

CPSC 3640/5400: Decentralized Payments, Contracts, and Finance for Humans and AI

Lecture 9a: Tokenization & Real-World Assets

Fan Zhang
Yale University
2026 Fall

Section II: DeFi as the new fintech frontier

- Organized into a few categories
- **DeFi Primitives:** What they are, how they are implemented
 - Apps: [Tokens](#), [Tokenization](#), Decentralized Exchanges, Oracles, (re-)staking
 - Infra for fast transactions
- **DeFi advantages:** things not possible in TradFi
 -  [Privacy \[today\]](#), Interoperability, censorship resistance,
- **DeFi risks:** new problems unique to DeFi & mitigation
 - order manipulation, human factors, bugs

What's new in Tokenized stocks & bonds

on Ethereum



Yale CPSC 3640/5400

Based on a presentation by Urbe Hub

<https://claude.ai/artifact/NjopwuEy4cLHs4AEKx3EkW>

What tokenization is, and what is going on now

What it is

A token on a blockchain that stands for a traditional asset: a stock share, a bond, a Treasury fund.

1 · Asset on-chain, or in custody

2 · Token on a shared ledger

3 · Trade and **pledge** 24/7 on-chain

Same asset, new rails: what changes is how it is recorded and moved.

Benefits: faster settlement · 24/7 trading · one shared record · instant collateral

Why so much activity now

The market grew fast

\$6.6B → \$38.6B of real-world assets on public chains, Mar 2025
→ Sep 2026

The rules arrived

SEC Innovation Exemption (17 Sep 2026) · US stablecoin law (GENIUS Act) in force by Jan 2027

Central banks joined

ECB Pontes settles tokenized trades in central bank money, live since 21 Sep 2026

The big names launched

Robinhood Chain (Jul 2026) · Coinbase stocks on Base (Aug 2026) · BlackRock BUIDL (since 2024) · Goldman's ~\$100B Treasury fund on Avalanche's private Lynq chain (Sep 2026)

3 common ways to tokenize

The token is the asset

the shares themselves are tokens

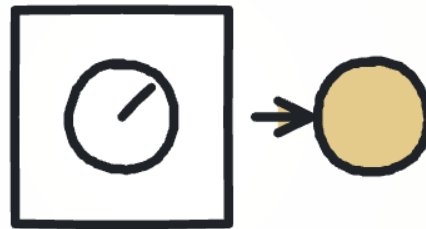


e.g. BlackRock BUIDL fund

you own: the fund share

Token = claims on the asset

a firm holds the real share for you



custodian

e.g. Coinbase stocks on Base

you own: a claim on the share

Token tracks the price only

an IOU that follows the share price



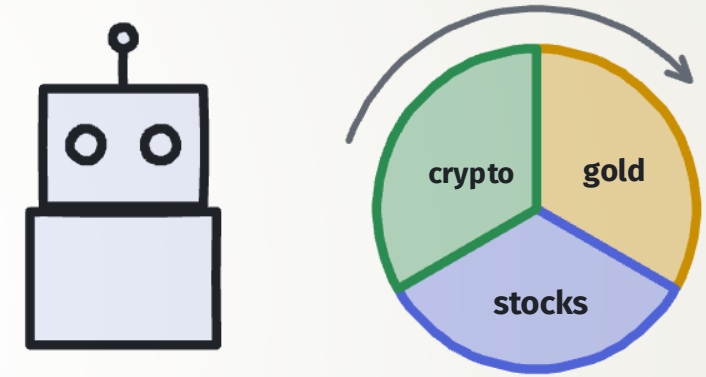
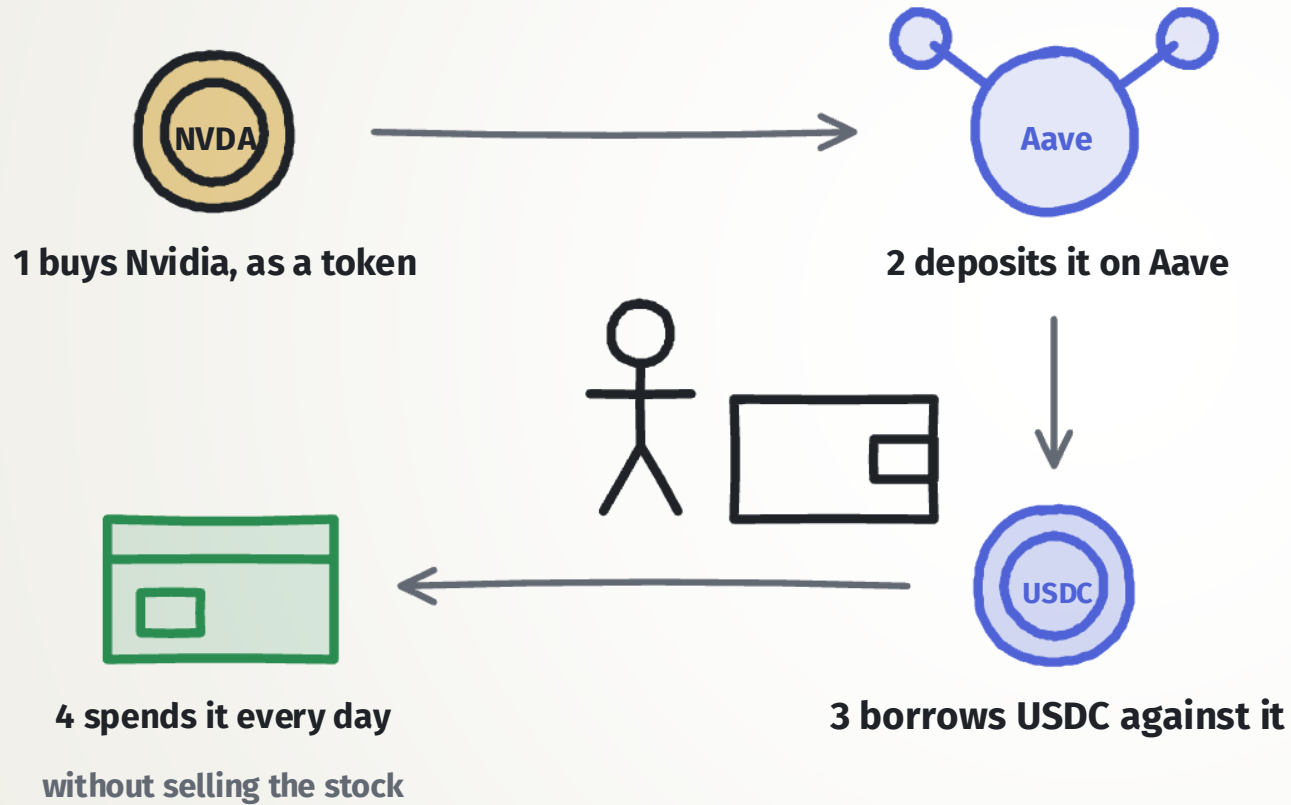
e.g. Robinhood stock tokens

backed by real shares, but no vote

you own: a claim on Robinhood

It's 2030

one user, one wallet, one standard · an illustrative scenario



Live today, in pieces: NVDA tokens · Aave v4 Equities Hub · cards that spend USDC

gold as ERC-20 (XAUT ≈ \$2.9B, PAXG ≈ \$1.8B) · AI agents trading stocks (beta) · mostly non-US

Robinhood vs Coinbase: two designs

	Robinhood Stock Tokens	Coinbase stocks on Base
issuer	Robinhood Assets (Jersey) Ltd	Coinbase Onchain SPV Ltd (Abu Dhabi)
what you hold	a debt security, no rights in the share	a bare-trust claim on the share
backing	1:1, shares held at Alpaca	1:1, shares held at Alpaca
voting	none	no direct vote
splits & dividends	ERC-8056 multiplier	B20 multiplier, dividends become shares
chain	Robinhood Chain (Arbitrum Orbit)	Base (OP Stack, L2BEAT Stage 1)
tokens live	195 (28 Sep 2026)	10 in Base docs (4 at launch)
who can buy	non-US; not UK, Canada, Switzerland	eligible non-US users
in DeFi	Uniswap, Morpho, 1inch	Aave v4 Equities Hub, Aerodrome
approved by	Liechtenstein FMA prospectus	ADGM FSRA prospectus

Key difference, in plain words: Robinhood owes you the stock's value (an IOU). Coinbase holds the real share in trust for you.

Old problems, new rails

	in TradFi today	on-chain	live example
settlement	T+1: cash waits a day (NSCC fund - \$3.7B after T+1)	bond and cash move together	BUIDL on Ethereum (2024) ECB Pontes (Sep 2026)
hours	US market 9:30-16:00 ET	open 24/7	Coinbase stocks on Base, weekends too
records	3 layers of books to match up: DTC, your broker, then you	one shared record	Broadridge DLR: \$8T repo in Jul 2026 · BENJI
collateral	fund shares must be redeemed first	tokens move in seconds	BUIDL accepted as collateral on Binance, Deribit
access	set by your broker, your country, fund minimums	same legal limits, checked by the token itself	Dinari: US stocks for US investors Robinhood tokens: non-US only
dividends, splits	46% of event data handled by hand	programmed payouts	BUIDL pays in new tokens ERC-8056 multiplier

Why tokenize? TradFi tells you

“

Every stock, every bond,
every fund—every asset—
can be tokenized.

Larry Fink

Chairman & CEO, BlackRock · 2025

“

We believe tokenization will
significantly change how markets
work and operate, bringing new
levels of liquidity, transparency
and efficiency to investors.

Frank La Salla

President & CEO, DTCC · 2026

“

Tokenization has the potential
to unlock the benefits of an
always-on financial ecosystem –
enhancing how investors access
markets, how issuers engage
with shareholders.

Tal Cohen

President, Nasdaq · 2026

“

Tokenisation will only matter if it makes
finance fundamentally better. A digital wrapper
around yesterday's infrastructure is not enough.

Theo Golden

Head of Digital Assets, Baillie Gifford · 2026

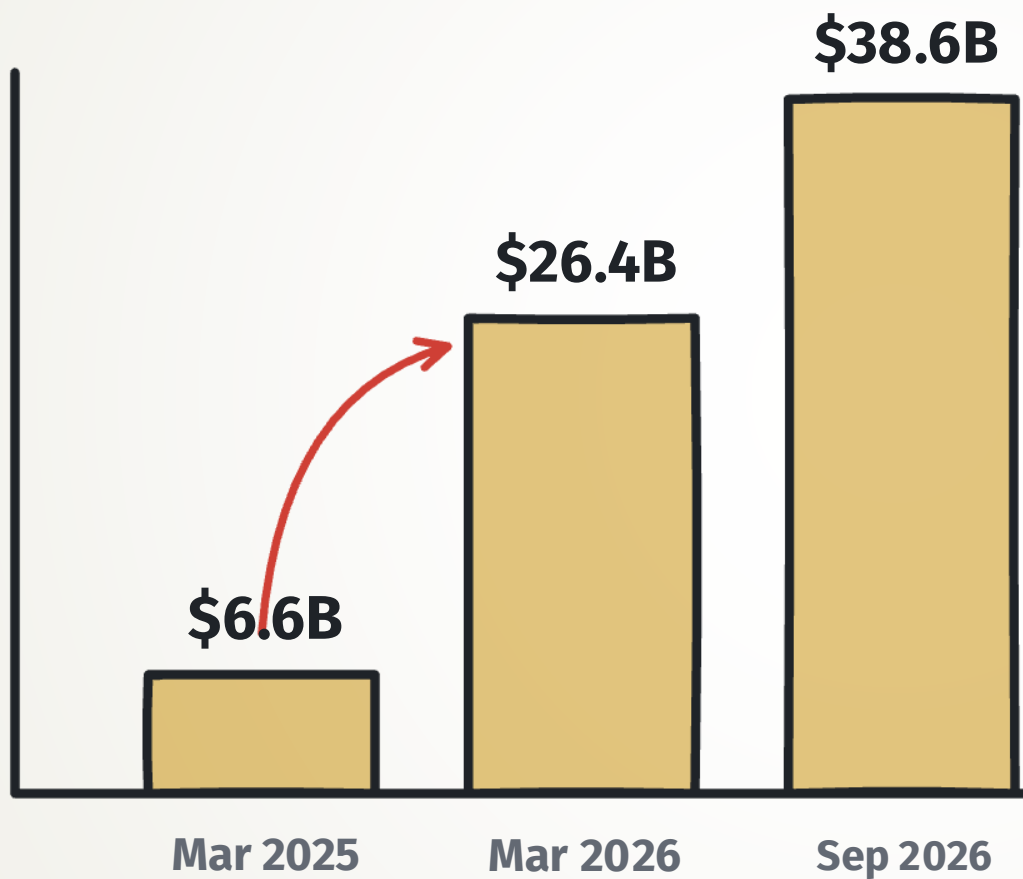
“

JPM Coin delivers the security of bank-issued
deposits and settlement, combined with the speed
and innovation of 24/7, near real-time
blockchain transactions.

Naveen Mallela

Global Co-Head, Kinexys by J.P. Morgan · 2026

The market today



\$38.6B

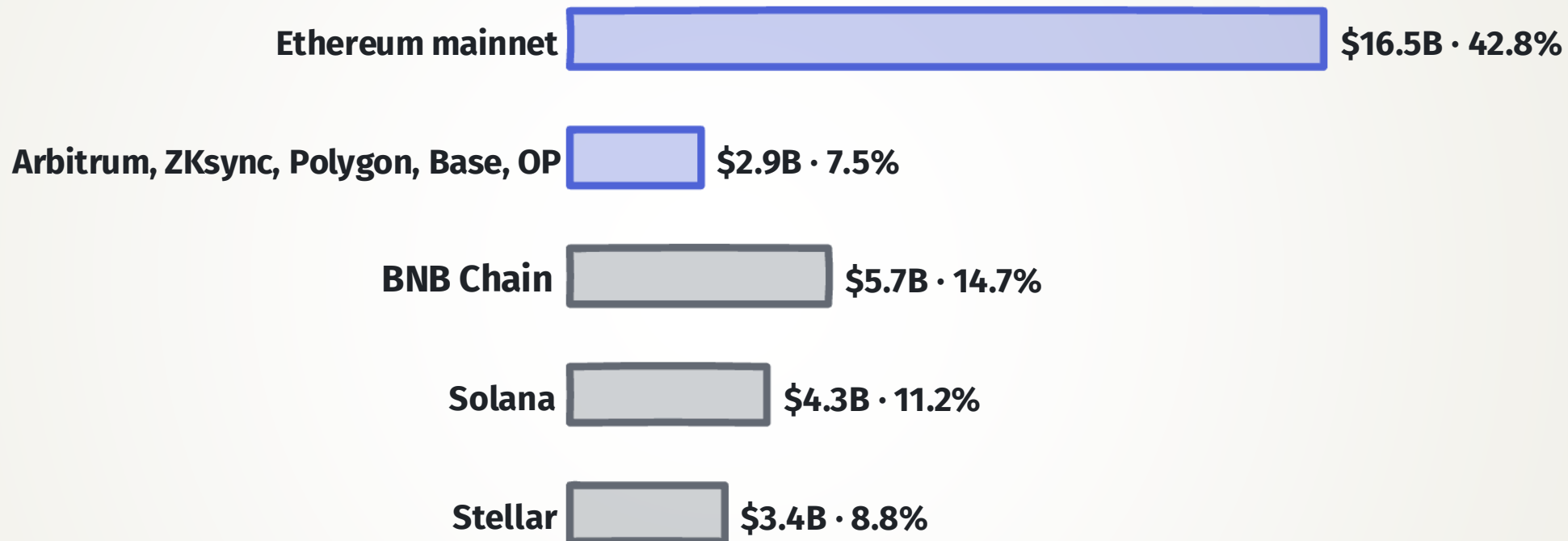
of real-world assets on public chains

stablecoins excluded

≈ 4x from Mar 2025 to Mar 2026

rwa.xyz, 28 Sep 2026 · same method throughout

Where it lives: Ethereum first



Ethereum + its L2s $\approx$ 50% of \$38.6B

Mostly cash: tokenized Treasuries

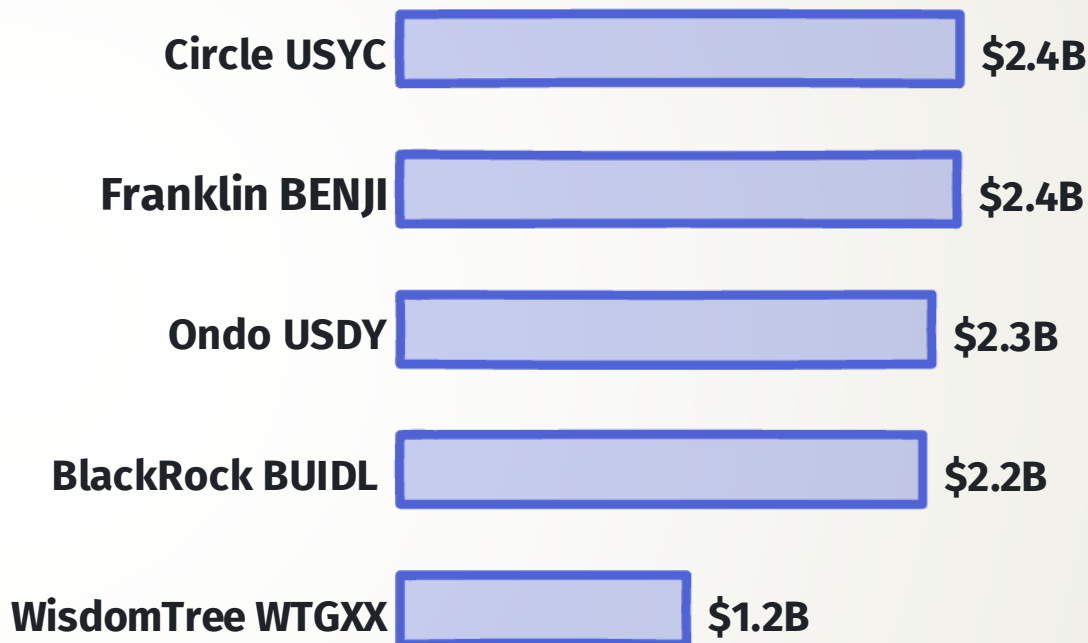
\$14.7B

**in tokenized Treasury
and money-market funds**

Treasuries = loans to the US government;
money-market funds hold safe, short-term debt

≈ 38% of all tokenized assets

≈ 40% of the \$14.7B is on Ethereum

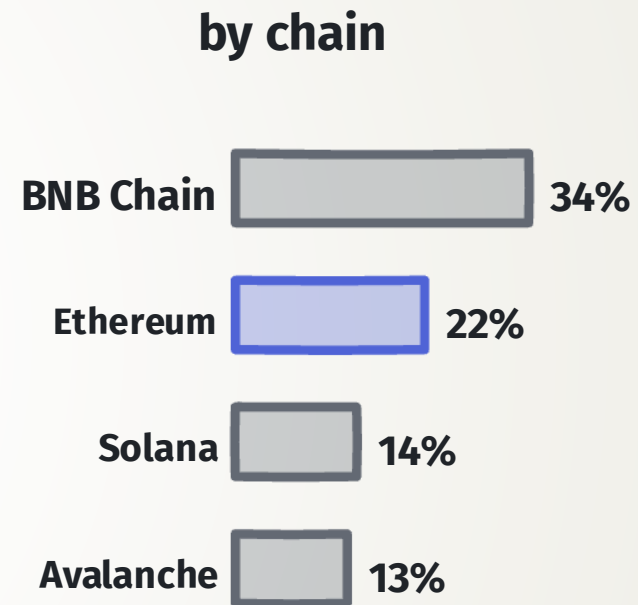
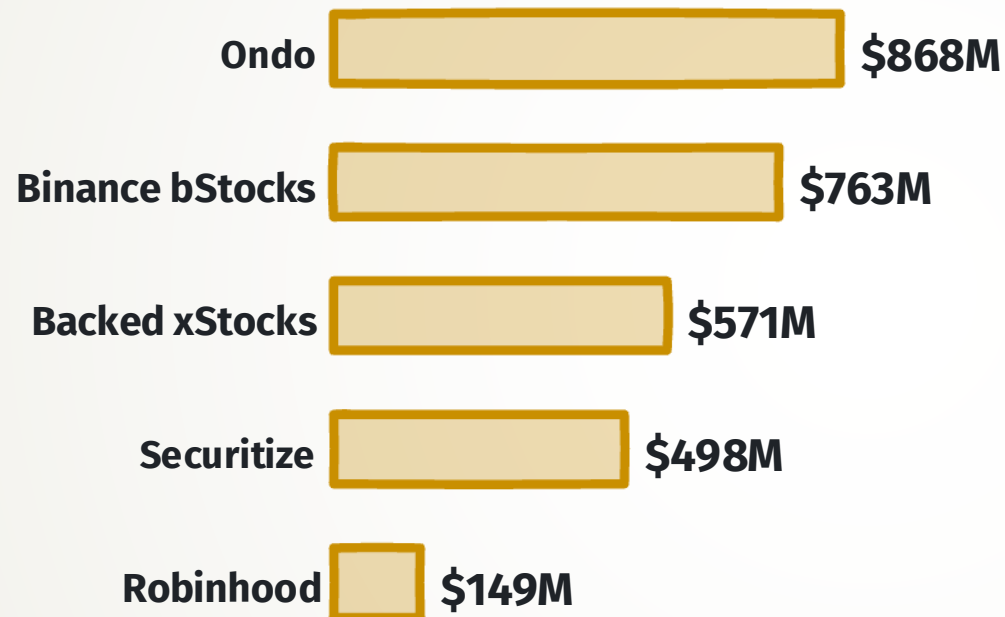


Beyond cash: Baillie Gifford \$BAGEY (Jun 2026), a UK-regulated bond fund
issued natively on Ethereum and Solana, with BNY · target yield ≈ 7%

3 · Data: now and estimated

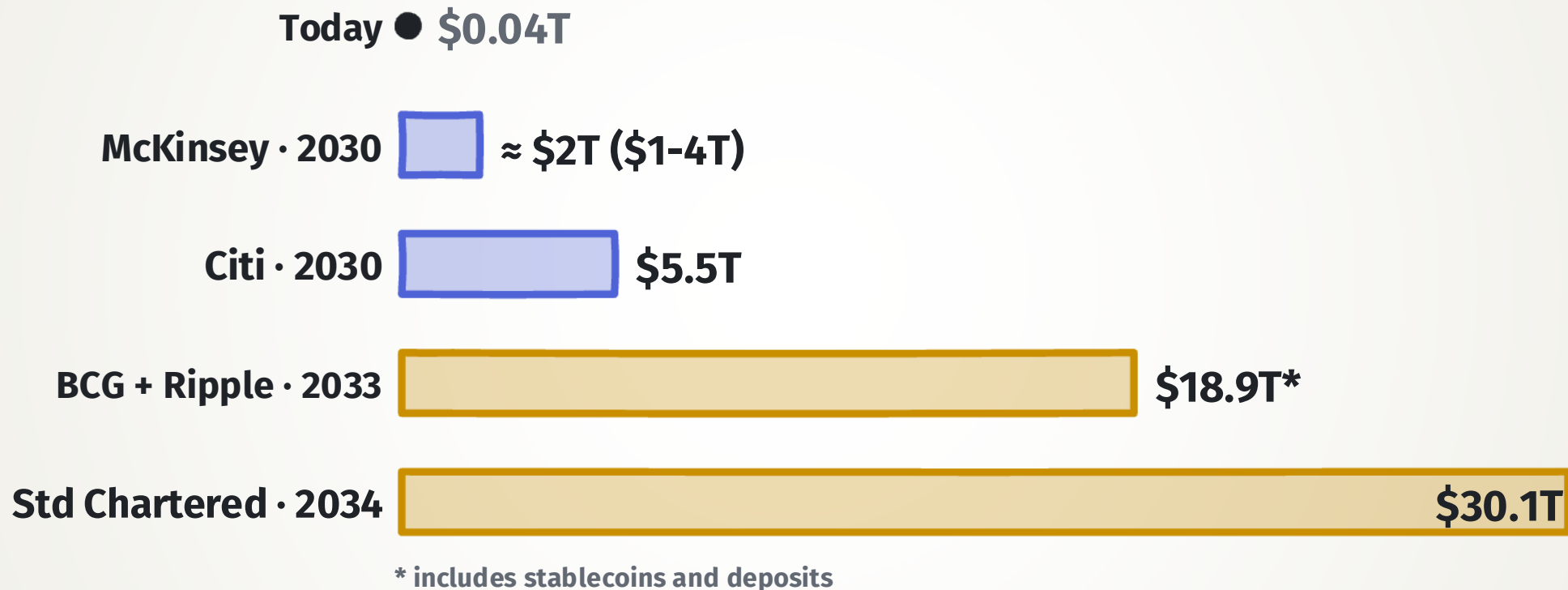
Tokenized stocks: still small

≈ \$3.15B in total (rwa.xyz, 28 Sep 2026)



issuer order and chain shares differ between sources

How big could it get?



Standard Chartered: \$2T by 2028, "the vast majority on Ethereum"

Securitize

the platform behind BlackRock BUIDL · NYSE: SECZ



licences

broker-dealer, ATS, transfer agent, RIA · EU DLT Pilot

flagship

BlackRock BUIDL \$2.24B · Apollo ACRED \$95M

VanEck VBILL \$56M · its own SECZ stock \$413M

chains and standard

10 chains · DS Protocol, a permissioned ERC-20

who can buy

mostly qualified or accredited investors, \$10K-\$5M minimums

backers

BlackRock led its \$47M round (2024) · SPAC at \$1.25B

2026: listed on NYSE as SECZ, tokenized its own stock (2 Jul)

Ondo Finance

the largest issuer of tokenized stocks

model

backed trackers:
price exposure, no share rights



\$3.88B

tokenized assets
rwa.xyz, 28 Sep 2026

licences

broker-dealer, ATS, transfer agent (Oasis Pro) · EU prospectus

flagship

Ondo Stocks \$868M, 408 stocks (#1)

USDY \$2.28B · OUSG \$393M

chains and standard

Ethereum, BNB Chain, Solana · ERC-20 · Ondo Network

who can buy

stocks and USDY non-US · OUSG for qualified purchasers

backers

Founders Fund, Pantera (2022) · BlackRock models (2026)

2026: FINRA opens a US route for its tokenized stocks (23 Jul)

Superstate

real public-company shares, recorded on-chain



licences

SEC-registered transfer agent · investment adviser

flagship

Opening Bell: Galaxy (GLXY), Forward (FWDI)

rails for Invesco USTB and Bitwise USCC

chains and standard

Ethereum, Solana, Plume · ERC-20

who can buy

KYC'd wallets · funds for accredited investors

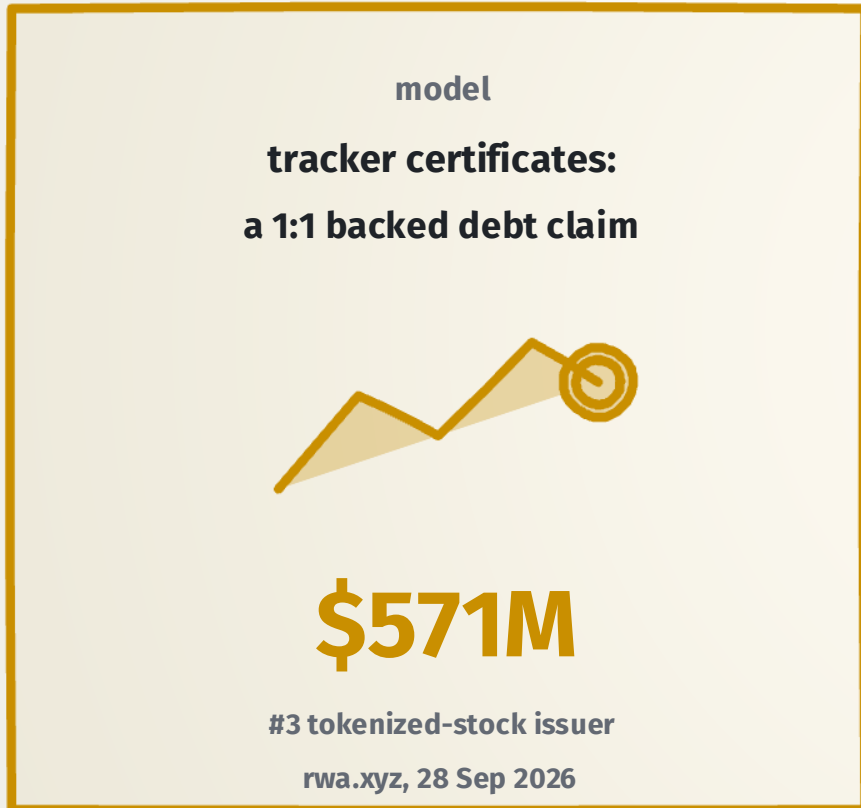
backers

Bain Capital Crypto, Distributed Global · \$82.5M (Jan 2026)

2026: launch partner of Uniswap v4 permissioned pools (23 Jul)

Backed xStocks

Kraken's tokenized stocks, issued under Swiss law



licences

Jersey issuer · EU prospectus (Liechtenstein) · Swiss DLT Act

flagship

500+ xStocks · \$35B+ traded since Jun 2025

yield vaults ≈ 2% · tokenized IPO access

chains and standard

Solana (\$405M), Ethereum (\$160M) + more · ERC-20 / SPL

who can buy

non-US only; Kraken also excludes UK, Canada, Australia

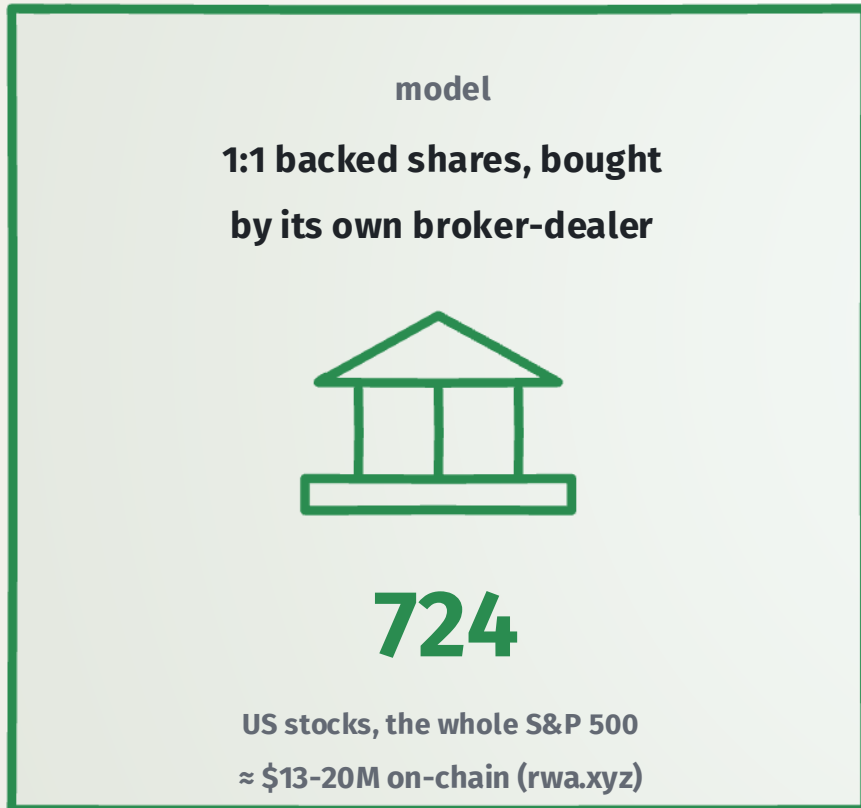
backers

owned by Kraken (Payward) since Jan 2026

2026: tokenized IPO access, starting with SpaceX (Jun)

Dinari

the US broker-dealer for tokenized stocks



licences

broker-dealer (FINRA/SIPC, Jun 2025) · transfer agent

flagship

dShares, bought in USDC from your own wallet

chains and standard

Arbitrum (most value), Ethereum, Base, Avalanche · ERC-20

who can buy

eligible US investors + 85 non-US jurisdictions

backers

Hack VC, Blockchange, VanEck Ventures · \$22.65M raised

2026: opens tokenized US stocks to US investors (4 Aug)

Five builders, side by side

	Securitize	Ondo	Superstate	xStocks	Dinari
you hold	the security itself	price exposure, no share rights	the share itself	a debt tracker certificate	a token backed 1:1 by shares
licences	broker-dealer, ATS, TA, RIA, EU pilot	broker-dealer, ATS, TA, EU prospectus	transfer agent, adviser	Jersey issuer, EU prospectus	broker-dealer, transfer agent
size	\$4.7B	\$3.9B	\$675M	\$571M	≈ \$13-20M
flagship	BUIDL, ACRED, VBILL, SECZ	Ondo Stocks, USDY, OUSG	Opening Bell, Invesco USTB rails	500+ xStocks, vaults, IPOs	724 US stocks (dShares)
main chains	10 chains	Ethereum, BNB, Solana	Ethereum, Solana, Plume	Solana, Ethereum + 8 more	Arbitrum, Ethereum, Base, Avalanche
who can buy	qualified or accredited	non-US; US route via FINRA (Jul)	KYC'd wallets	non-US only	US investors + 85 countries
2026 moment	NYSE listing 2 Jul	FINRA US route 23 Jul	Uniswap v4 pools 23 Jul	IPO access Jun	US launch 4 Aug

sizes: rwa.xyz, 28 Sep 2026 · TA = transfer agent · RIA = registered investment adviser

The SEC Innovation Exemption

An SEC order of 17 Sep 2026, valid for five years (to 2031)

What the SEC now allows



New trading venues can offer tokenized US stocks



They can use automated pools (AMMs) without registering as an exchange



People who put money into the pools are not treated as dealers

What this means for DeFi apps



Uniswap-style pools qualify if access is controlled



The code can run on public blockchains like Ethereum



Stocks can trade for stablecoins, ETH or money funds



Lending isn't covered: Aave and Morpho can't use it



Fully decentralized code needs no exemption at all

(SEC Commissioner Hester Peirce)

The rules



same rights as the real share: dividends, votes



no synthetic or linked tokens



issuers get 30 days and can block third-party tokens



volume caps · halts with the exchange · no credit

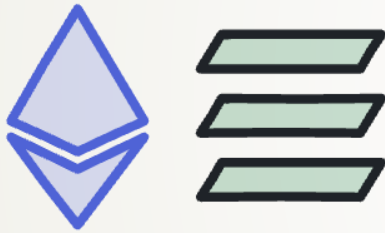


retail can join through verified access

Tier 1: 75 symbols, 0.25% of volume · Tier 2: 250 symbols, 2.5% · trades public within 10 min

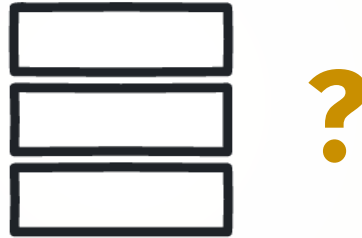
Which chains qualify?

public ledger: anyone can read & write, no permission



Ethereum · Solana

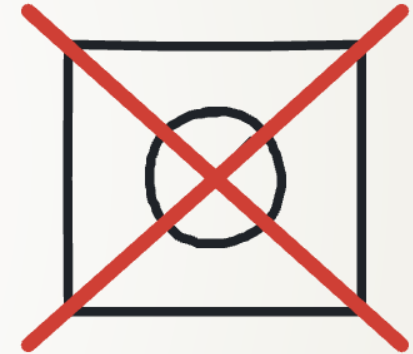
clearly fit



Layer 2s · Tempo

not named: ask SEC staff

Tempo: open to deploy, chosen validators



private bank ledgers

out

What happens next



first venue notices expected in Q4 2026



no venue has filed yet (28 Sep)



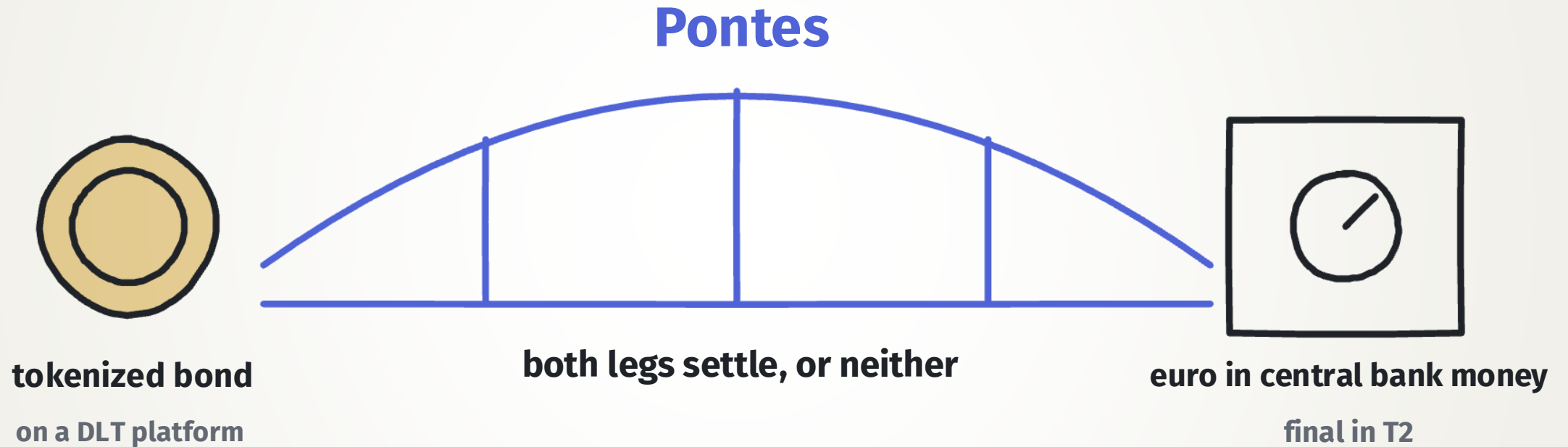
SIFMA: fragmentation risk, wants formal rules



Uniswap will file a comment letter

Federal Register 22 Sep 2026 · comment file 4-927 · no deadline set

ECB Pontes: a notary for tokenized trades



live since 21 Sep 2026

Inside Pontes

run by the Banque de France, Banca d'Italia, Bundesbank and Banco de España



1 seller locks the bond, tied to a secret

2 buyer pays in cash tokens or directly in T2

3 paid: secret released, bond to the buyer · not paid in 30 min: bond back to the seller

fees: €2,500 per bank, €15,000 per DLT operator, one-off · pilot hours 09:00-16:00, indicative

Appia, and Pontes vs Appia

Appia

the blueprint for a tokenized Europe, due 2028

- asset standards and interoperability
- monetary policy and collateral
- central bank money on DLT
- cross-border links (BIS Agorá)
- a safe, resilient ecosystem
- impact on existing infrastructure

open question: one shared ledger,
or many linked networks?

	Pontes	Appia
purpose	a bridge to central bank money	the design of the future system
status	live since 21 Sep 2026	analysis, experiments
horizon	2026 → 2028	blueprint in 2028
scope	euro settlement, all T2 currencies 2028	collateral, standards, cross-border
technology	Fabric ledger + Hash-Link	open: one ledger or many
output	a live service	a blueprint

Pontes: pros and cons

pros

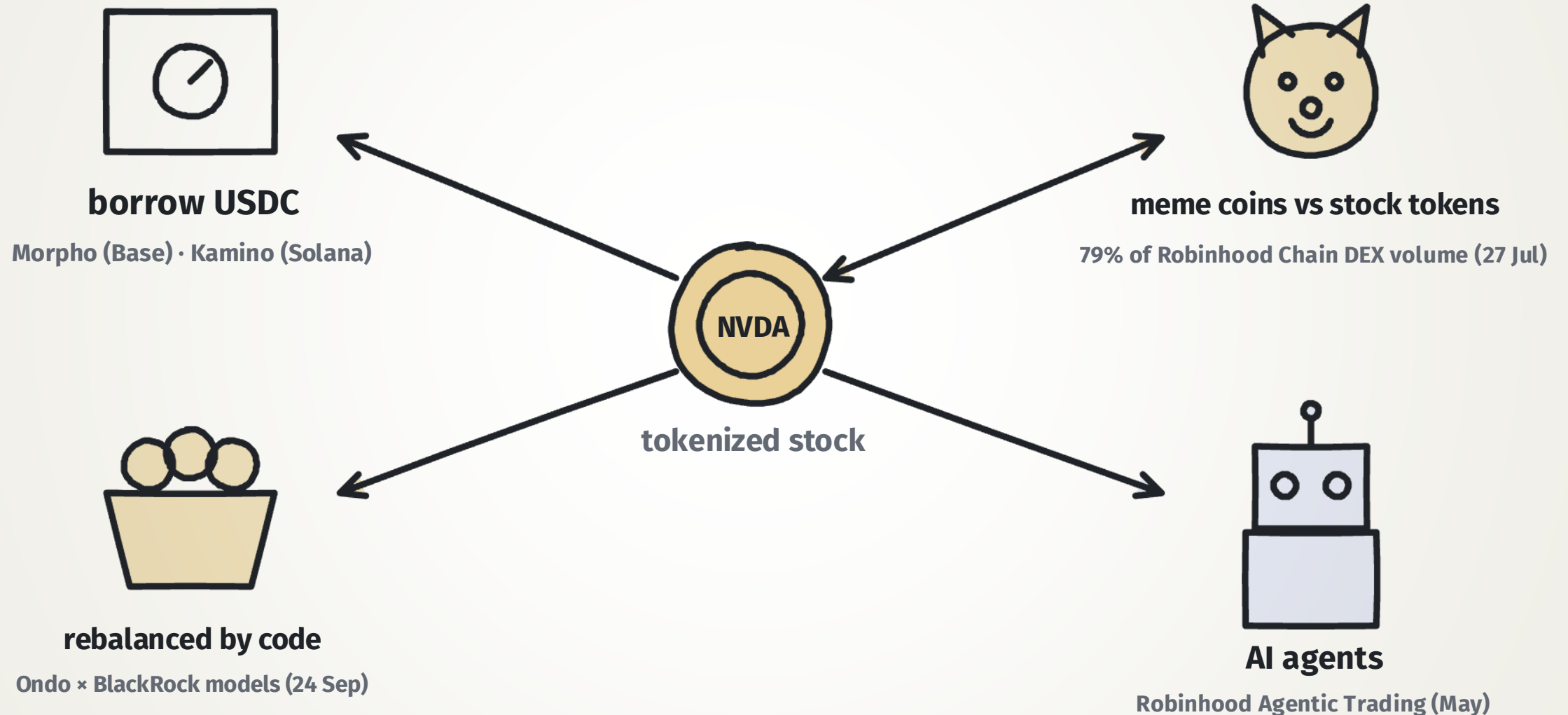
- ✓ the money cannot fail
- ✓ both legs, or neither
- ✓ uses existing ECB accounts
- ✓ works with many platforms

cons

- ✗ weekday hours today, 24/7 aim 2028
- ✗ regulated institutions only
- ✗ euro only, for now
- ✗ cash finality still in T2

The safest road in Europe, with a toll gate for banks only.

A stock becomes a building block



What DeFi brings to TradFi

interoperability



TradFi today

moving stocks between brokers
takes up to 4 business days

on-chain

one token, many apps
NVDAC: Aerodrome, Morpho, Aave

and BUIDL as collateral on 3 exchanges

transparency



TradFi today

Archegos hid \$160B in swaps
Credit Suisse lost \$5.5B

on-chain

supply and trades are public
SEC: trades out in 10 minutes

still: RH token supply misread by 56%

decentralization



TradFi today

GameStop 2021: \$6.9B clearing call,
brokers restricted buying

on-chain

Ethereum: blocks since 2015
Uniswap core can't be changed

still: Base stopped 33 min (2025)

Stocks in DeFi vs at a broker

	at a broker	as a token in DeFi
hours	9:30-16:00 ET, 23/5 from Dec 2026	24/7, halts follow the exchange
settlement	T+1	near-instant
custody	street name: Cede & Co., then your broker	your own wallet, your keys
smallest unit	fractional shares from \$1-5	divisible to 18 decimals
borrowing	Reg T 50% initial, 25% maintenance	Morpho liquidates at 62.5% · Aave 65-79%
leverage	options and futures	stock perps up to 10-20x (trade.xyz)
votes & dividends	full	Robinhood none · Coinbase no direct vote
protection	SIPC up to \$500k	no SIPC in self-custody
who can buy	your country's brokers	mostly non-US; Dinari for US
prices	exchange quotes	oracles (Chainlink 24 /5)
fees	\$0 online commission	gas + pool fee 0.01-1% + spread

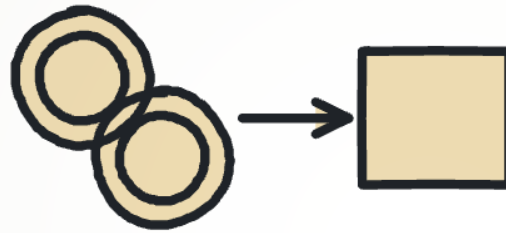
Earn, margin, and a lot of perps



≈ 2% a year

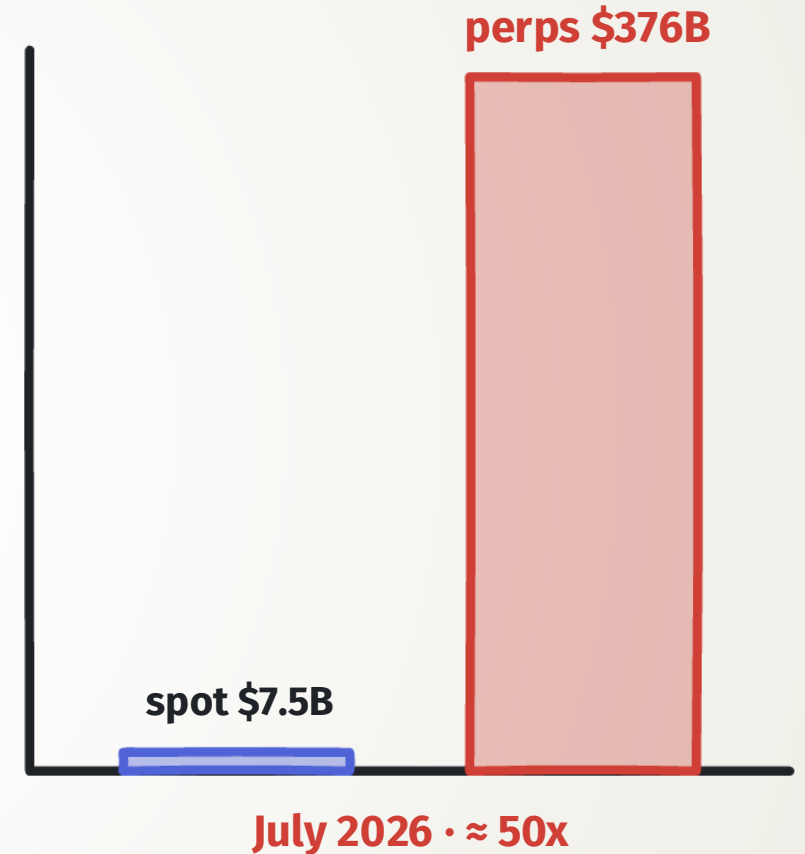
paid in the stock

Kraken xStocks vaults



stocks as margin

6 xStocks on Bybit



Most of the activity is speculation, not ownership.

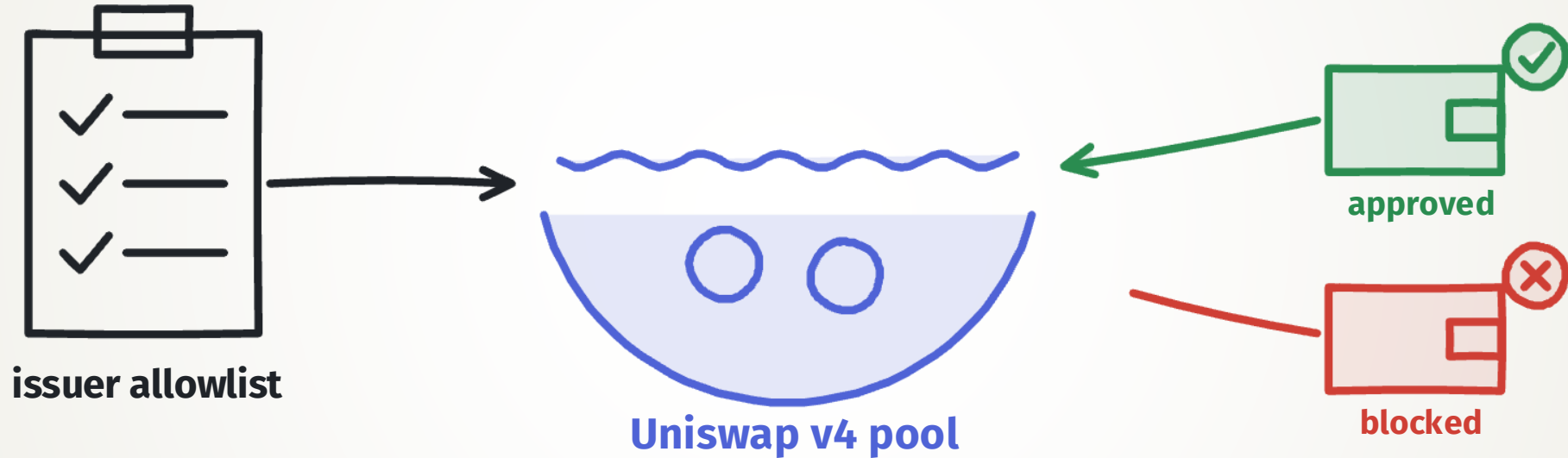
The token standards, side by side

	ERC-20	ERC-3643	ERC-7943	ERC-8056	ERC-4626/7540
status	Final · 2015	Final · 2021	Final · 2026	Draft · 2025	Final · 2021/23
what it does	basic token	permissioned security token	minimal compliance hooks	splits & dividends multiplier	fund vaults async redemptions
identity / KYC	—	on-chain ID (ONCHAINID)	app asks canSend / canReceive	—	—
transfer rules	none	enforced in the token	canTransfer check	—	—
freeze / force	no	yes	yes	no	no
used by	BUIDL (permissioned ERC-20)	Dowgo · DTCC in the association	CMTAT	Robinhood Stock Tokens	Centrifuge

Base B20 is a native standard with freeze, seize and a multiplier, not an ERC

Uniswap v4: permissioned pools

live since 23 Jul 2026 · Superstate · Securitize · Dowgo

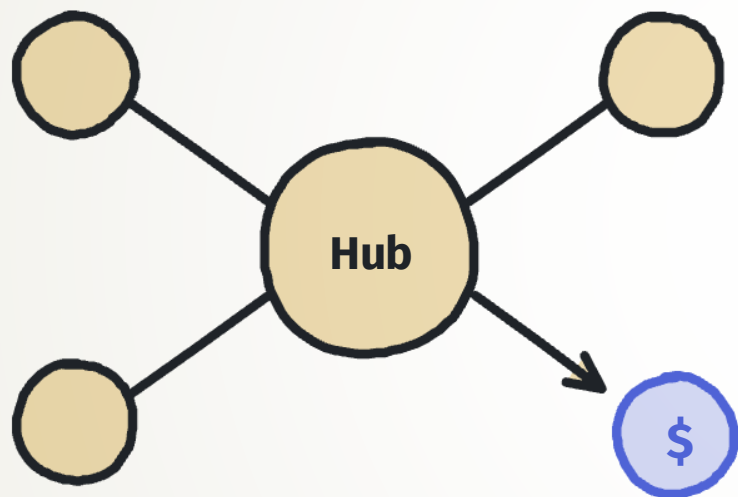


UNI $\approx$ +20-30% after the SEC order

a regulated US operator must run the venue

Aave v4: the Equities Hub on Base

live since 25 Sep 2026 · non-US users only



7 Coinbase stocks → USDC loans

caps: \$32M supply · \$21M borrow

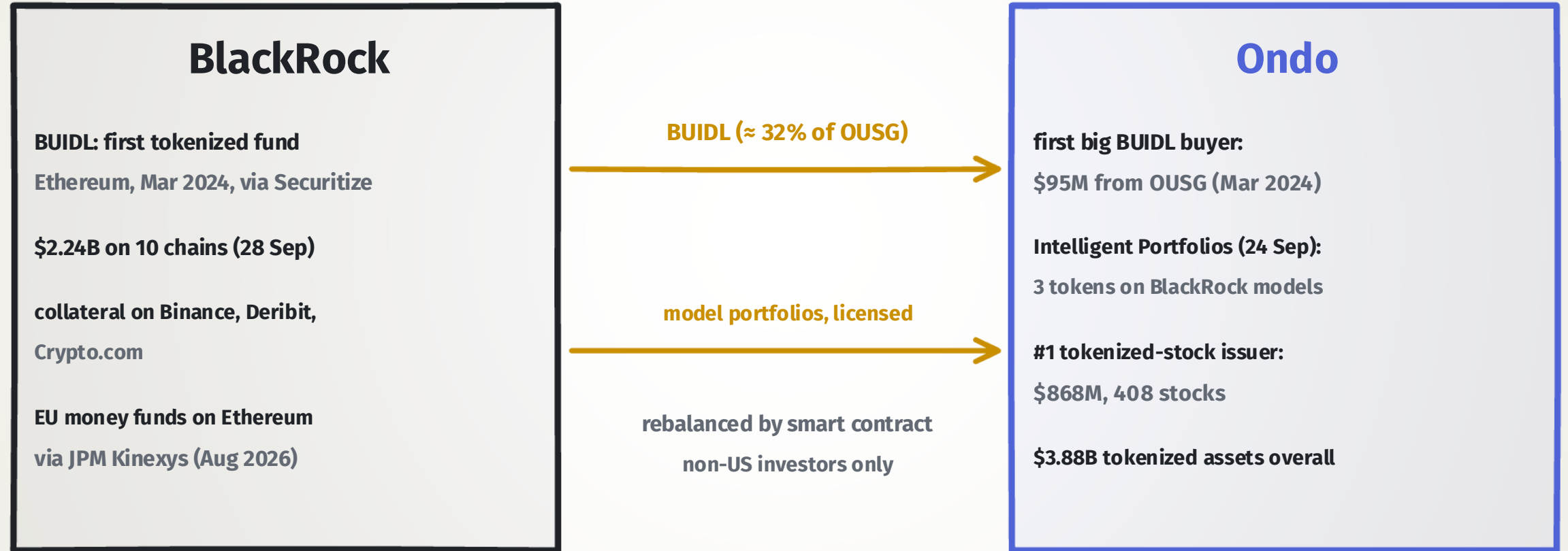
collateral factors 65-79%

Apple · Amazon · Alphabet · Meta
Microsoft · Nvidia · Tesla

 **lending is outside
the SEC exemption**

BlackRock × Ondo

BlackRock makes the product, Ondo takes it on-chain



"Every stock, every bond, every fund—every asset—can be tokenized." Larry Fink, 2025

What Ethereum still lacks

the gap

- **privacy: positions are public**
- **finality: $\approx$ 13-15 minutes**
- **throughput: gas limit 60M**
- **fragmentation: stocks split across L2s**
- **L2 control: one sequencer on Base**

what's coming

EF privacy work · EthSystems spin-out

seconds targeted $\approx$ 2029 (research)

Glamsterdam targets Dec 2026

intent-based interop (ERC-7683)

L2BEAT: Stage 1

Where others are ahead

Canton

privacy by design
DTCC tokenizing Treasuries

BNB Chain

largest share of
tokenized stocks (34%)

Solana

95% of stock-token volume
in one June week



Ethereum's edge: the most RWA value, the deepest standards and DeFi

Next steps

legal



SEC crypto rules: comments by 20 Oct

first exemption venues: Q4 2026

GENIUS Act in force by 18 Jan 2027

EU DLT Pilot upgrade: in talks

adoption



DTCC tokenization: Oct 2026

Nasdaq × Kraken tokens: Q2 2027

UK tokenized gilt: by Q1 2027

Pontes on T2 hours: 2027

tech



Glamsterdam: Dec 2026 target

ERC-8056: still a Draft

Pontes 24/7 + Appia: 2028

finality in seconds: ≈ 2029

On one line



Same assets.

New rails.



Questions?

Sources

rwa.xyz dashboards, 28 Sep 2026 (market, chains, funds, stocks)

CoinDesk, 8 Mar 2026 (growth) · Token Terminal (cross-check)

Citi GPS "Tokenization 2030" (Jun 2026) · McKinsey (Jun 2024)

BCG + Ripple (Apr 2025) · Standard Chartered + Synpulse (2024)

DTCC · Broadridge · FINRA · SIPC · BlackRock 2025 letter

CoinGecko Tokenized Equities Report (Sep 2026)

SEC order 34-106402 and press release 2026-90 (17 Sep 2026)

S&C, Sidley, Skadden, Cooley memos · SIFMA statement

ECB Pontes docs, Appia page, press releases (Sep 2026)

EIPs 20, 3643, 4626, 7540, 7943, 8056 · Base B20 docs

issuer and protocol docs, SEC filings, announcements

Ethereum Foundation blog · ethereum.org · L2BEAT

Each slide's speaker notes list its sources and links.