Flash Memory Summit

DNA Data Storage at Scale

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A SNIA TECHNOLOGY AFFILIATE

Archive Storage Continues Explosive Growth

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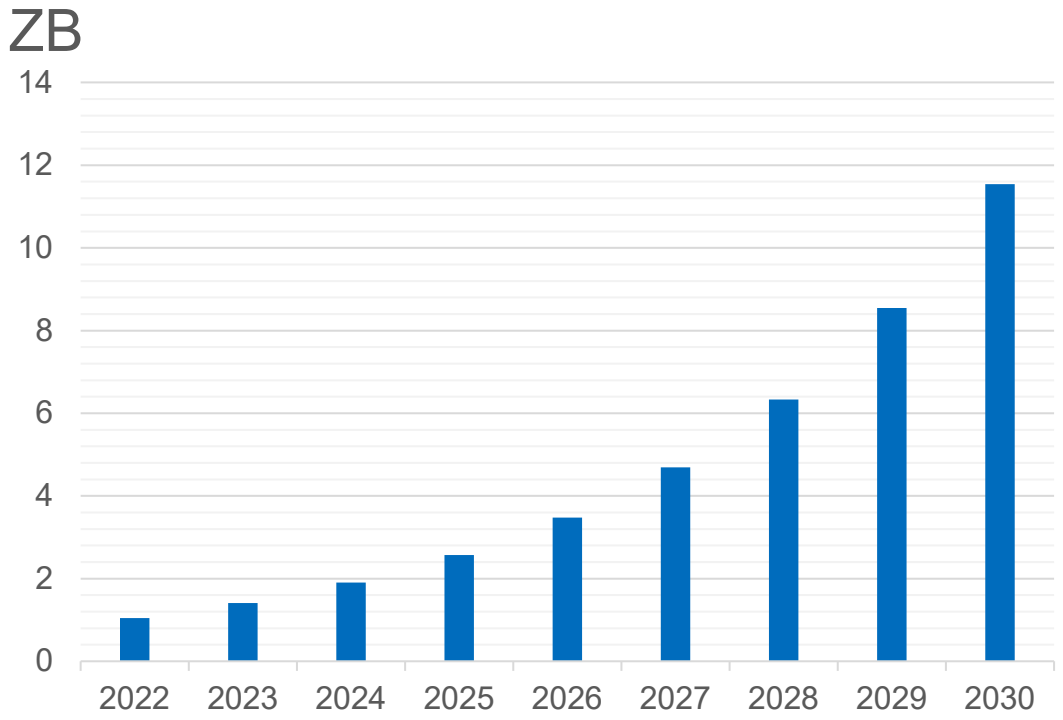
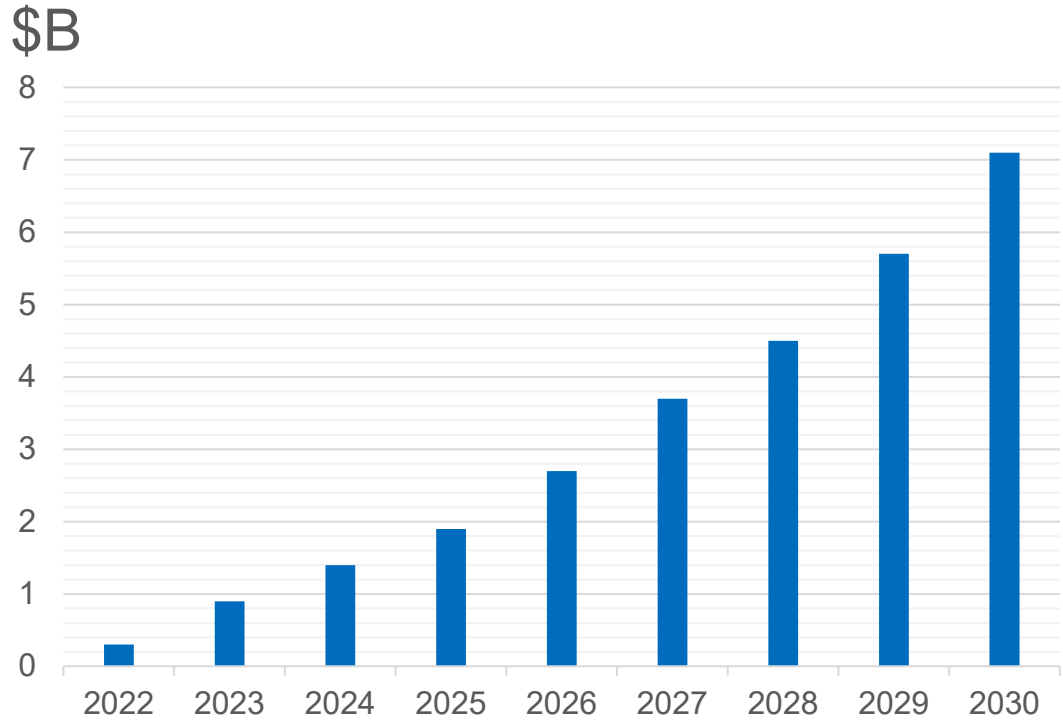
Archive Storage shipments projected to exceed 11ZB



Demand for New Storage Solutions scaling to $7B+



Data Retention Indefinite: Policy & Reality - No inclination to hit the delete key!

Source: Furthur Market Research, August 2022

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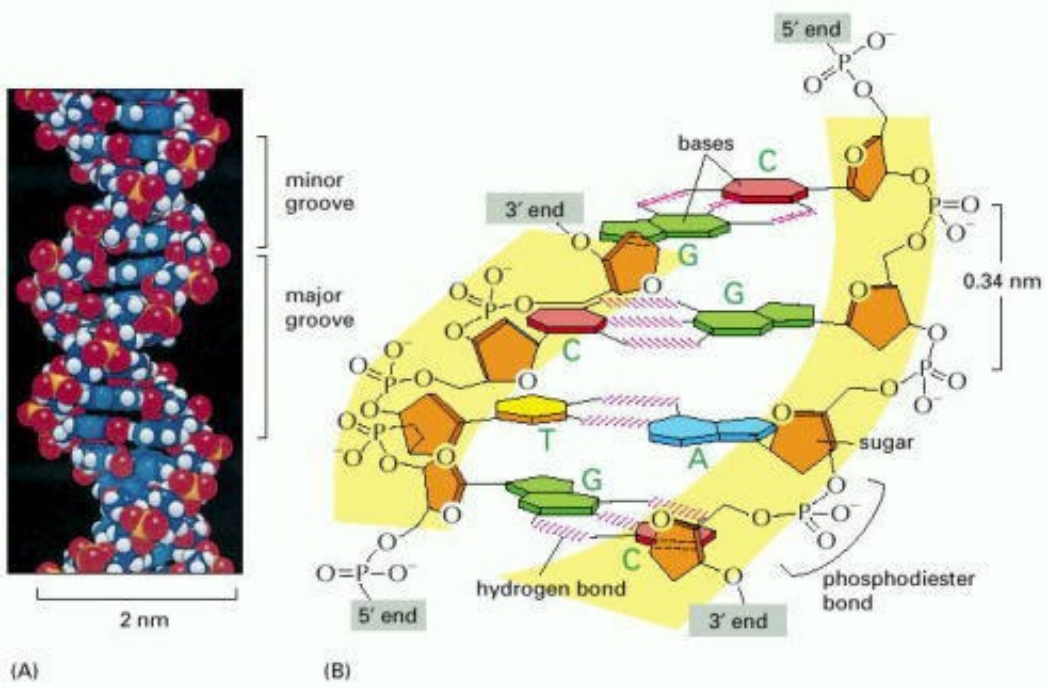
35 YEARS OF NAND FLASH MEMORY INNOVATION

Designing Storage Using Nature's Playbook

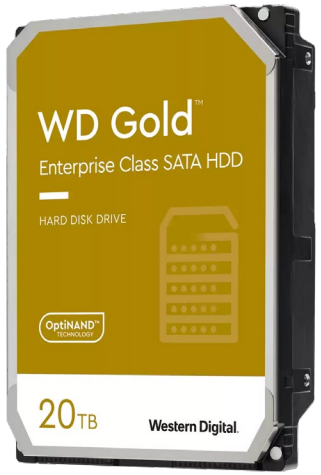
- The physics of DNA is well understood
- Synthesis & sequencing technologies exist
- DNA bases store bits: A, C, T, G → 00, 10, 01, 11
- 1,000+ years lifetime when properly packaged
- Data is the Medium, *Software Defined Storage*
- Stable format, always able to read natural DNA
- Sustainable, lowest energy storage carbon footprint



Source: https://www.ncbi.nlm.nih.gov/books/NBK26821/

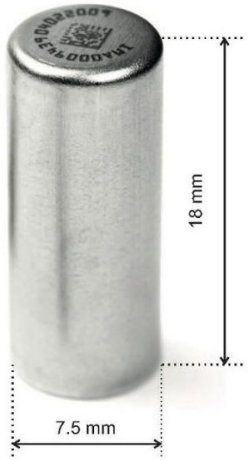
DNA Data Storage addresses the evolving huge need to cost-effectively and reliably store and retrieve the deep archives of enterprise data

Storage Capacity No Issue for DNA Data Storage



Capacity: 20 TB
By volume: 51.3 MB/mm^3
By weight: 29 GB/g

Capacity: 18 TB
By volume: 77.4 MB/mm^3
By weight: 90 GB/g



29,000x volumetric density

5,000,000x mass density

>10x migration longevity

Capacity: 250 µl
By volume: ≈ **16.6 B/nm^3**
By weight: ≈ **450 EB/g**

DNA Data Storage Solution Concepts

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Vault – Century Archive

- Offline / Offsite / Air-Gapped archiving solution
- High density / Small footprint “Time Capsule”
- Currently shipping MB-class pilots to customers
- Expect to introduce GB-class pilots soon
- **Lowest long-term TCO**

7.5mm x 18mm

Library – Accessible Archive

- Fully automated DC system with std I/F & API
- Modular system for standard DC environment
- Operated by IT team using STaaS deployment
- Highest volumetric storage capacity
- **Lowest long-term TCO**

Looking for innovative early-adopters, customers that will help shape the product!

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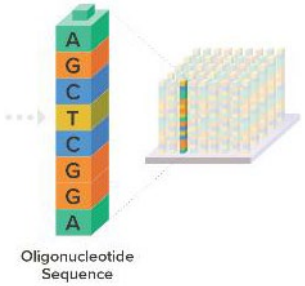
DNA Data Storage – Key Technology Enablers



Synthesis

TB scale

TB per day

Water-based

Storage/Retrieval

PB scale

Automation

Easy copy & store

Sequencing

TB scale

TB per day

Non-destructive

System

Data center ready

Software integrated

Object storage APIs

World's Highest Density DNA Synthesis Chip

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- DNA is synthesized on a semiconductor chip
  - Use a 2D array of electrochemical reactors to synthesize strands of DNA
  - After synthesis, the DNA is washed into a tube, then amplified, purified, and packaged
- Chip capacity is limited by the array pitch and chip size
  - There is a scaling limit; each reactor needs to produce enough DNA to store practically
  - Given the scaling limits, writing 1 TB per chip may be the practical limit
- 1GB POC Synthesis chip built on 300mm wafers
  - 1GB → 64 GB → 256 GB → 1 TB
  - *Twist is currently bringing up the 1GB chip and designing the 64 GB chip*

Areal Density Capability (ADC) demonstrated
100M sequences per square centimeter!

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Summary

- Continued explosive demand growth for Archive Storage is driving the need to discover storage technologies with 100x higher Areal Density Capability
- DNA Data Storage enables cost-effective, scalable and sustainable Archive Storage Solutions, paving the way from the Zettabyte to the Yottabyte Era
- DNA Data Storage will emerge ‘bottom-up’ to address all deep-but-accessible archive storage needs
- Most advanced semiconductor technology will enable next generation synthesizing & sequencing solutions writing & reading TB-class DNA

