Next-Generation Nanofabrication for Health and Technology

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Disclaimer:

Dr. Bathe is a co-founder, scientific advisory board member, investor and equity holder in **Kano Therapeutics, Inc.** and **Cache DNA, Inc.**

Is DNA the next silicon?

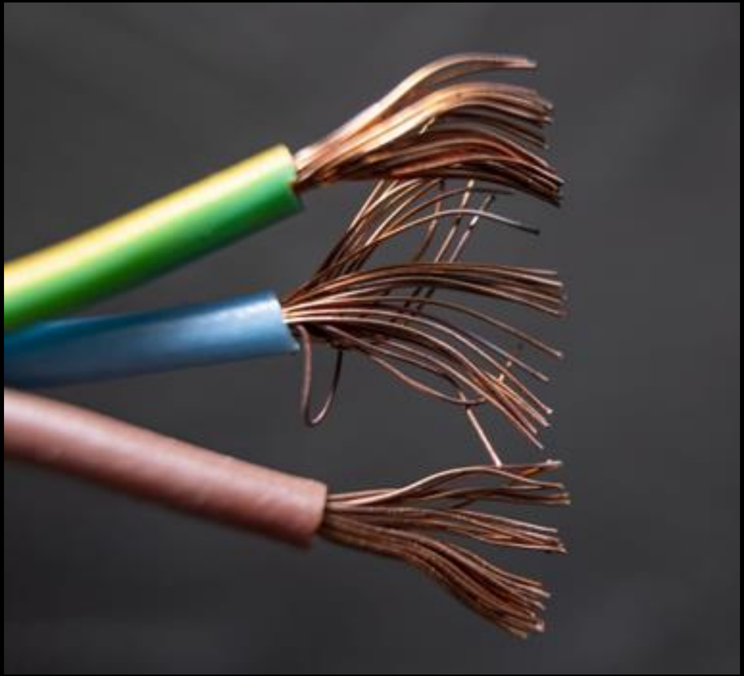
"Disruption occurs when we ***create new things***, not just improvements along a current path…

…we want to ***revolutionize*** the world, not just evolve our capabilities."

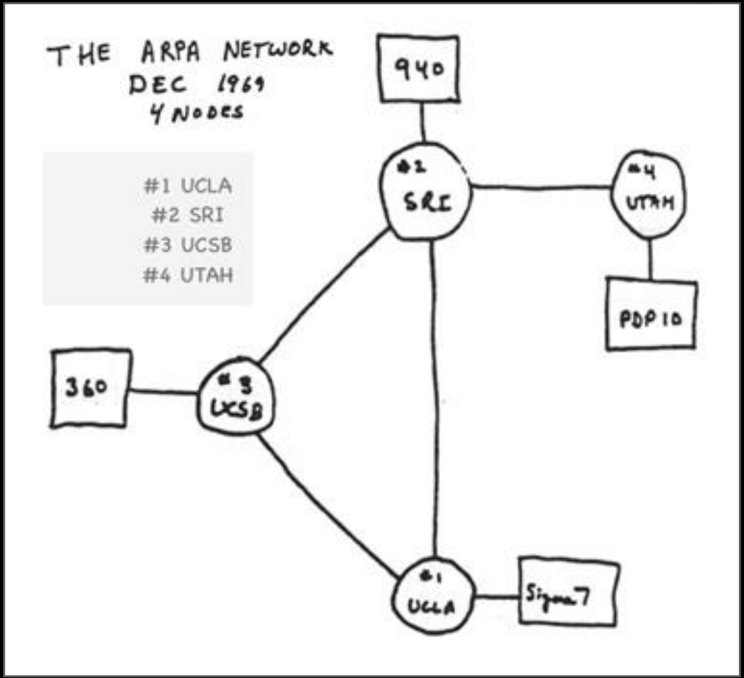
–Dr. Whitney Mason
Director, DARPA MTO

Voices of DARPA Podcast, "More than microchips"
Ep 85

Copper wires

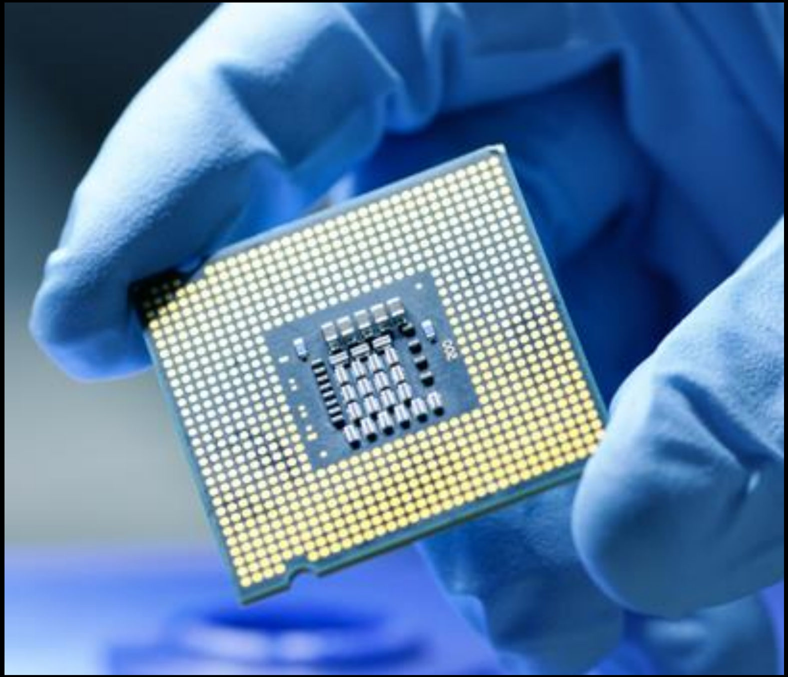


Birth of the internet



Silicon

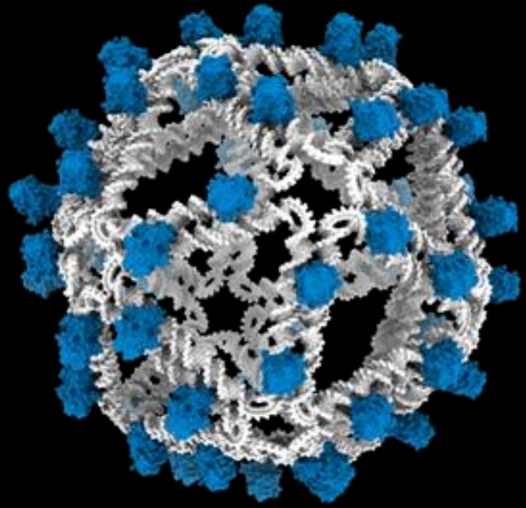
Birth of Moore’s Law



DNA is the code of life: ATGC

But also a nanoscale fabrication material

1 nanometer*



10 nanometers

*1 nanometer = 1 billionth of a meter

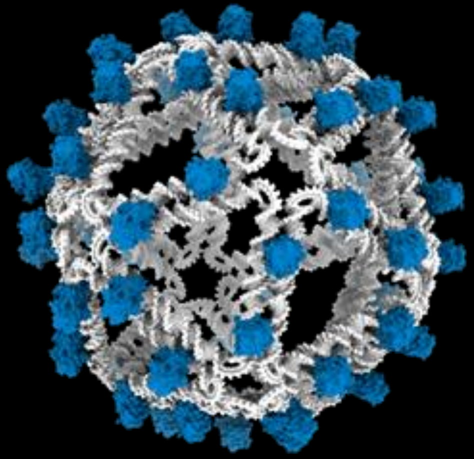
And a digital storage medium

exabyte data center

A 0
T 1
G 1
C 0

1 exabyte of DNA

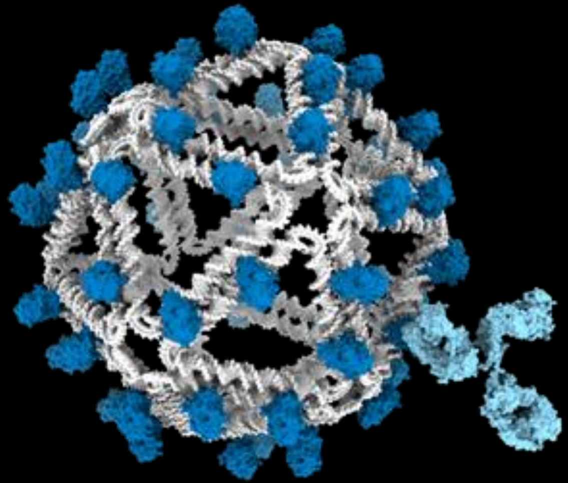
Part I:
Vaccines & active immunotherapies



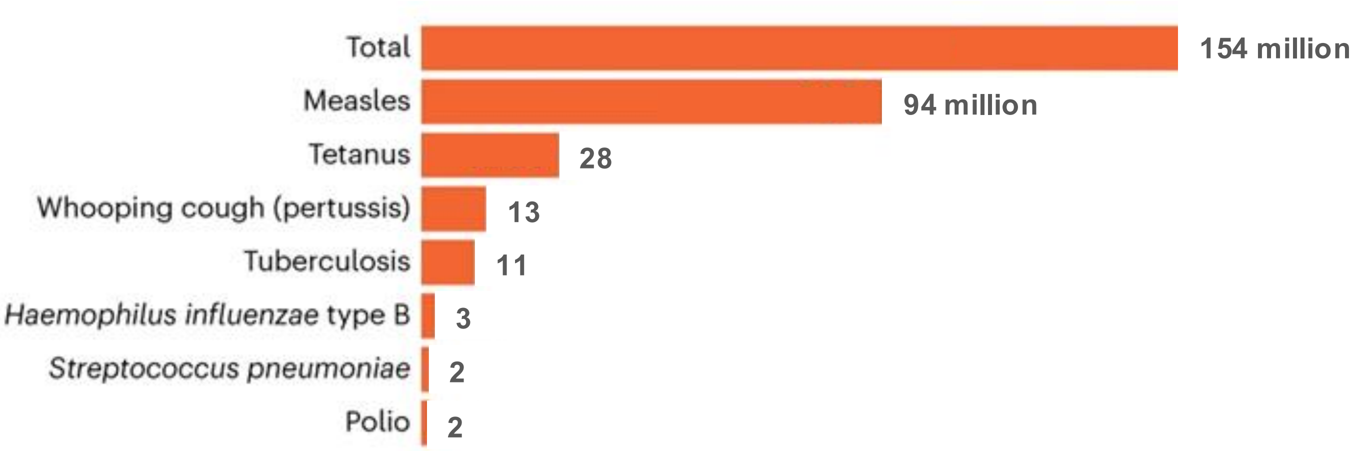
Part II:
Data storage and global genomics

Part III:
Quantum materials

Part I: Vaccines & active immunotherapies



150+ million lives saved by vaccines since 1975

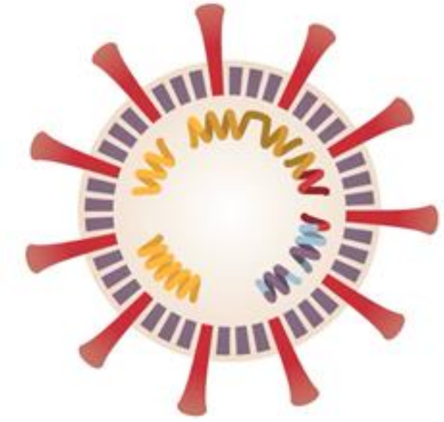


The Lancet: 403: 2307 (2024) & *Nature News* (2025)

Most successful vaccines are virus-like particles (VLPs)

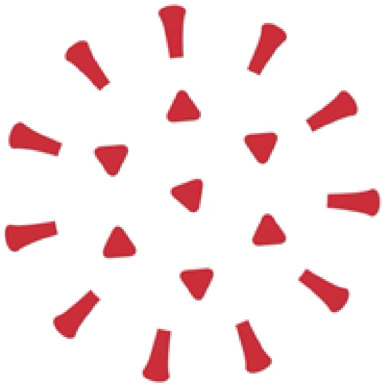
Whole Attenuated Virus

- Chickenpox
- Measles, mumps, rubella
- Hepatitis A
- Flu
- Polio
- Rabies
- Rotavirus
- Shingles
- Smallpox
- Yellow fever



Recombinant Protein VLP (pVLP)

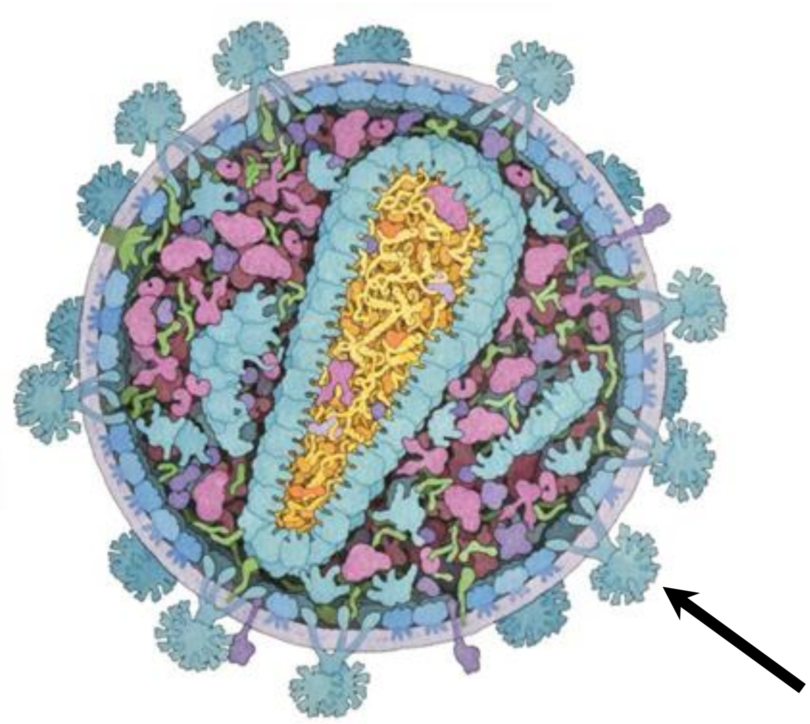
- Hepatitis B
- HPV



Source: fda.gov

Despite many successes, numerous pathogens have been impossible to vaccinate against.

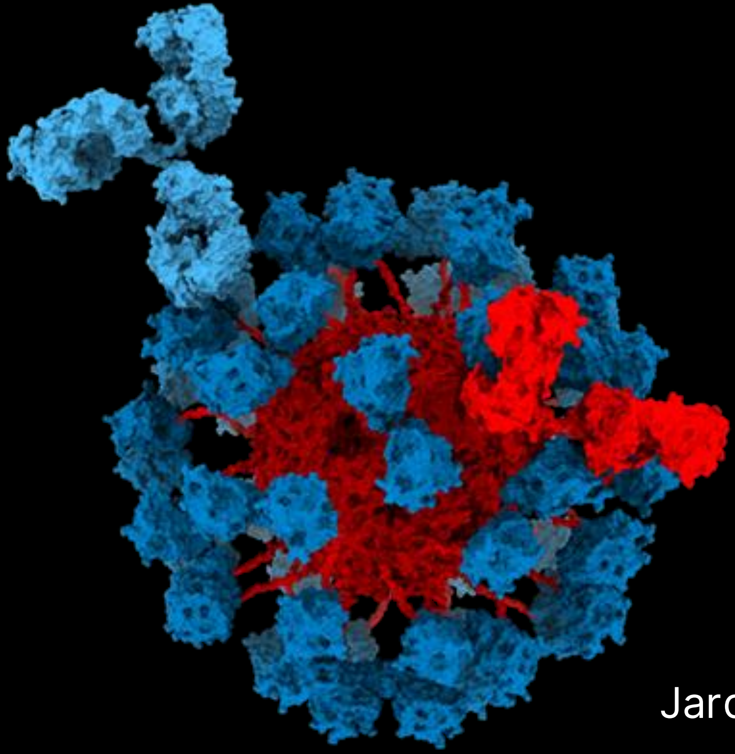
Why is HIV so challenging to vaccinate against?



- Glycosylated envelope protein, gp120
- High mutation rate of gp120
- Sub-dominant antigen

gp120

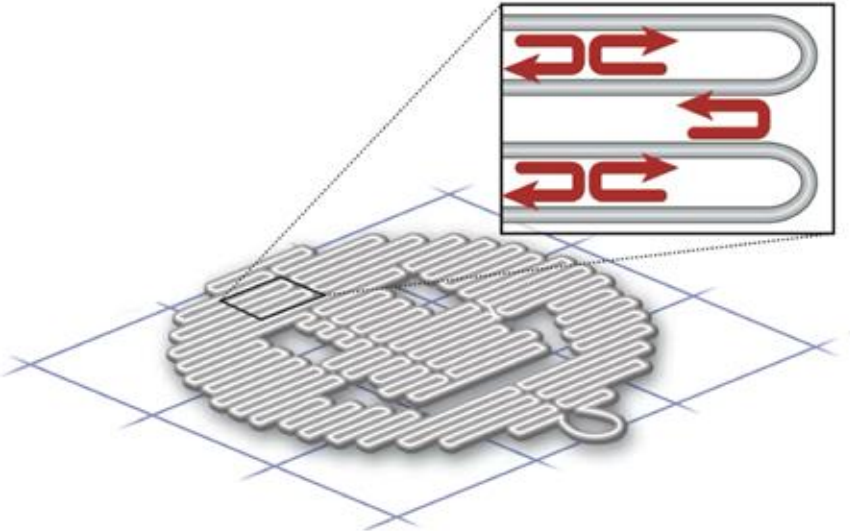
Clinical HIV vaccine (protein VLP: pVLP)



Jardine et al., *Science* (2015; 2016)
Leggat et al., *Science* (2022)

Origami
oru = “to fold”
kami = “paper”

“DNA origami”

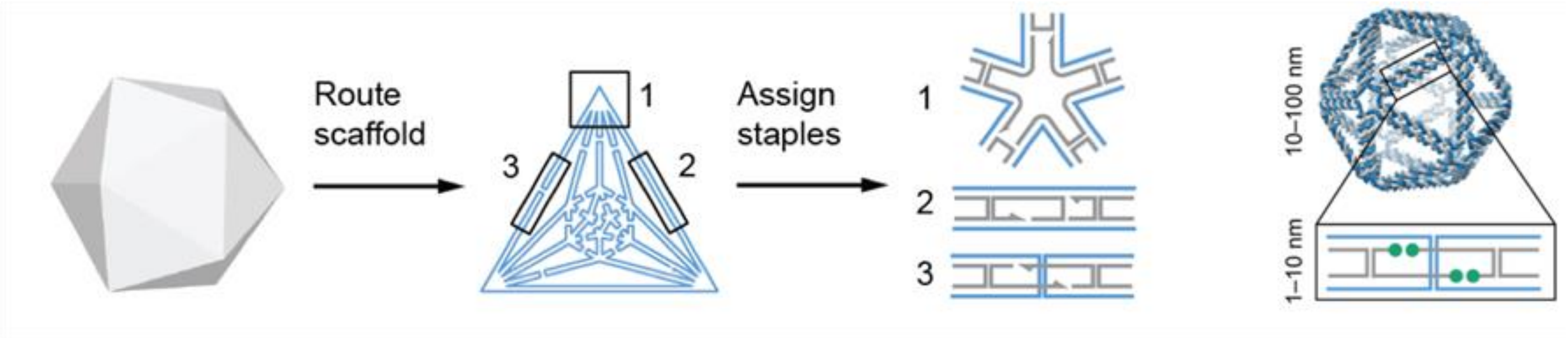


Rothemund, *Nature* (2006)

DNA virus-like particles: dVLPs

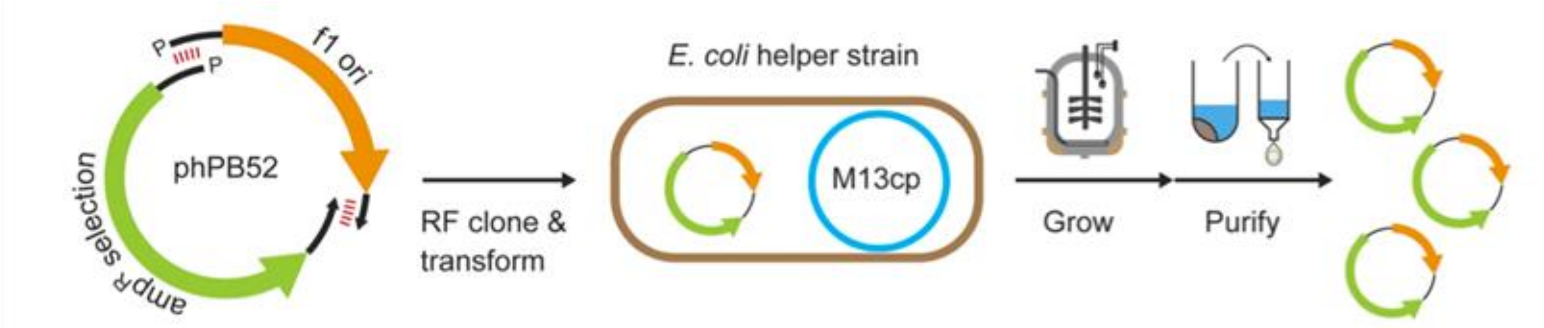
Science 352: 1534 (2016)

Scalable biomanufacturing of dVLPs



Science 352: 1534 (2016)

cssDNA templates:



Sci Rep 9: 6121 (2019)

Commercial Translation:

Safe, scalable & efficient 10kb cssDNA templates for gene therapeutics

kanotherapeutics.com

KANO

Leadership

Floris Engelhardt
CEO/CSO
Co-Founder

John Vroom
CBO
Co-Founder

Seth Ettenberg
Independent Director
CEO of BlueRock Therapeutics

Vinny Beranek
Board Director
The Engine Ventures

Ann DeWitt
Board Observer
The Engine Ventures

Lise Rechsteiner
Board Observer
Vsquared Ventures

Gilles Cottier
Board Observer
Launchpad Venture Group

Advisors

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Co-Founder
Global nucleic acid technology leader
(MIT, BROAD)

Stephen Sofen
CMC expert
(Abata, CRISPR Tx)

Prof. Brian Shy
Global Cell engineering leader
(UCSF, Gladstone)

Prof. Jacob Corn
Global Cell engineering leader
(ETH Zurich)

Funding

THE ENGINE VENTURES
vsquared ventures
LAUNCHPAD VENTURE GROUP
Amino Collective
Taihill Venture
metaplanet.
NIH
Cam MASSACHUSETTS CENTER for ADVANCED MANUFACTURING at the MassTech Collaborative

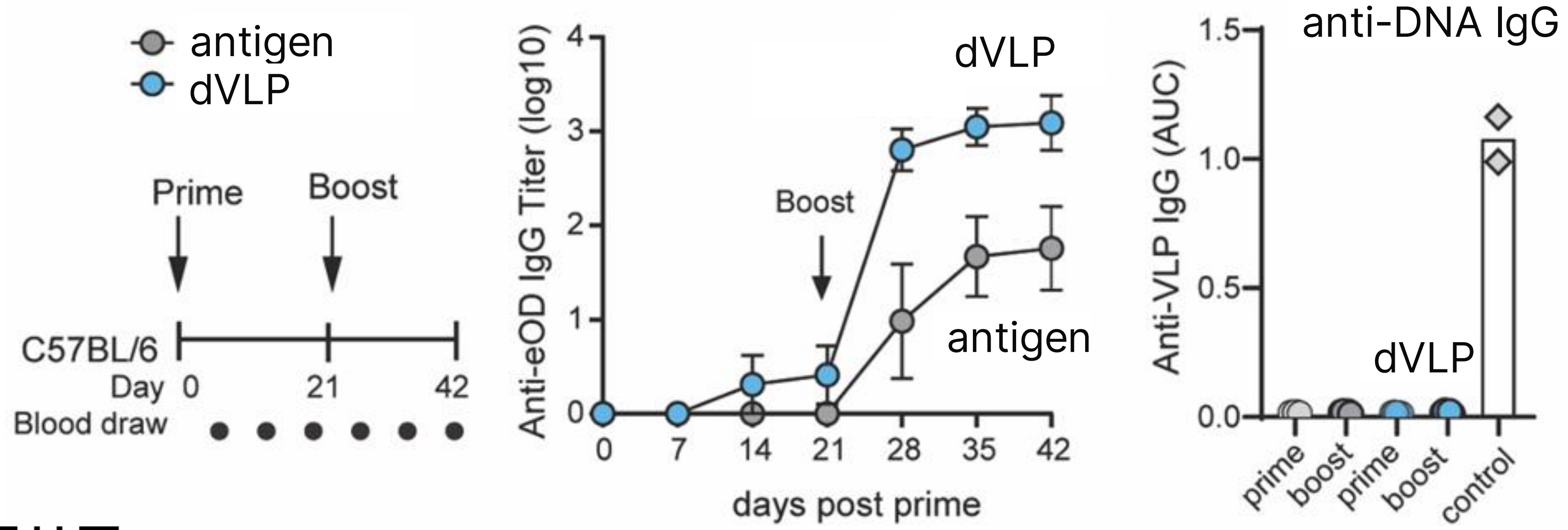
KANO

Perfecting the DNA message

End of Commercial Translation Aside

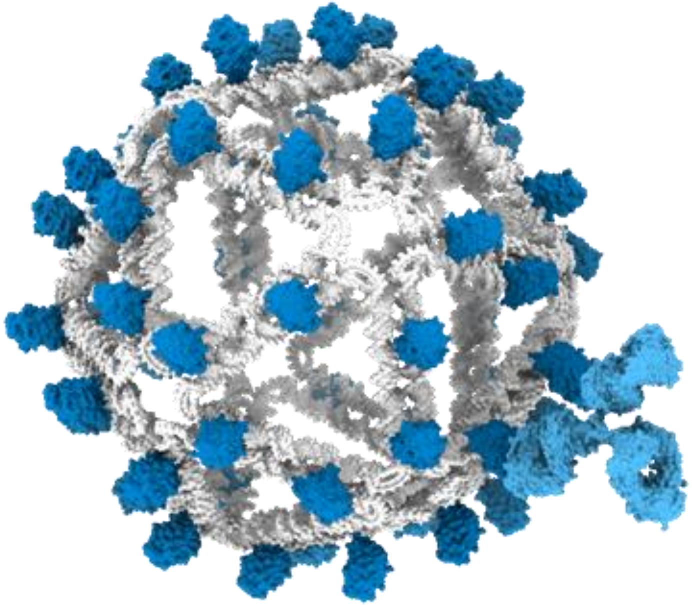
kanotherapeutics.com

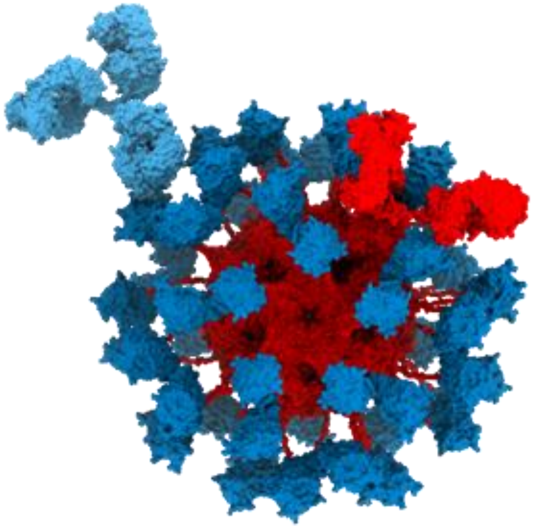
dVLPs generate antigen-specific antibodies ***without DNA antibodies***



Science 6785: 6785 (2026)

dVLP scaffold is "invisible"

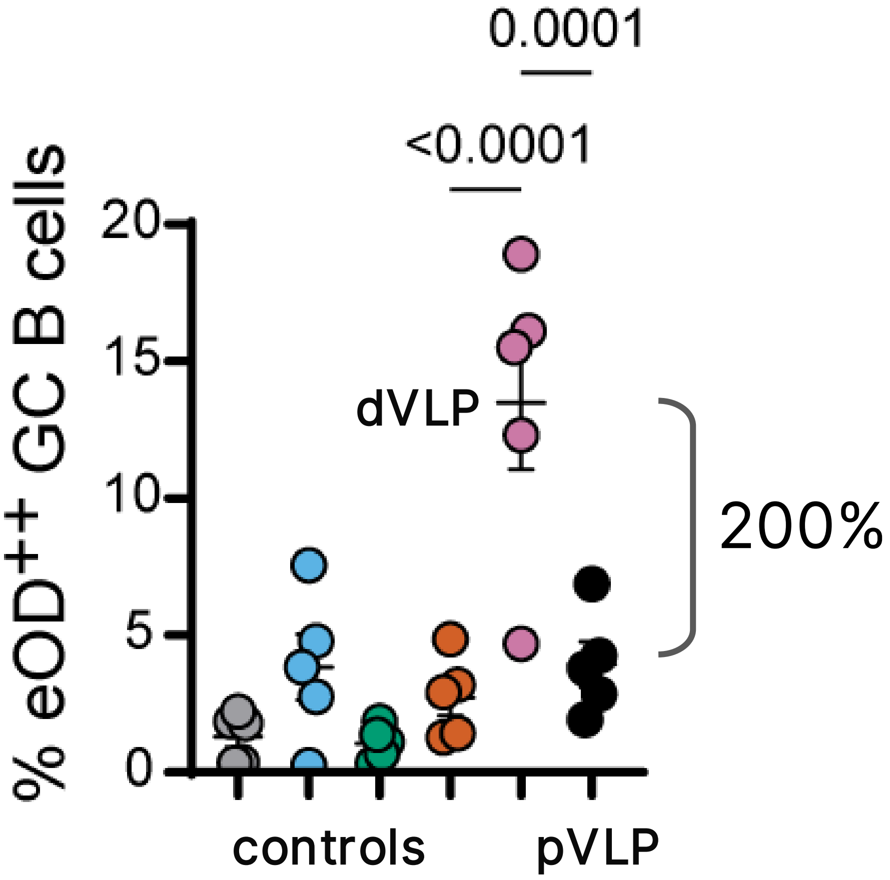




Nat Commun 15: 795 (2024)

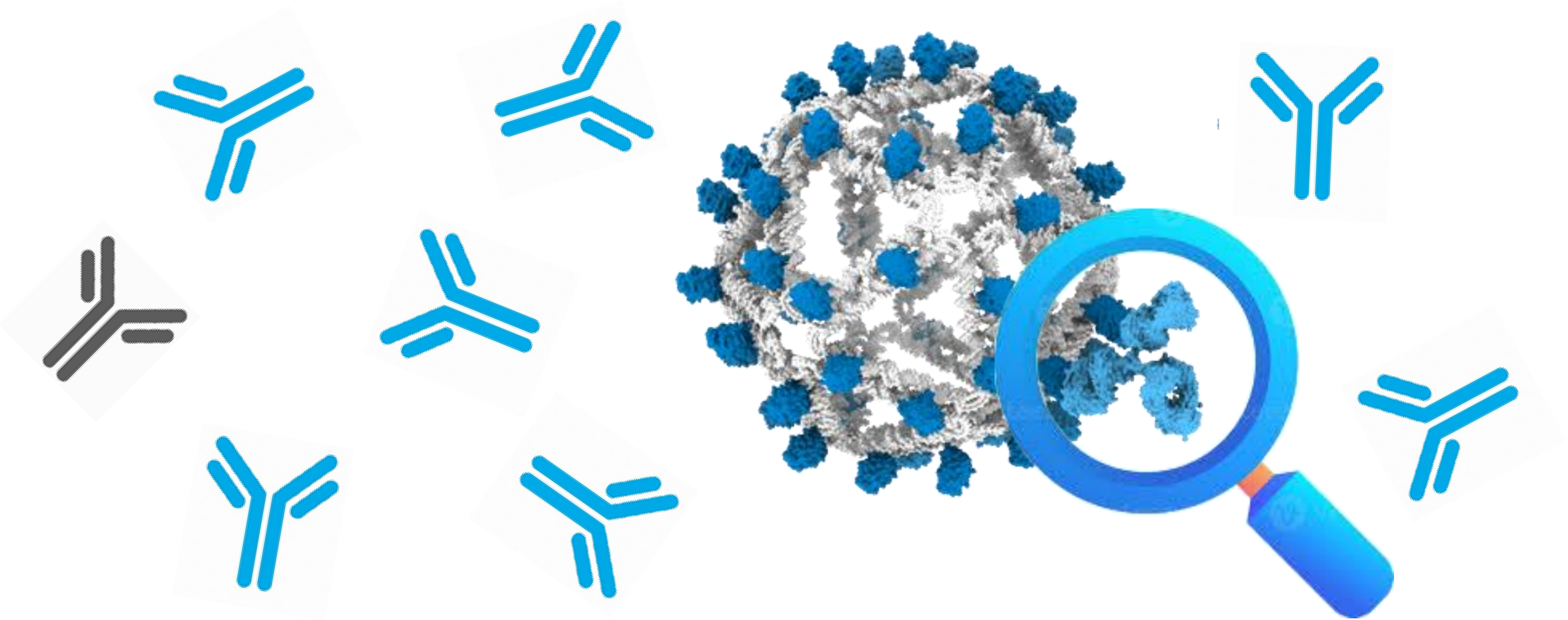
Science 6785: 6785 (2026)

dVLPs yield ***3-fold higher*** on-target B cells



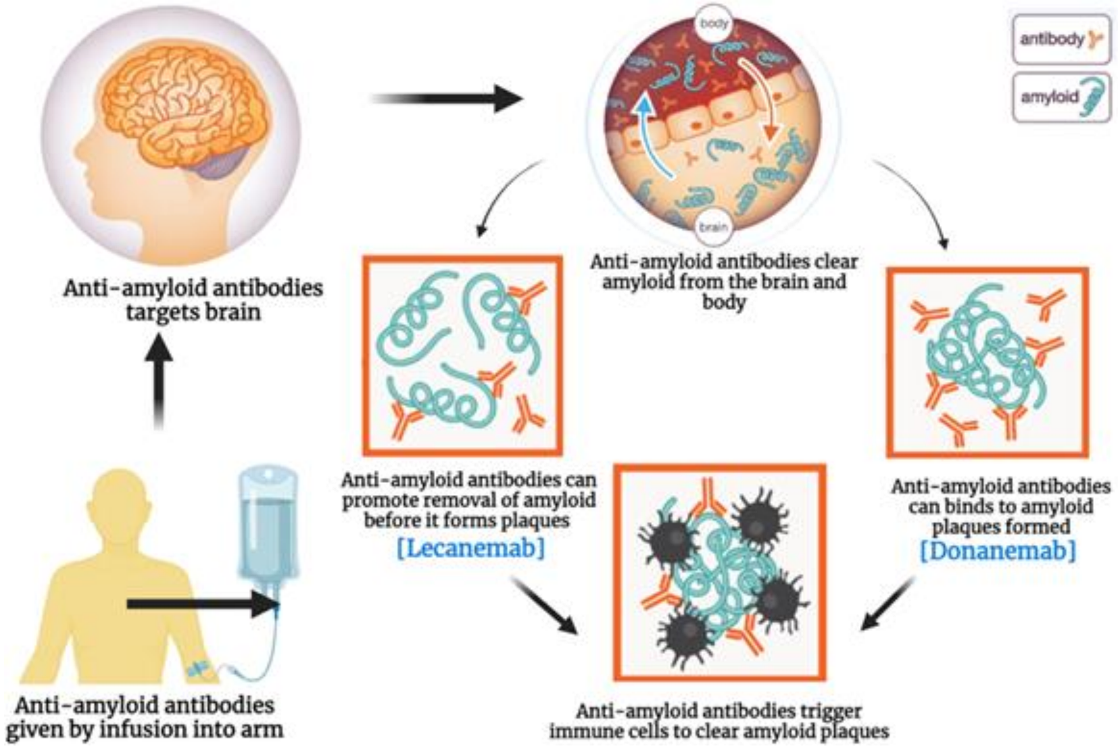
Science 6785: 6785 (2026)

dVLPs “immune focus” on the antigen



Commercial Translation:

Vaccinate against Alzheimer’s



Dr. Grant Knappe

doi 10.1002/cdt3.155

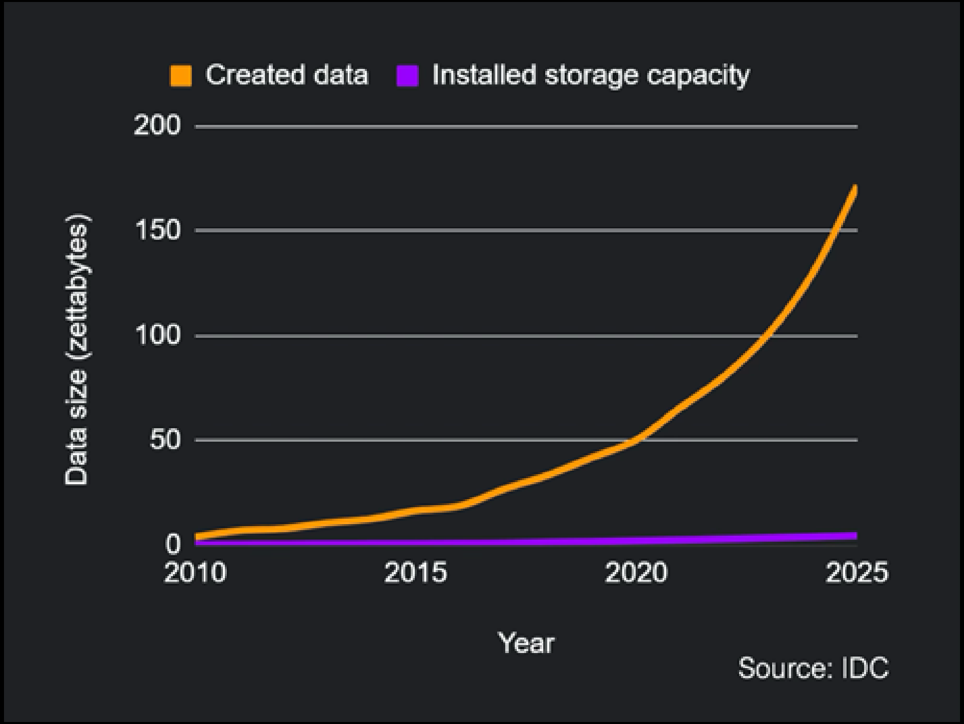
MIT Deshpande Center for Technological Innovation

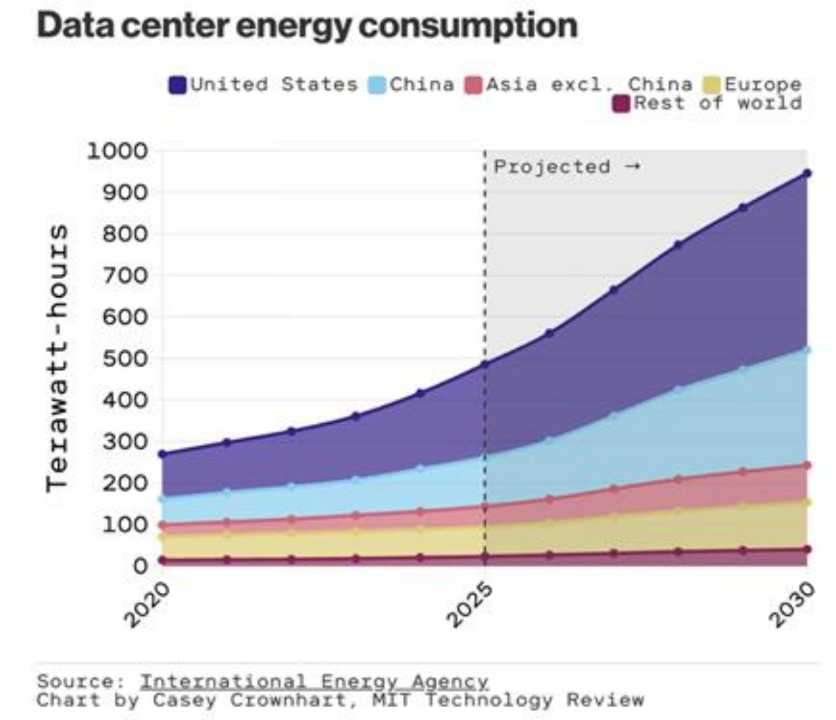
Part II: Data storage & global genomics

exabyte data center

bio freezer farm

AI is data- & energy-starved





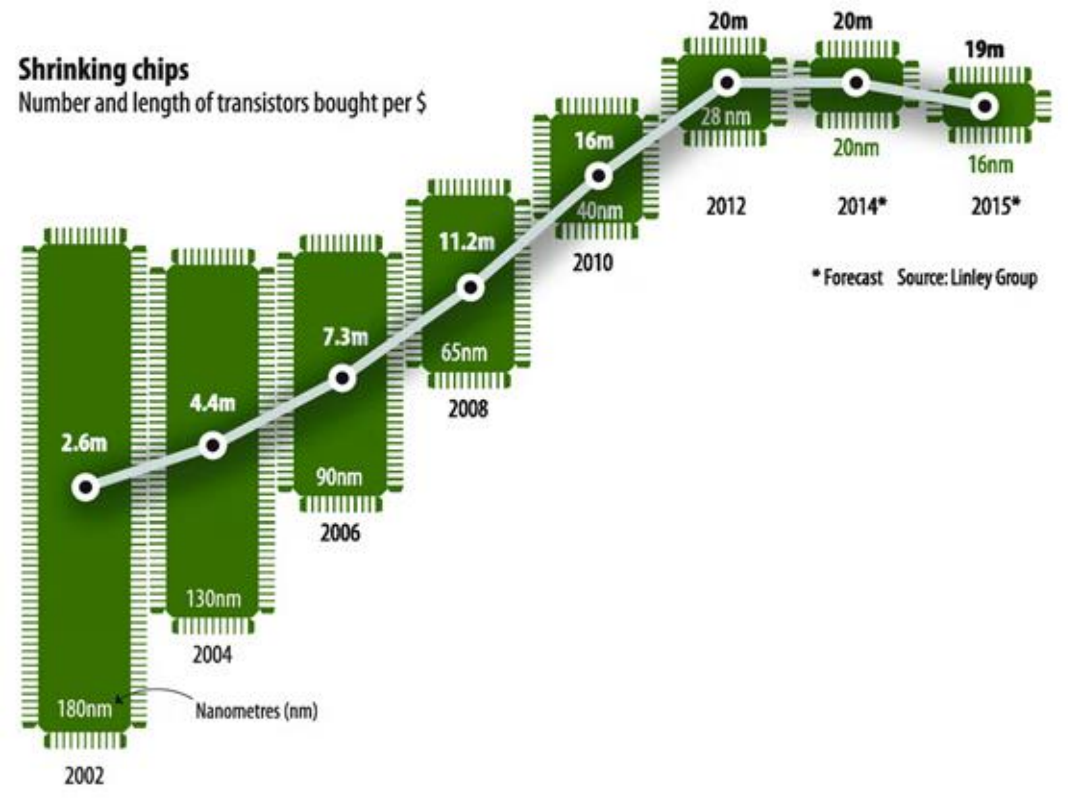
"The End of Moore's Law"

–*The Economist* (2015)

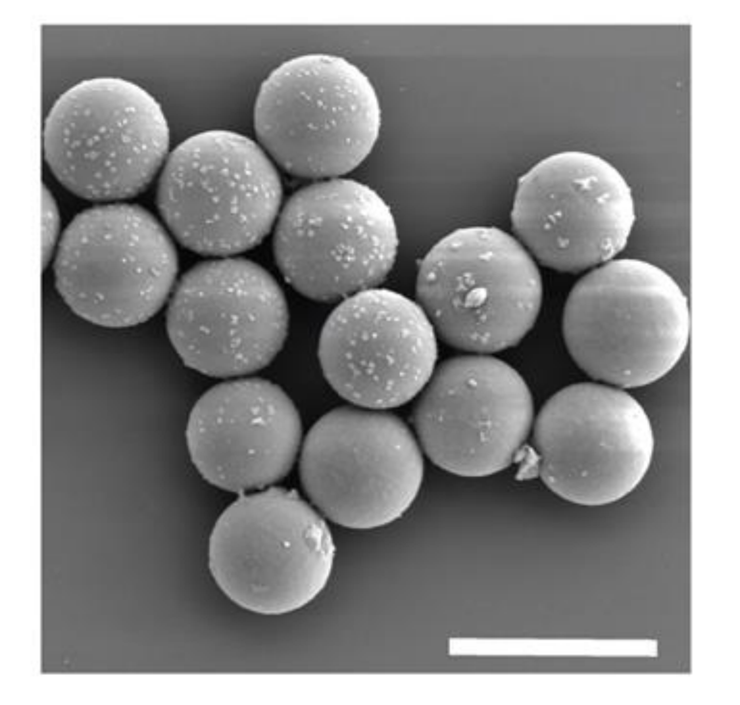
and

"Kryder's Law" ended in 2010

–*Scientific American* (2005) & *The Register*



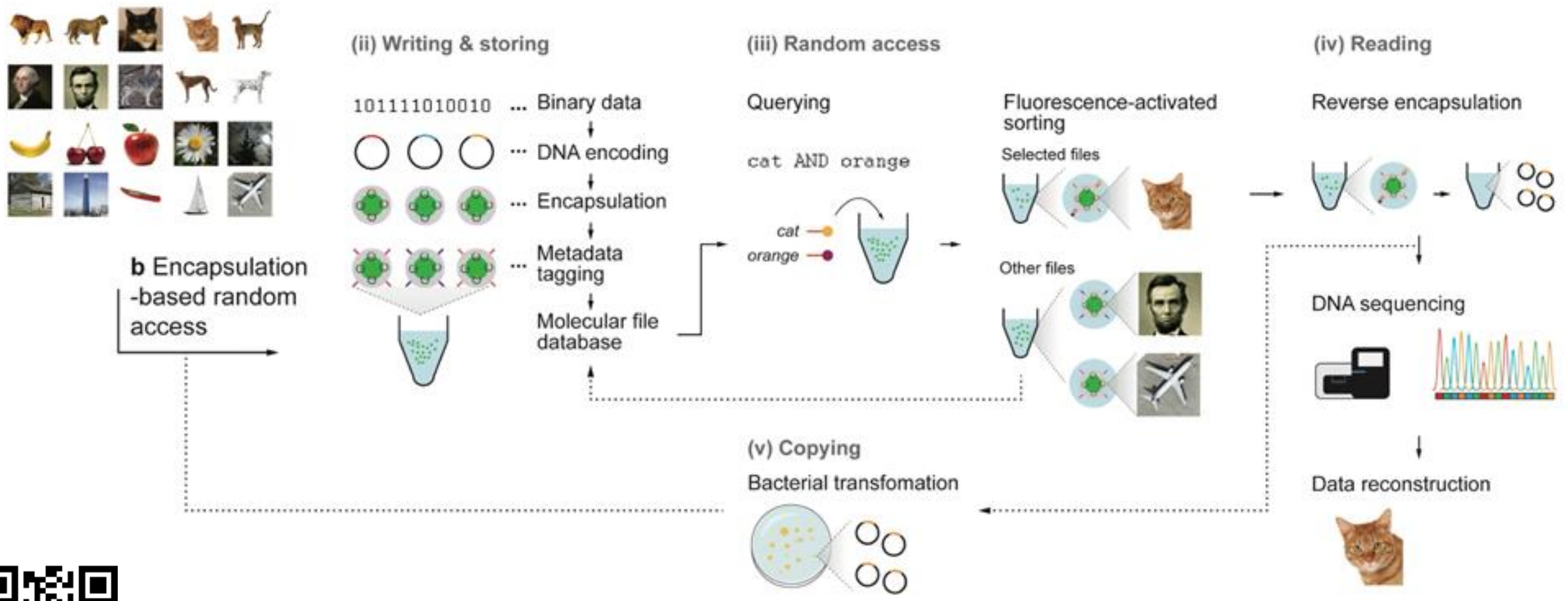
Micron-sized silica particles store DNA



- ATGC ⇒ 0110
- room temperature
- no energy input
- permanent
- EB/cm^3 data density

Nature Materials 20: 1272 (2020)

Scalable DNA data random access memory



Nature Materials 20: 1272 (2020)

DNA data storage is not viable today due to the high cost of DNA synthesis.

Biodiversity

Pathogen surveillance

Global human genomics





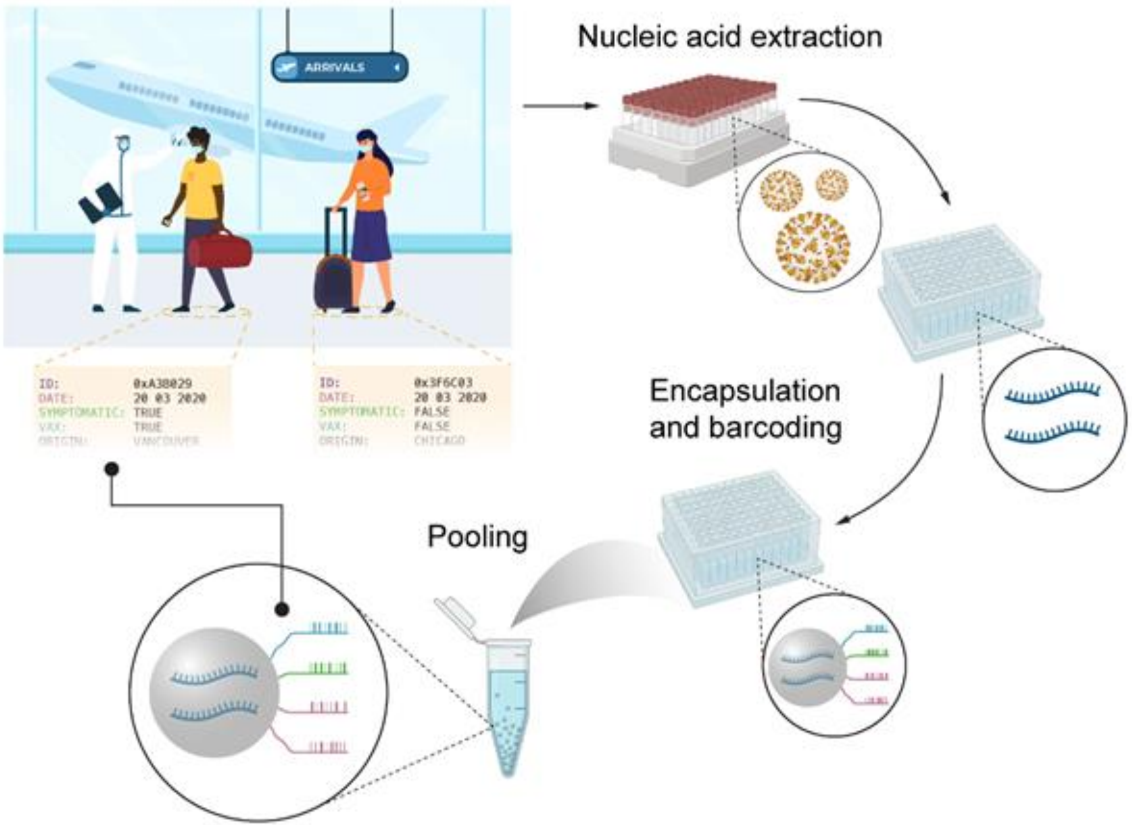
~8 billion human genomes worldwide

Only ~50 million sequenced (<1%)

Scalable & point-of-care sample access is needed

Point-of-care access

Automation



Banal et al., *ACS App Mat & Int* (2021)
Berleant et al., *Nat Comm in press* (2026)

Commercial Translation:

Scalable, stable, room temperature biosample collection & storage

cache-dna.com

Cache is dedicated to building enduring solutions

Our interdisciplinary team of operators brings materials expertise to empower researchers worldwide

Mike Becich, MS/Ex-MBA
CEO, Co-founder

Stanford University

James Banal, PhD
Technical Founder

Adrian Fehr, PhD
Head of Product

Shoulian Dong, PhD
Head of Chemistry

We are supported by world-class Scientific & Clinical advisors

Mark Bathe, PhD
Scientific Founder

George Church, PhD
Scientific Advisor

Jeremiah Johnson, PhD
Scientific Advisor

Paul Blainey, PhD
Scientific Advisor

Krystal Tsosie, PhD, MPH
Clinical Advisor

Joseph Lehar, PhD
Scientific Advisor

Heather Williams, PhD
Clinical Advisor

Cache

Nucleic Acids are Critical Across the Life Sciences

$7.2B
DNA & RNA Biobanking

$20B
cfDNA Liquid Biopsy

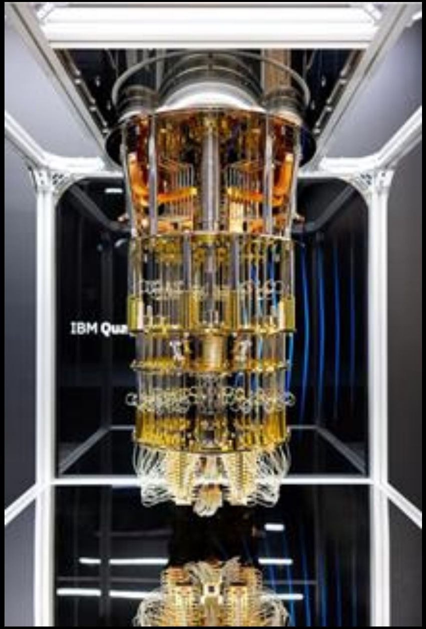
$54B
Multi-omics Drug Discovery

23,000
CAP/CLIA Labs

70M samples/year
Fortune 500 CRO

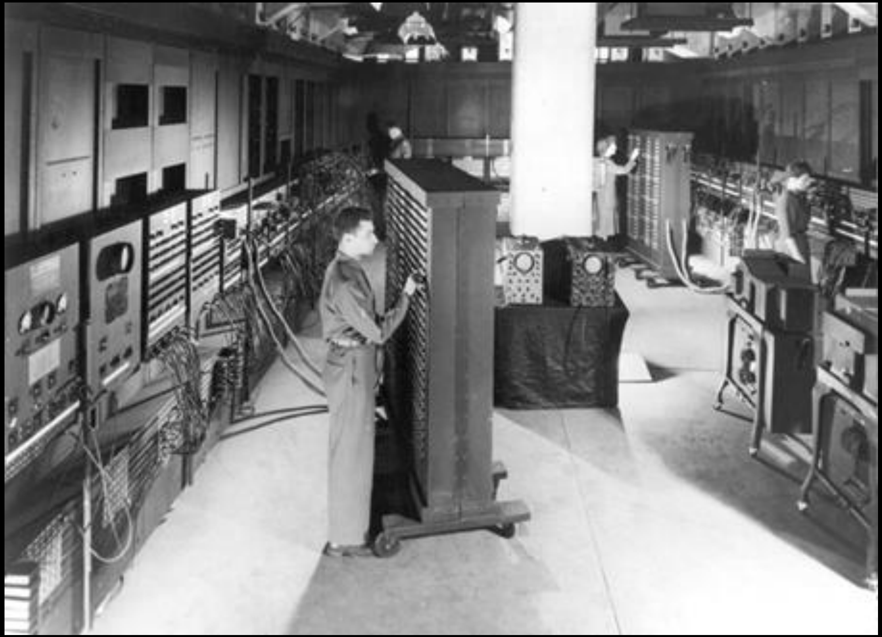
Part III:
Quantum materials

Quantum computer



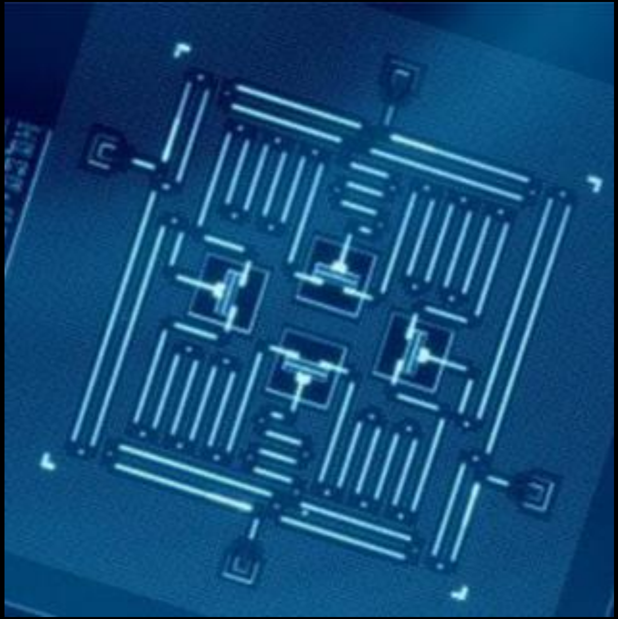
IBM, UTokyo, & UChicago (2024)

Digital computer



US Army ENIAC (1946)

Transmon qubits



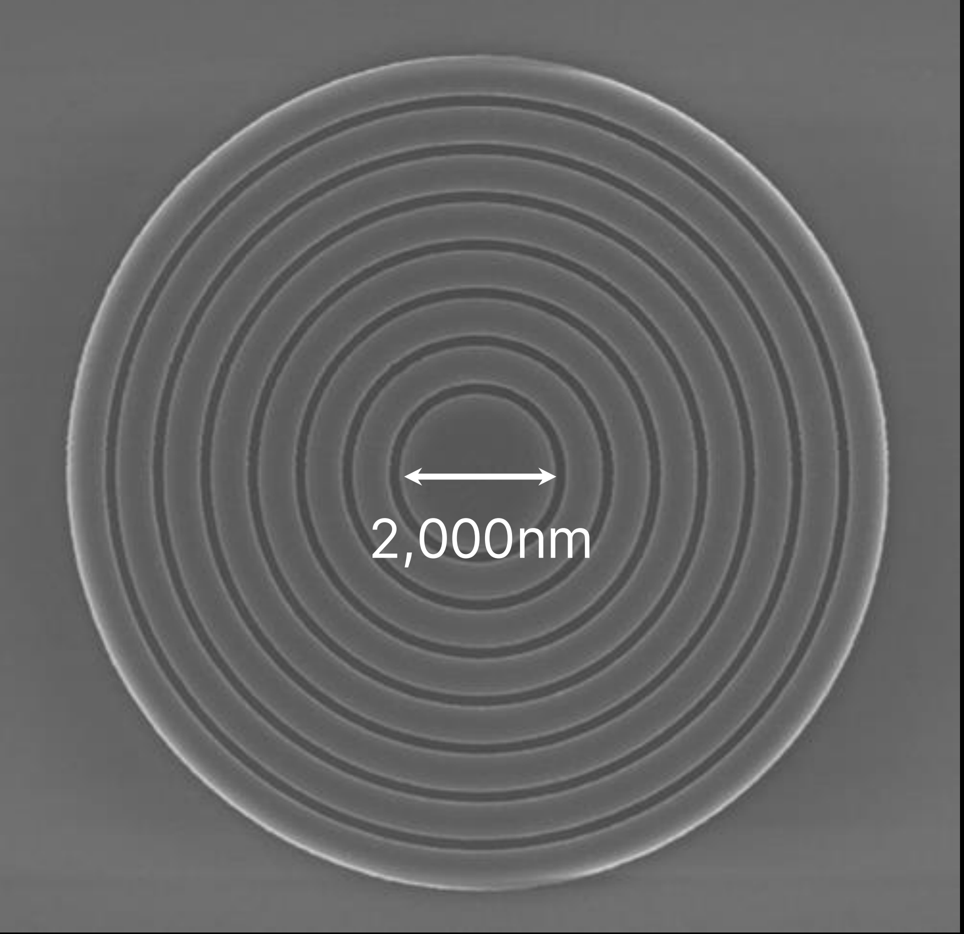
npj Quant Inf 3: 2 (2017)
Nat Comm 12: 1779 (2021)

Vacuum tube transistors

Over 50 years and more than 12 disruptive technological advances

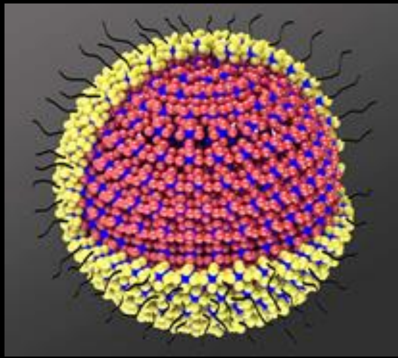
Engineering single-photon emission for quantum devices.

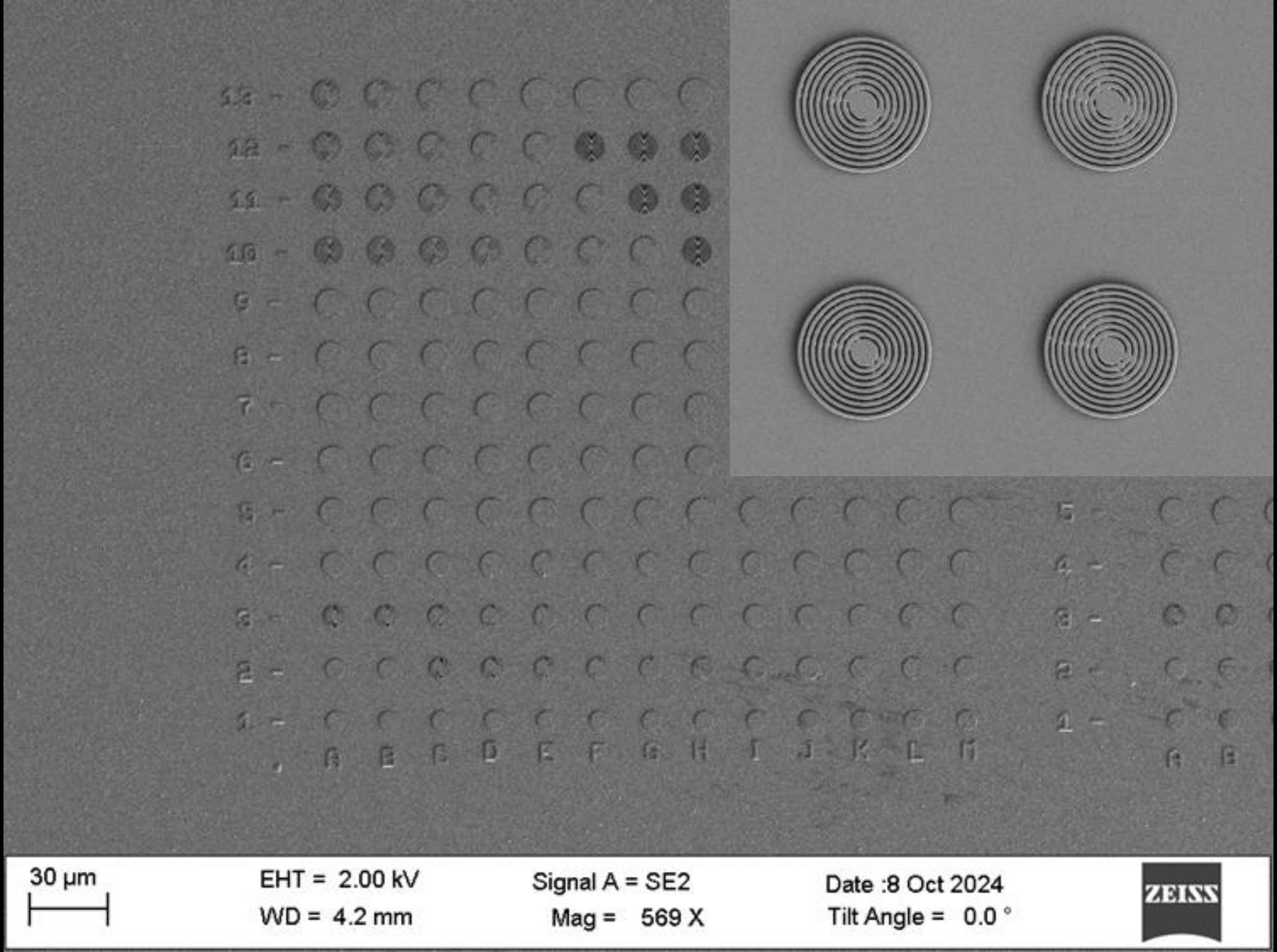
Photonic cavity



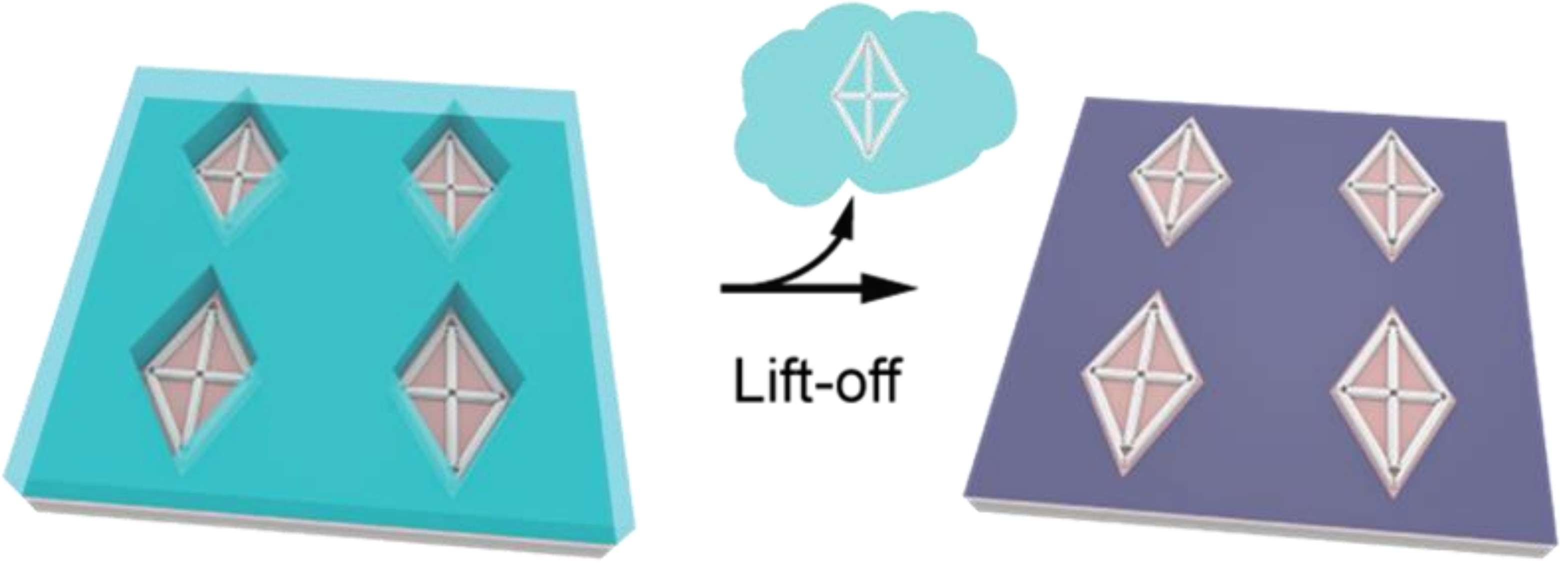
Moungi G. Bawendi
2023 Nobel Prize
in Chemistry

Quantum dot
~5nm



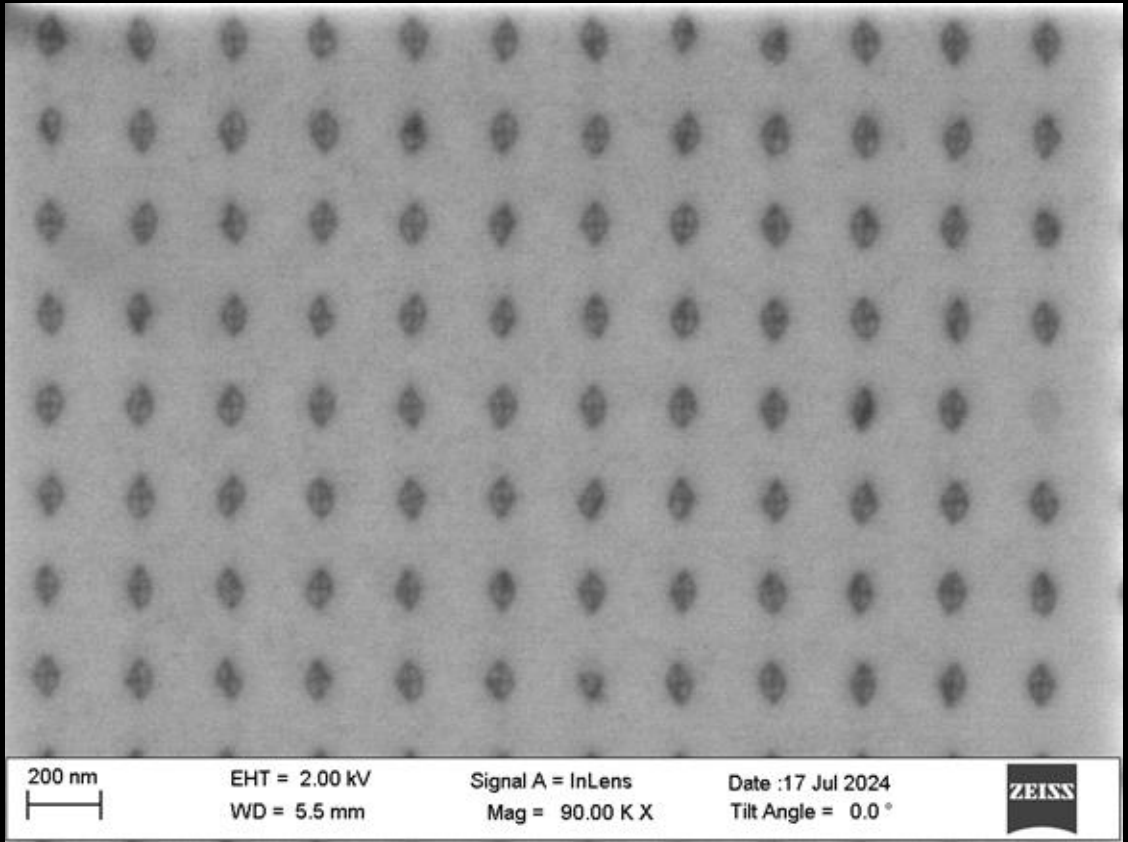

30 µm
EHT = 2.00 kV
WD = 4.2 mm
Signal A = SE2
Mag = 569 X
Date :8 Oct 2024
Tilt Angle = 0.0 °

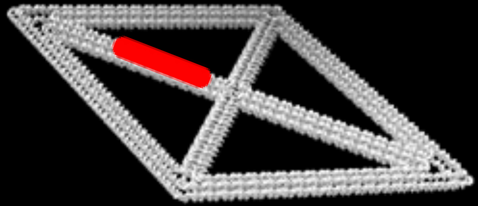
Lithographic patterning of DNA origami on Si

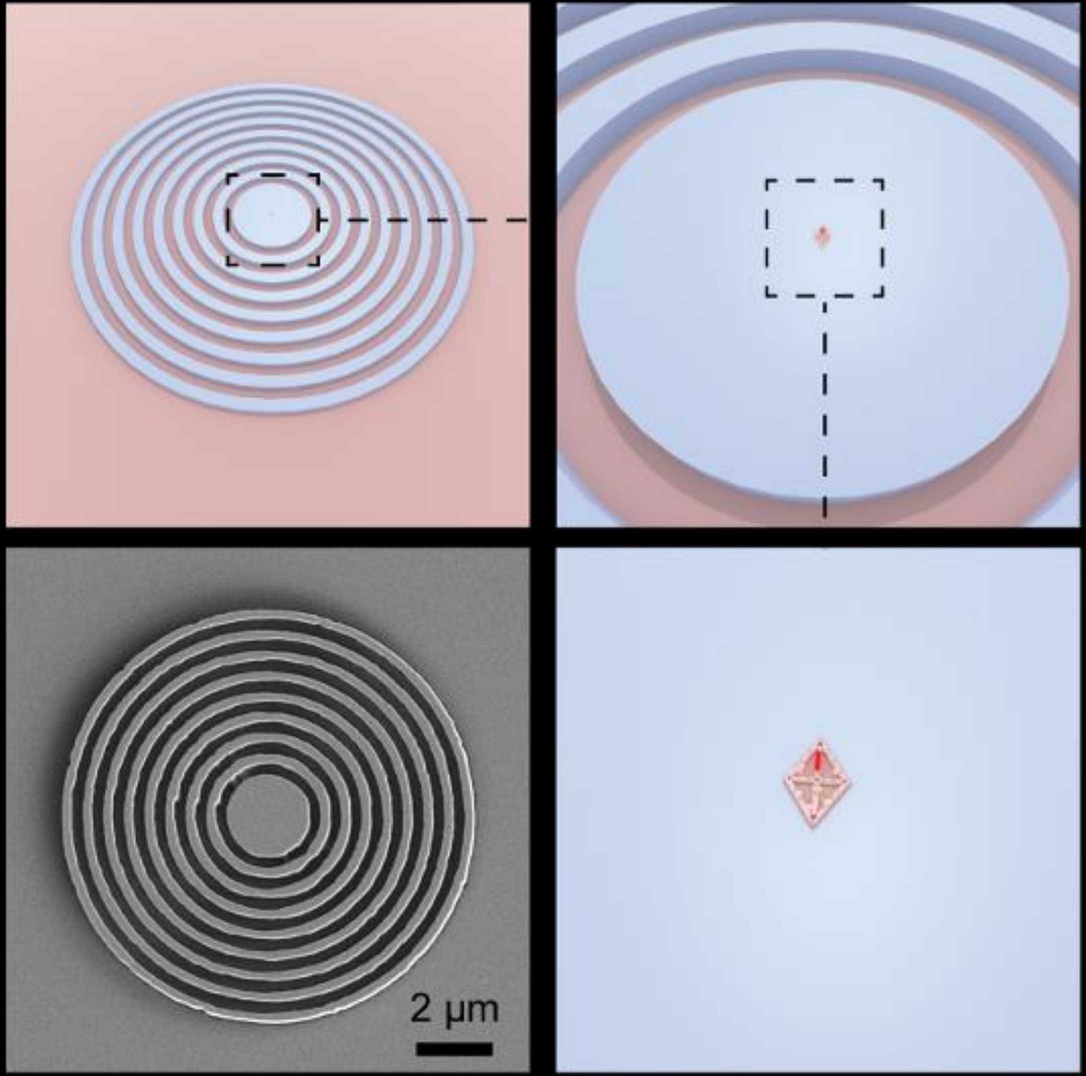


Luo et al.
biorxiv (2026)

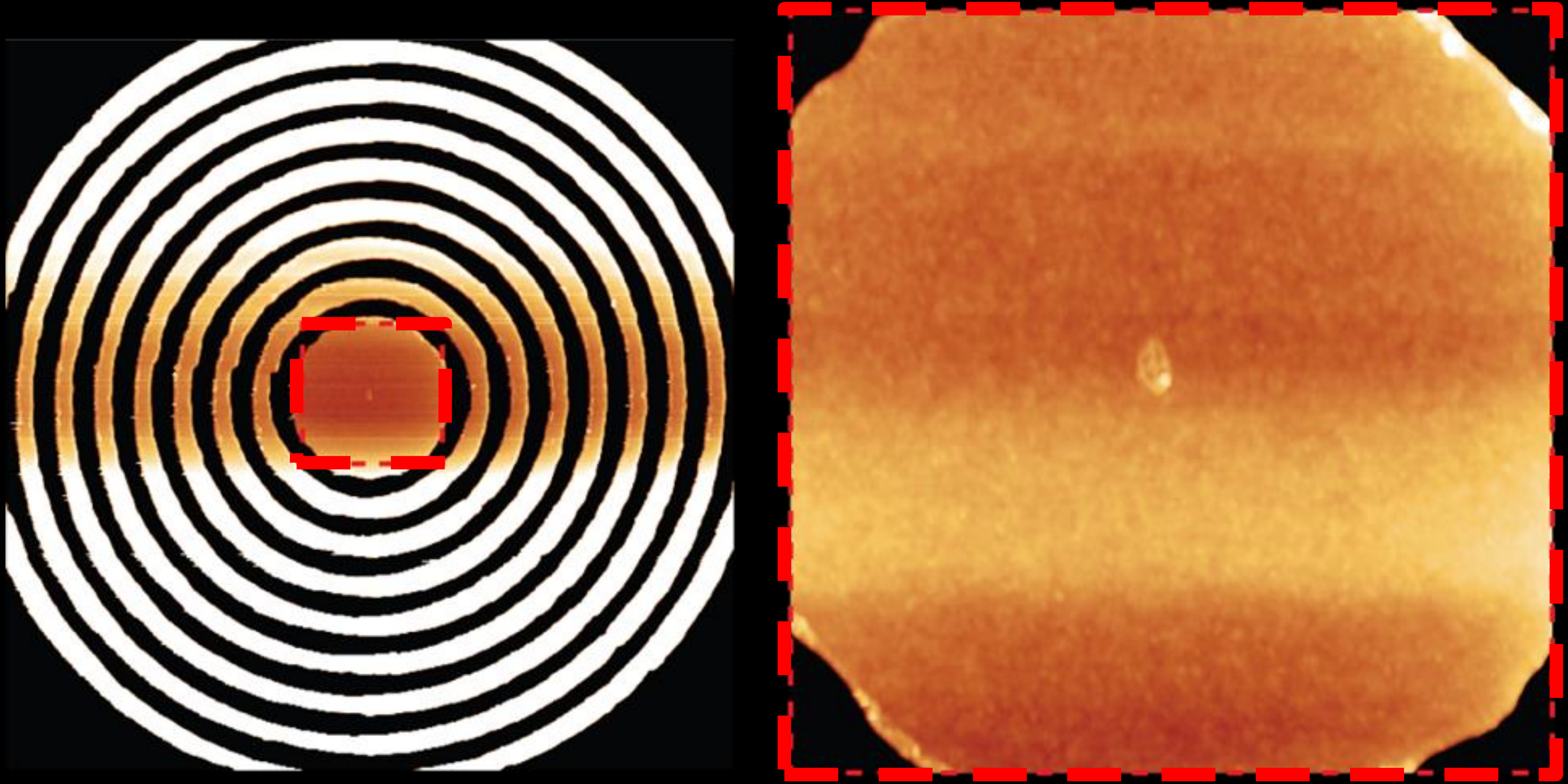
Lithographic patterning of DNA origami on Si







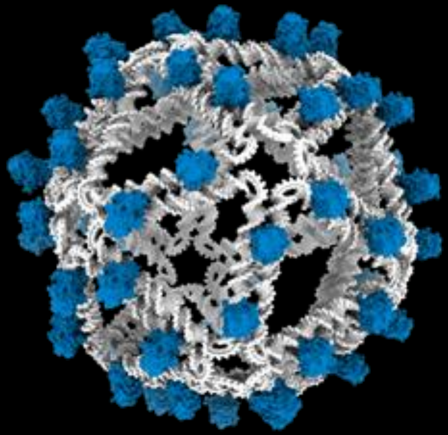
Luo et al.
biorxiv (2026)



Is DNA the next silicon?

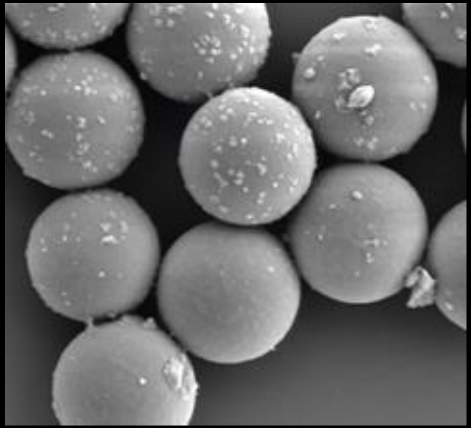
Part I:

Vaccines & active immunotherapies



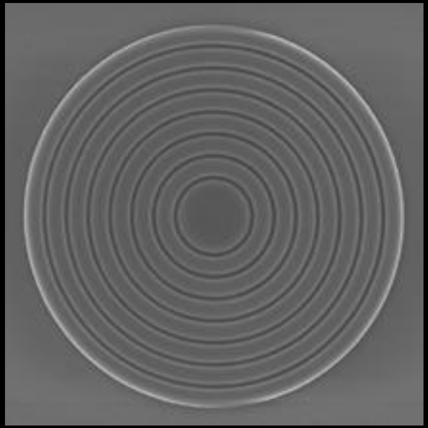
Part II:

Data storage and global genomics

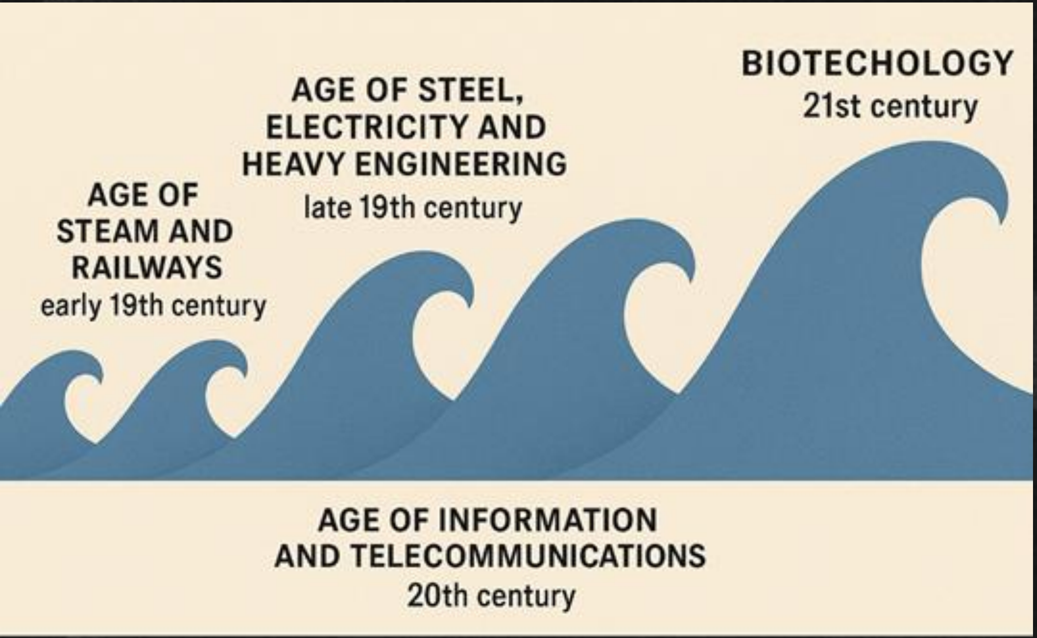


Part III:

Quantum materials



Biotechnology is in its infancy



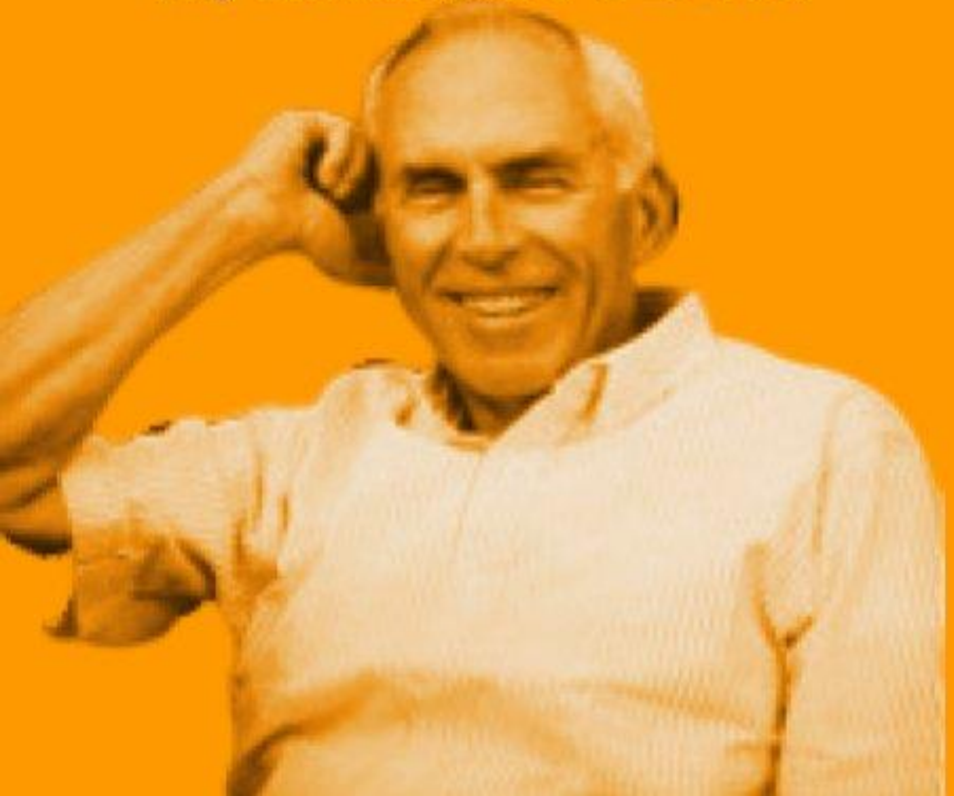
Kondratiev (1926)
Schumpeter (1939)

1950s: DNA structure
1970s: DNA cloning
1980s: DNA synthesis
2000s: DNA sequencing
2010s: DNA editing

Biotech is building on semi-conductors, robotics, AI, etc.

Amara’s Law

Roy Charles Amara 1925-2007



We tend to overestimate the effect of a technology in the short run, and underestimate the effect in the long run.

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Anna Romanov
Eike Wamhoff

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Daniel Lingwood, Ragon Institute & HMS

Quantum collaborators:
Juejun Hu, MIT
Farnaz Niroui, MIT