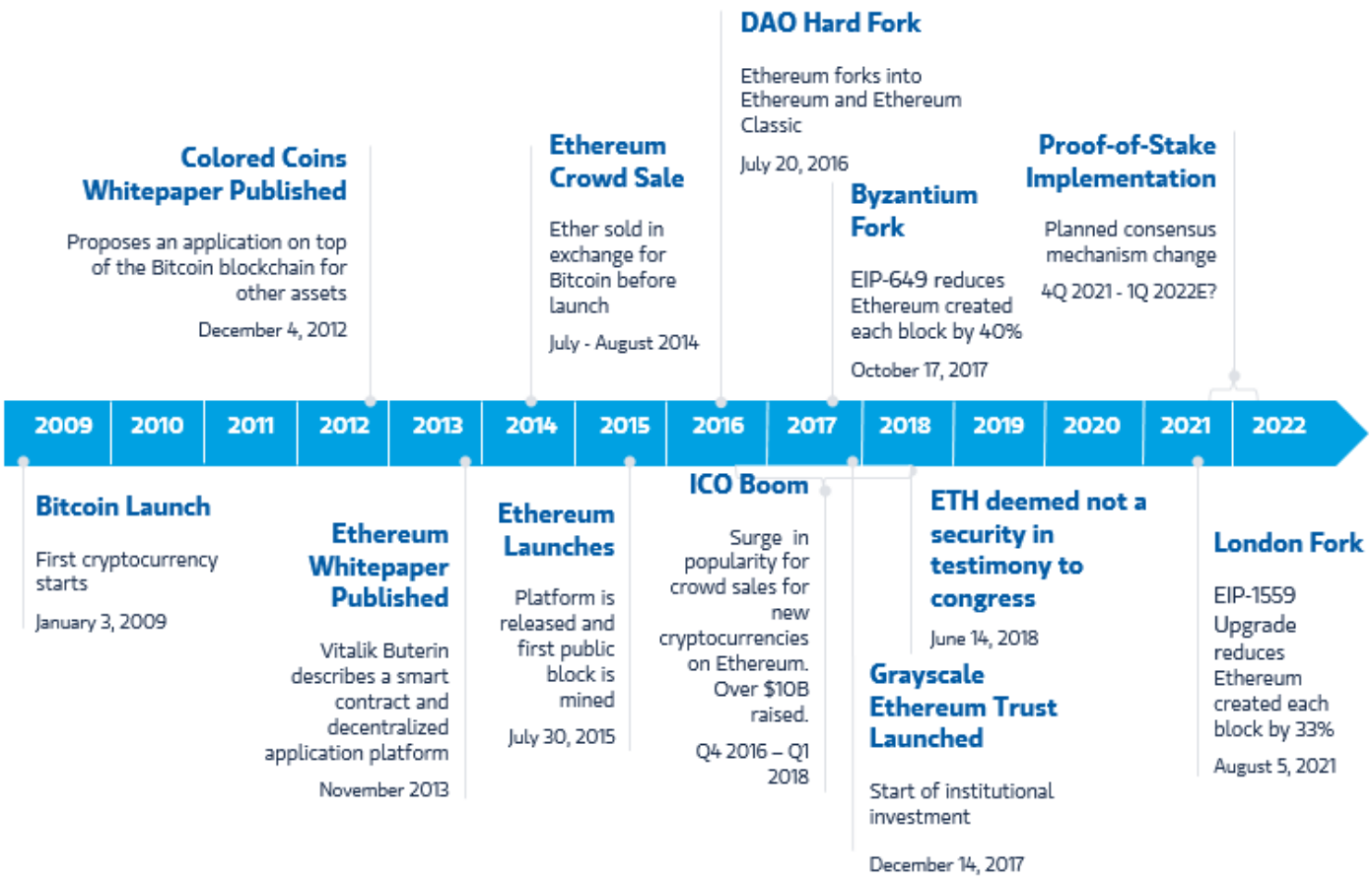
# Appendix: Who Built Ethereum?

Vitalik Buterin, the 27-year-old founder of Ethereum, was an early cryptocurrency enthusiast. He cofounded *Bitcoin Magazine* in 2012. Buterin was interested in extending Bitcoin's capabilities beyond those of being a decentralized, permissionless savings account. Early attempts to extend Bitcoin's capabilities had centered around the idea of "colored coins," described in Meni Rosenfeld's Dec. 4, 2012 Colored Coins white paper.[9] Exhibit 11 shows key events in Ethereum's history.

The Colored Coins white paper introduced the idea of using small amounts of Bitcoin—for example, one 100 millionth of a bitcoin—as a token to represent something else. The paper suggested tokens could potentially represent stocks, commodities, new currencies and other financial instruments. Colored coins allowed assets to be stored digitally in a trustless manner in Bitcoin wallets on the Bitcoin blockchain. While Buterin was intrigued by this idea, ultimately he felt that Bitcoin's programming language, "Script," was too limiting to build complex programs.

The Ethereum whitepaper "A Next-Generation Smart Contract and Decentralized Application Platform" was published in November 2013.[10] It laid out a vision of a decentralized world computer that could run smart contracts, i.e., programs that would run on the network. While simple code could be run on Bitcoin, it was missing key features, such as loops (lines of codes that repeat) and the ability to store variables on the blockhain. This "blockchain blindness" made it hard to program complicated applications using Bitcoin. Buterin and the other founders sought to create an entirely new blockchain named Ethereum that was easier to program.

**Exhibit 11: Ethereum's Journey to Becoming the Second-Largest Cryptocurrency**




Source: Morgan Stanley Wealth Management Global Investment Office as of Dec. 21, 2021

A crowd sale in the summer of 2014 provided the initial funding for the project. After almost a year of development, the network went live on July 30, 2015. In its third year, the network became instrumental in the initial coin offering (ICO) boom of 2016 to 2018. ICOs were a technique for crypto entrepreneurs to raise money for new software applications by using Ethereum. In an ICO, cryptocurrency was sent to a Bitcoin or Ethereum address, and Ethereum tokens were sent back to the contributor. These tokens could be used as currency, for voting rights (governance) or for other purposes.

Amid the ICO boom, which was the first product market fit for Ethereum, an estimated $5 billion was raised for crypto-based startups in 2017.[11] ICOs were a simple way to use Ethereum's capabilities to fund new ventures. After the euphoria faded, Ether crashed by 94%—from $1,405 in January 2018 to $83 in December 2018. It did not surpass the 2018 high until January 2021. Exhibit 12 shows the money raised in ICOs alongside Ether's price.

## Exhibit 12: Ethereum Was Intertwined With the Initial Coin Offerings Bubble


Source: Coindesk.com, ICObench.com, Morgan Stanley Wealth Management Global Investment Office as of Dec. 21, 2021

# Glossary

**Block Reward** Ether given to crypto miners for creating a new block.

**Burning** Sending a cryptocurrency to an address with no password. Burning reduces the supply of cryptocurrency outstanding.

**Client** Software run by nodes on a network. There can be many clients compatible with the protocol.

**Contract Account** An account on the Ethereum blockchain associated with a smart contract. The smart contract code executes when it receives a message from another account.

**Correlation** This is a statistical measure of how two securities move in relation to each other. This measure is often converted into what is known as correlation coefficient, which ranges between -1 and +1. Perfect positive correlation (a correlation coefficient of +1) implies that as one security moves, either up or down, the other security will move in lockstep, in the same direction. Alternatively, perfect negative correlation means that if one security moves in either direction the security that is perfectly negatively correlated will move in the opposite direction. If the correlation is 0, the movements of the securities are said to have no correlation; they are completely random. A correlation greater than 0.8 is generally described as strong, whereas a correlation less than 0.5 is generally described as weak.

**Decentralized Autonomous Organization (DAO)** An organization without a hierarchical management, meant to function in a decentralized manner.

**Dapp** A decentralized application built on a peer-to-peer network like Ethereum.

**Decentralized Exchange (DEX)** A decentralized application that lets users swap tokens.

**Decentralized Finance (DeFi)** Decentralized financial products and services provided through decentralized applications that are composed of smart contracts on the blockchain

**Ethereum Improvement Proposal (EIP)** A design change in Ethereum features or processes.

**Externally Owned Account (EOA)** A cryptocurrency address for users on Ethereum. EOAs contain balances of different tokens associated with the address.

**Ethash** The proof-of-work algorithm for Ethereum that governs the process by which Ether is mined.

**Ether (ETH)** Native cryptocurrency on the Ethereum network.

**Ethereum Virtual Machine (EVM)** A runtime environment for code and smart contracts.

**Fork** A point at which one blockchain splits into two. This can happen if two groups of miners are unable to communicate or if a software change on some computers is not compatible with software running on other computers.

**Gas** Fees in Ether for miners to process transactions.

**Gwei** A denomination of Ether used to price gas. One ether equals 1,000,000,000 gwei.

**Hash** A coded identifier produced by a hash function.

**Internal Transaction** A transaction from a contract account to another contract account or externally owned account.

**Message** An internal transaction on Ethereum that's only sent within the Ethereum Virtual Machine.

**Non-Fungible Token (NFT)** A type of token that enables each token to be unique and not directly interchangeable. NFTs can represent ownership of digital or physical assets like art and collectibles.

**Node** A computer running a software client that joins it to the Ethereum network.

**Private Key** A secret string of numbers and letters that enables access and proves ownership of an account.

**Proof-of-Stake (PoS)** A consensus mechanism that requires nodes to prove ownership of a certain amount of Ether to participate in transaction validation on the network.

**Proof-of-Work (PoW)** A consensus mechanism that requires miners to spend energy (work) by finding a solution to an algorithmic puzzle before they can update the blockchain (on Ethereum, the Ethash algorithm).

**Public Key** A string of numbers and letters connected to a private key that can be used to verify a user's digital signature. Cryptocurrency addresses are derived from public keys.

**Smart Contract** A self-executing program that operates in a predictable way based on inputs.

**Solidity** The main programming language on Ethereum.

**Stablecoin** A cryptocurrency coin linked to another asset's value, such as the US dollar or gold.

**Staking** The process of depositing Ether to become a validator on the network.

**Validator** A node that checks transactions and creates new blocks under the proof-of-stake consensus mechanism and is the alternative to a miner on the proof-of-work consensus mechanism.

**Volatility** This is a statistical measure of the dispersion of returns for a given security or market index. Volatility can either be measured by using the standard deviation or variance between returns from that same security or market index. Commonly, the higher the volatility, the riskier the security.

**Wallet** Computer software that holds private keys and that's used to access and control Ethereum accounts.

# Endnotes

[1]https://www.christies.com/features/Monumental-collage-by-Beeple-is-first-purely-digital-artwork-NFT-to-come-to-auction-11510-7.aspx

[2]https://www.frontiersin.org/articles/10.3389/fphy.2021.631665/full

[3]https://www.fool.com/the-ascent/cryptocurrency/articles/what-is-axie-infinity-axs-and-should-you-buy-it/

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[5]https://www.nba.com/news/dapper-labs-creators-of-nba-top-shot-get-305m-in-funding

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[8]https://www.nasdaq.com/articles/how-ethereum-layer-2s-are-leveling-up-defi-2021-06-08

[9]http://www.ma.senac.br/wp-content/uploads/2018/05/ColoredCoinswhitepaper-DigitalAssets.pdf

[10]https://ethereum.org/en/whitepaper/

[11]https://news.crunchbase.com/news/2017s-ico-market-grew-nearly-100x-q1-q4/

# Disclosure Section

Disclosure Section

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