STORAGE DEVELOPER CONFERENCE
SDC 21
BY Developers FOR Developers

Virtual Conference
September 28-29, 2021

A SNIA Event

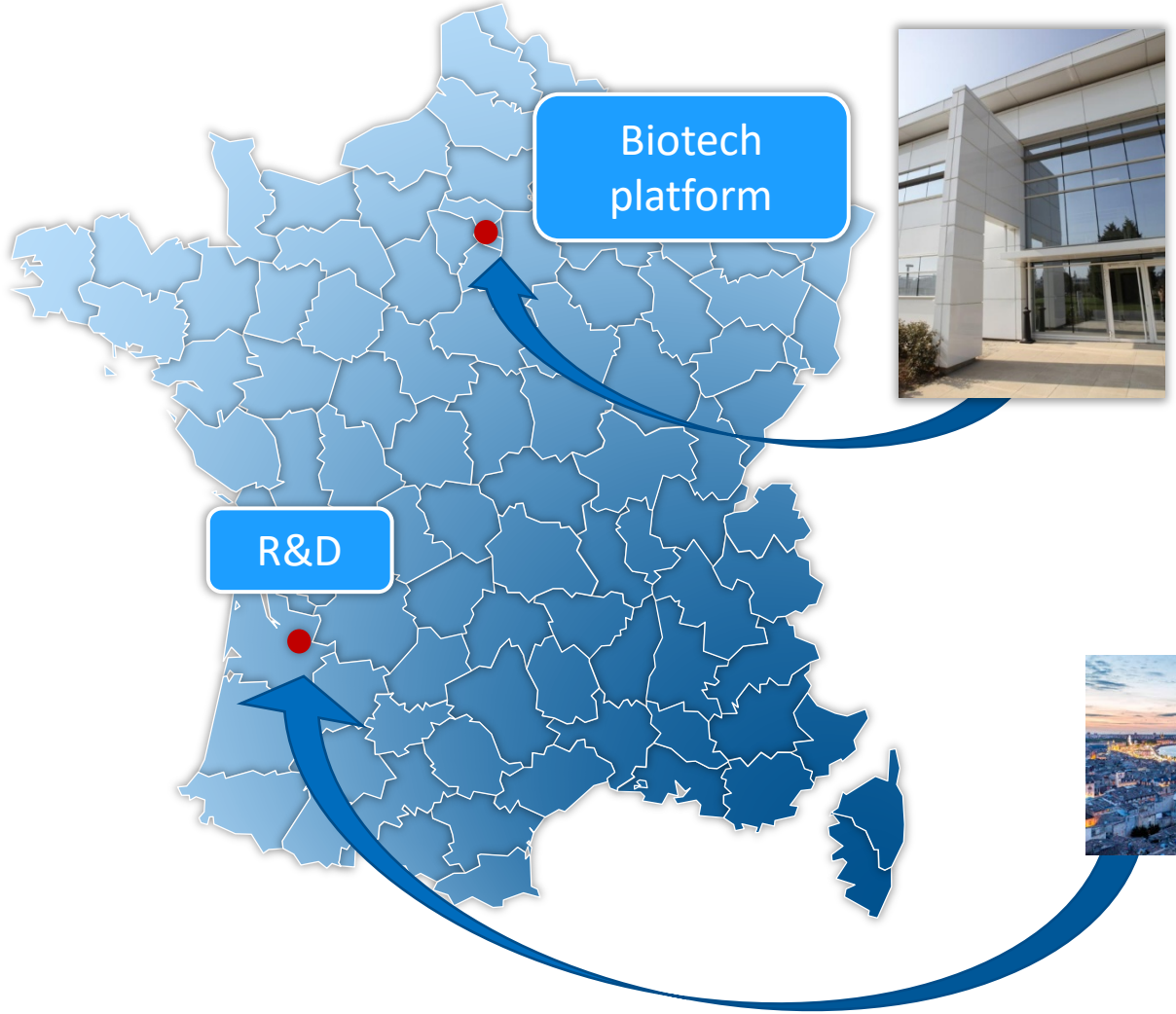
Storing Data over Millennia

Long term Room Temperature Storage of DNA

Presented by Marthe COLOTTE, PhD

imagene

imagene innovative ambient storage of biospecimen



European Biopark
Evry Genopole (Paris)

- 2 sites:
  - Biotech platform
  - R&D Lab

Bordeaux

How to store DNA for the long term?

From literature to industrialization

Current storage approaches

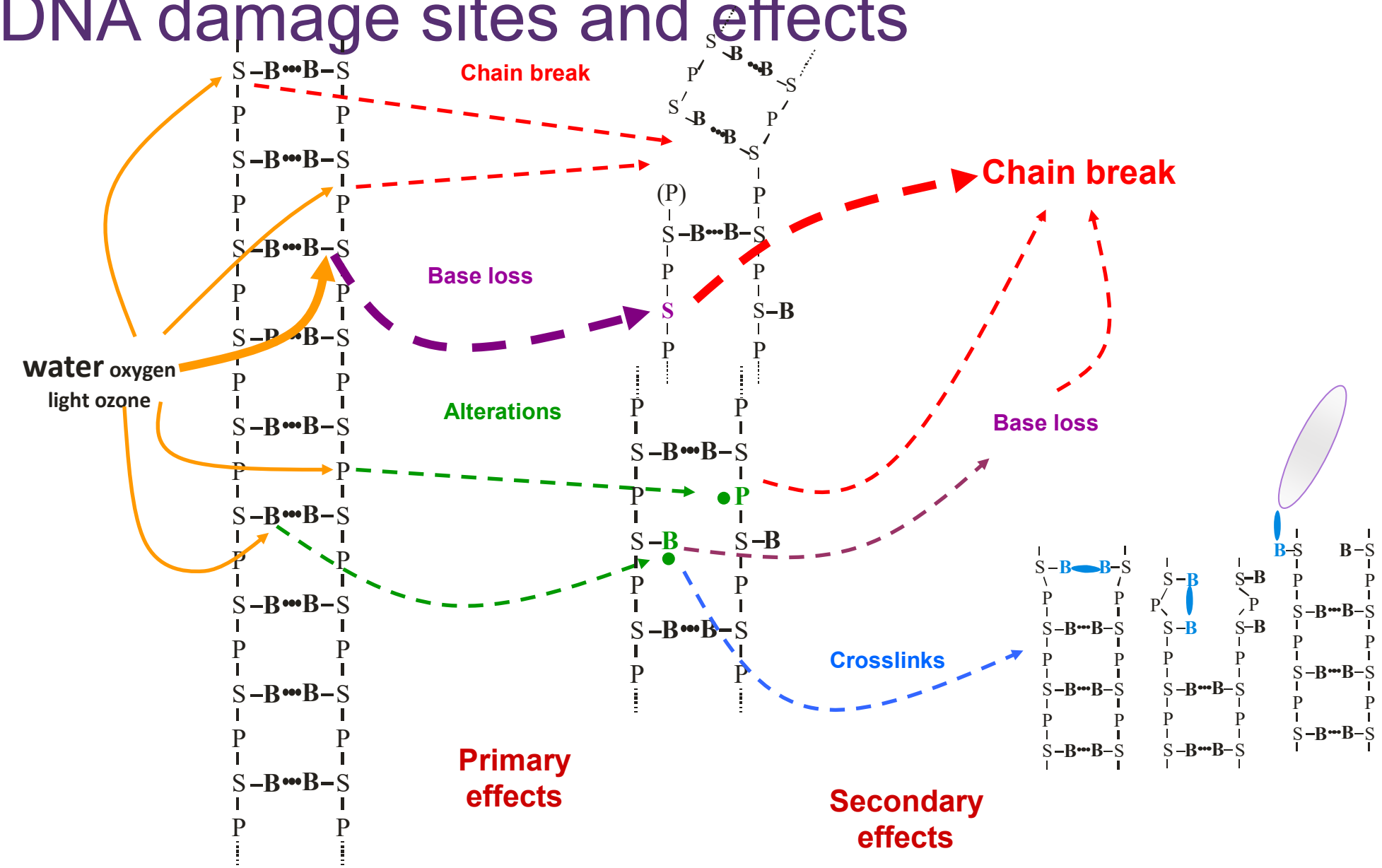
Current storage of DNA in freezers (at -20°C to -80°C)

has major drawbacks

- High costs (electricity, maintenance, air conditioning, alarm, monitoring systems…)
- Difficulty in automating storage and retrieval
- Risks of loss or degradation of precious sample collections/ data due to technical failures (power outage…) or natural disasters

→ Room temperature storage is appealing, but how?

DNA damage sites and effects



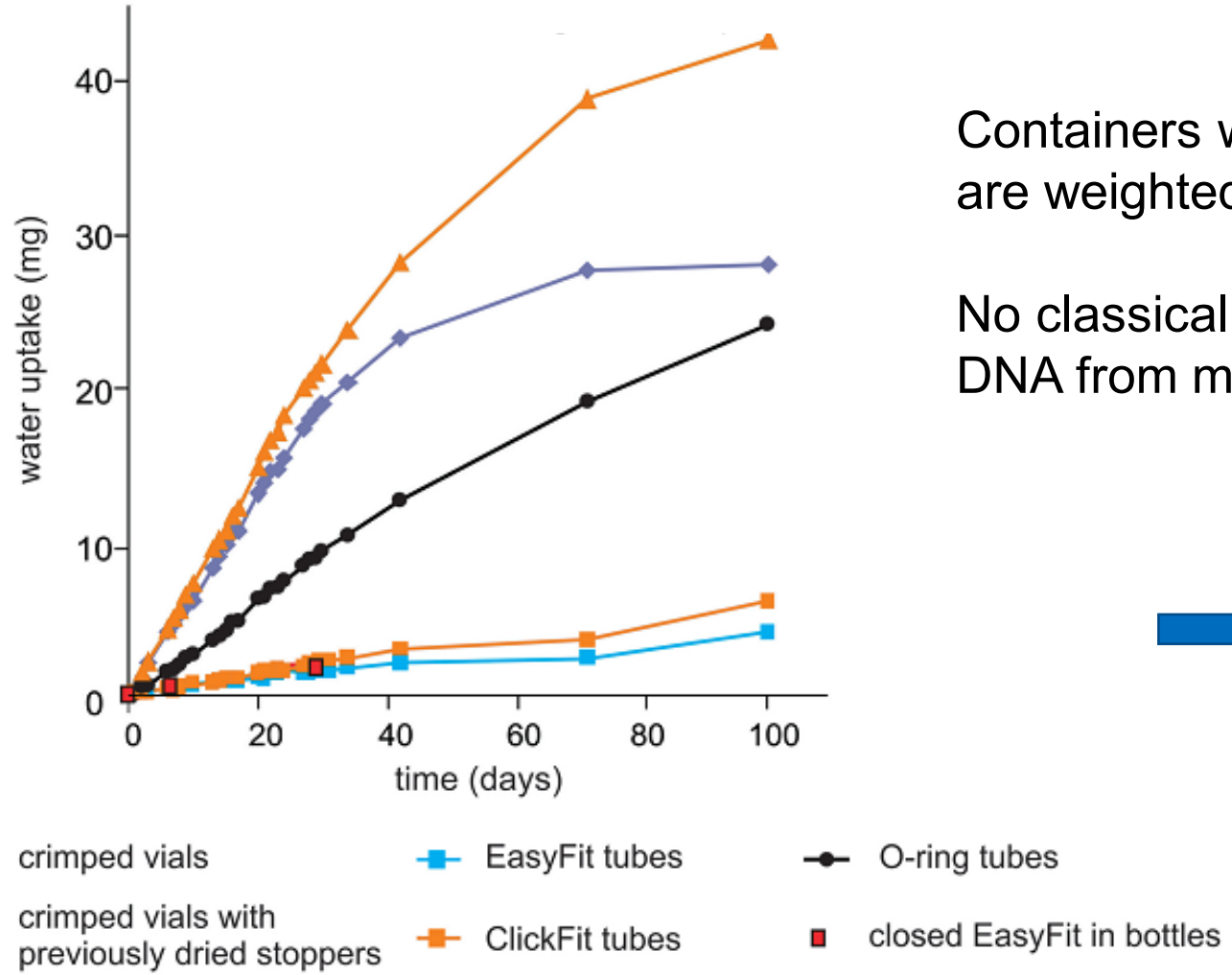
Conclusions on DNA damage

- Main and most deleterious event: depurination followed by chain breakage

- Main degradation factors
  - Water +++
  - Oxygen, ozone, other atmospheric pollutants
  - Contaminants, co-extractants, …

→ Drying the DNA (and keeping it dry) is the solution

Looking for a suitable container



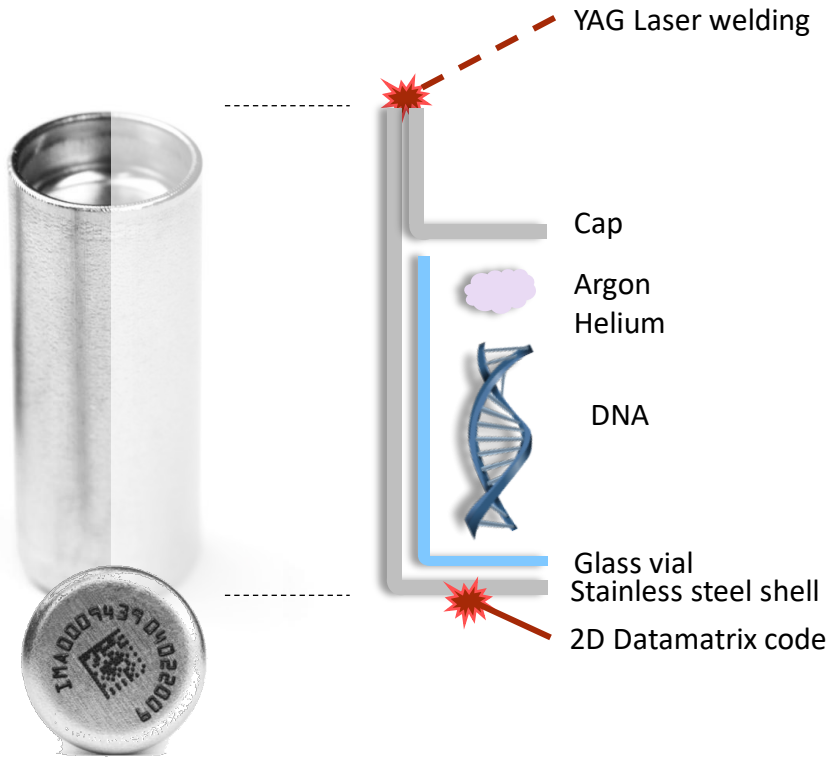
Containers with water sorbent ($CaCl_2$) are weighted as a function of time.

No classical tube or vial is protecting DNA from moisture of the atmosphere.

→ Need for an hermetic container: the DNAshell® minicapsule

The DNAshell® technology

- Imagene stainless steel capsules:
  - metallic shell
  - glass vial
  - metallic cap
- After drying the capsule is sealed by YAG laser welding allowing to maintain the desiccated sample under an inert atmosphere
- 2D barcodes are etched on the capsules for full traceability
- Racks conform to SBS standard (for automation)



0.7 cm^3 (300 µL) – 1.3 g

Process workflow

DNA in solution

QC analysis → Aliquoting → Desiccation → Encapsulation → Sealing control

dna shell

Laboratory Information Management System

Permanent tracking of samples, operations, and minicapsules

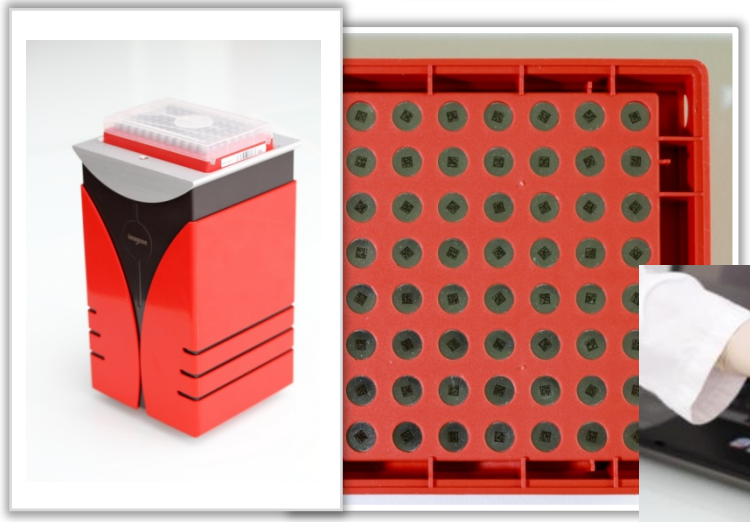
Throughput: ~ 5,000 minicapsules / 8 hours
with the Bioshielder Power® encapsulation station

Storage and use of the capsules

From **ten**
-80°C freezers to **one** storage station

Room temperature semi -automated storage station

Capacity: 250 000 minicapsules / 3 m² footprint



2D code reader:
Decode 1- 96 minicapsules 2D codes in less than 2 seconds.

Cherry picker

shellOpeners

DNA recovery

- Minicapsule opening with a “shellOpener”
- Water or buffer addition for DNA rehydration (no chemical steps)
- Brief solution mixing by pipetting
- DNA ready for use
- Quantitative DNA recovery from pg to mg

Portable shellOpener

Benchtop shellOpener

Advantages

Easy access

Room temperature manual and automated storage

Energy saving

No energy consumption, no need for air conditioning nor specific infrastructure

Tracking

Laser etched, duplication-proof 2D barcode.

Integrity and stability

Samples are fully protected from water, oxygen and light effects. Easy recovery.

Secured access

Each minicapsule is individually sealed by laser beam. No accidental opening or cross-contamination.

Cost savings

Less space required. No additional cost once the samples are encapsulated.

Easy and sustainable logistics

No more temperature controlled shipment.

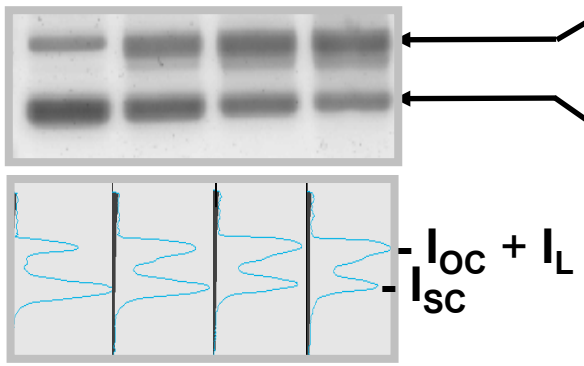
Stability studies and publications

Validation of the technology

Measuring chain breaking

SCC= supercoiled plasmid

$SCC = I_{SC} / (I_{OC}+I_L+I_{SC})$



Gel, profiles, and SCC determination

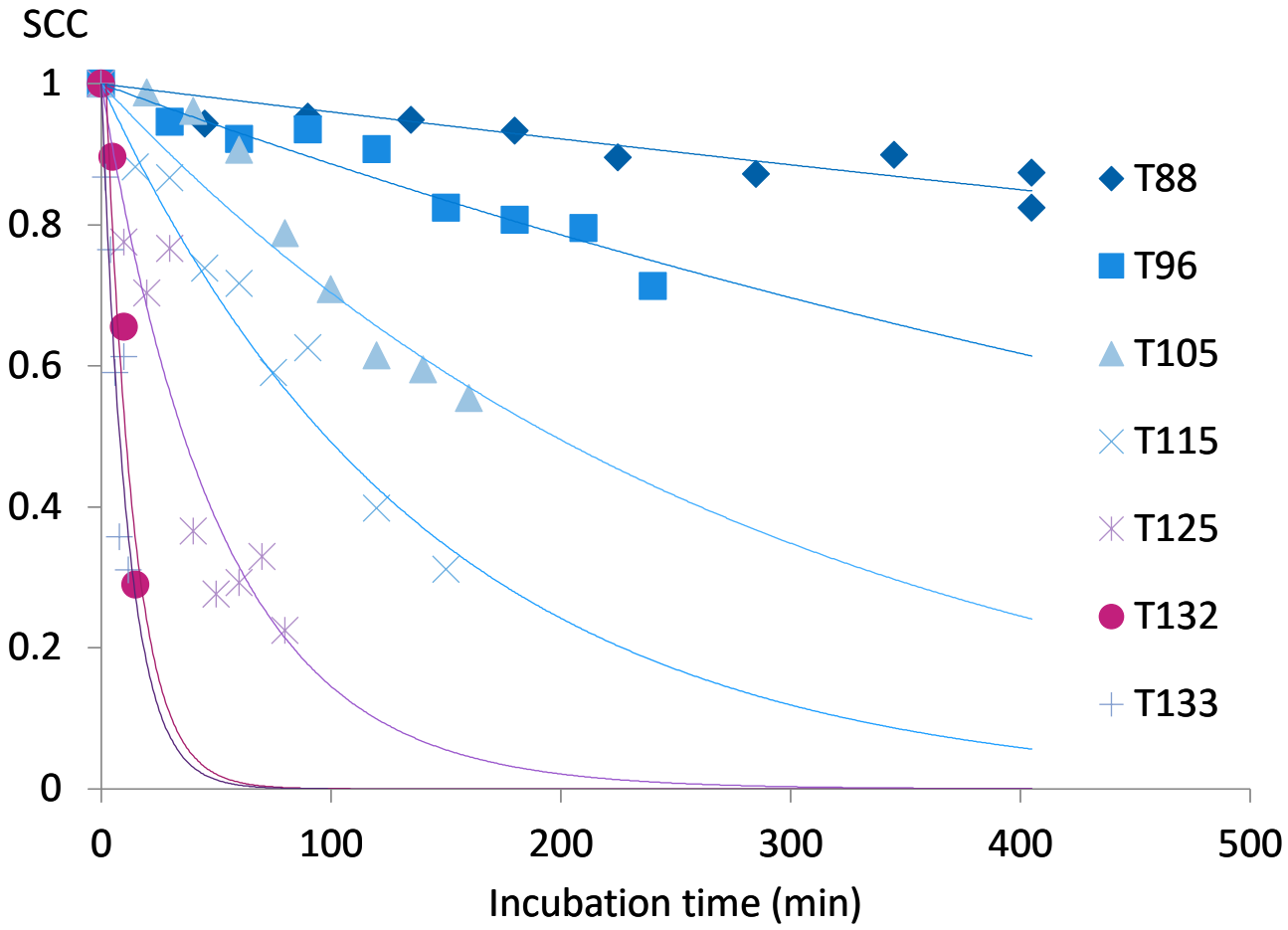
Open circle
OC

Supercoiled
SC

$SCC = e^{-k_T \times t \times (n-1)}$

- *SCC*
- k_T: s^{-1}. nt^{-1}
- t: s
- n: plasmid size (nt)

Accelerated degradation studies



Exponential curve fitting:

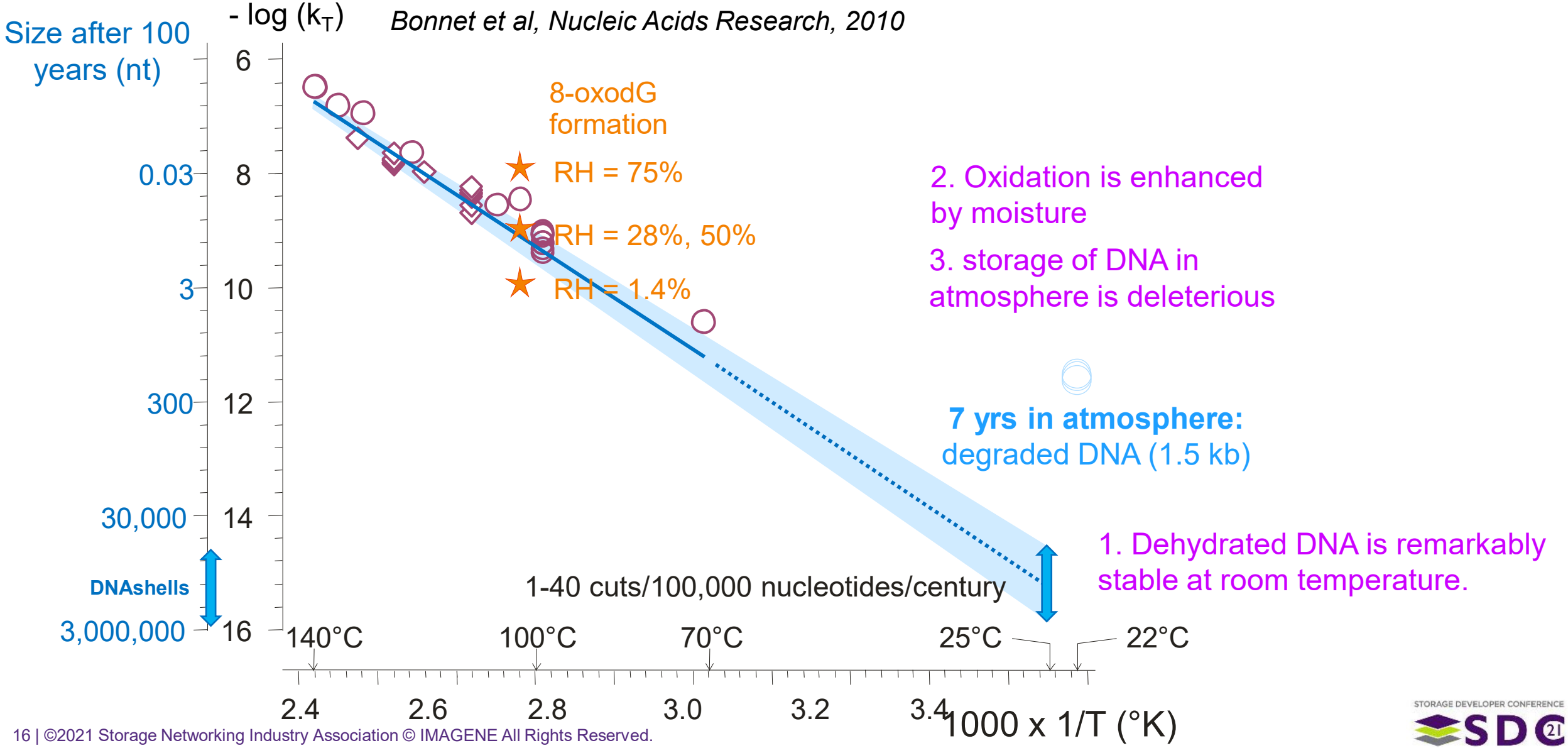
$SCC = \exp[-k_T \times t \times (n-1)]$

→ k_T determination for each incubation temperature T

↓

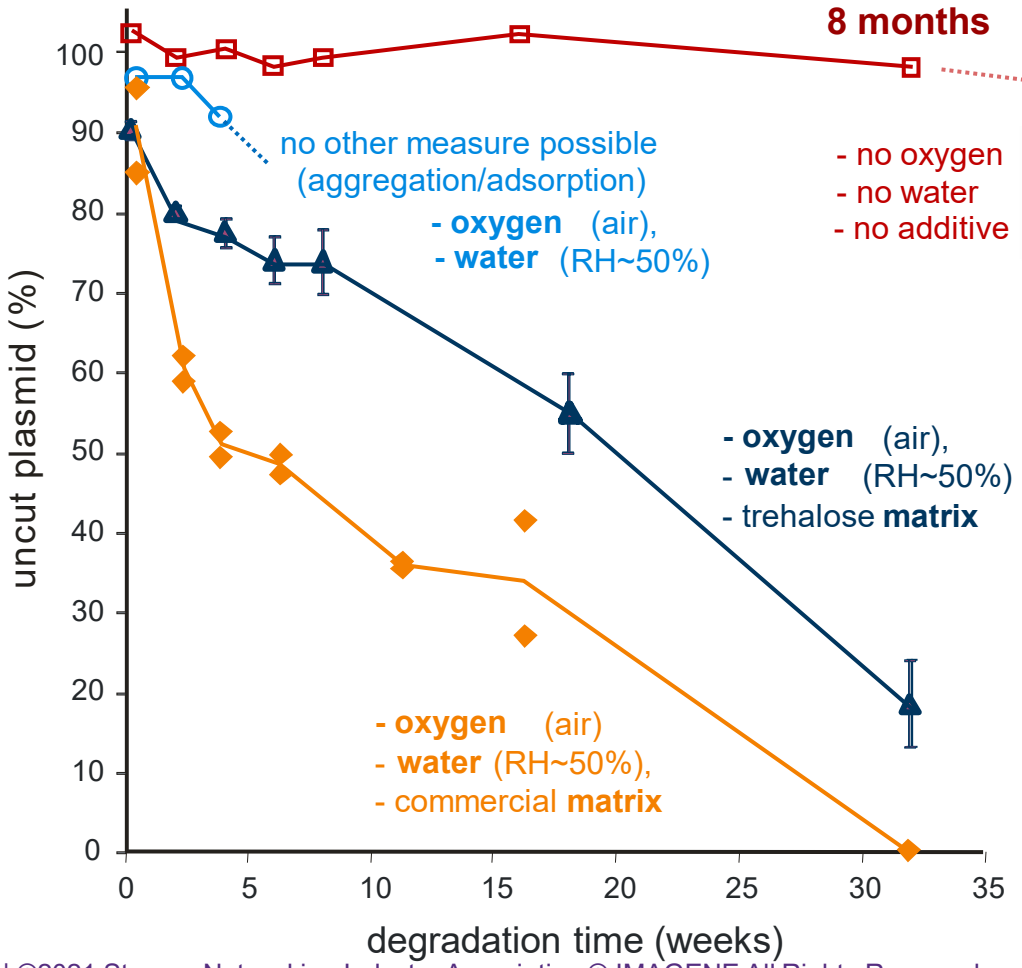
Arrhenius plot

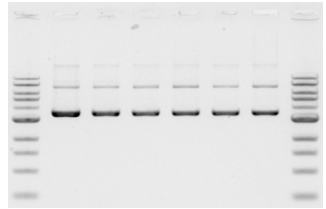
Arrhenius plot (dehydrated DNA)



Real time room temperature study

Confirmation of deleterious effect of atmosphere and DNA stability at RT





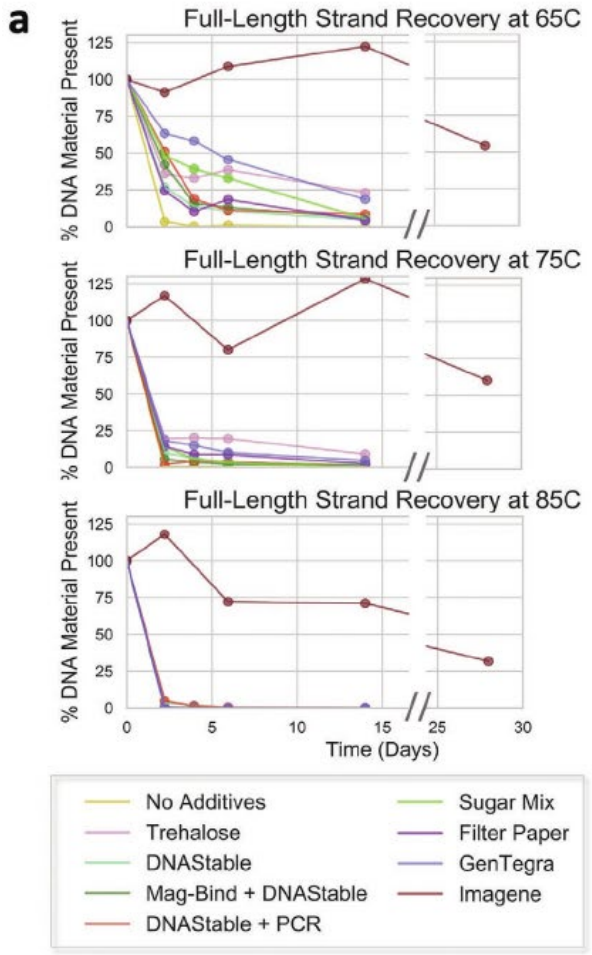
- Adverse effect of air exposure
  - Aggregation
  - Rapid degradation
- DNAshell® affords an efficient protection

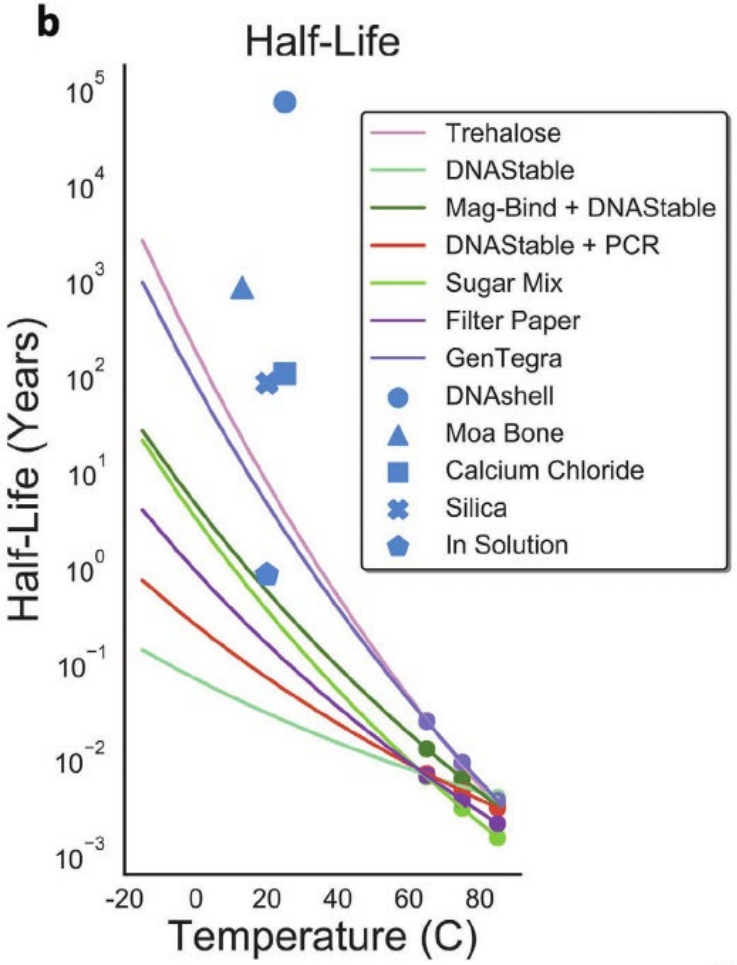
Colotte et al, Biopreservation and biobanking, 2011

External validation of DNAshell® for data storage

Organick et al. 2021 - by Microsoft Research, University of Washington and ETH-Zurich

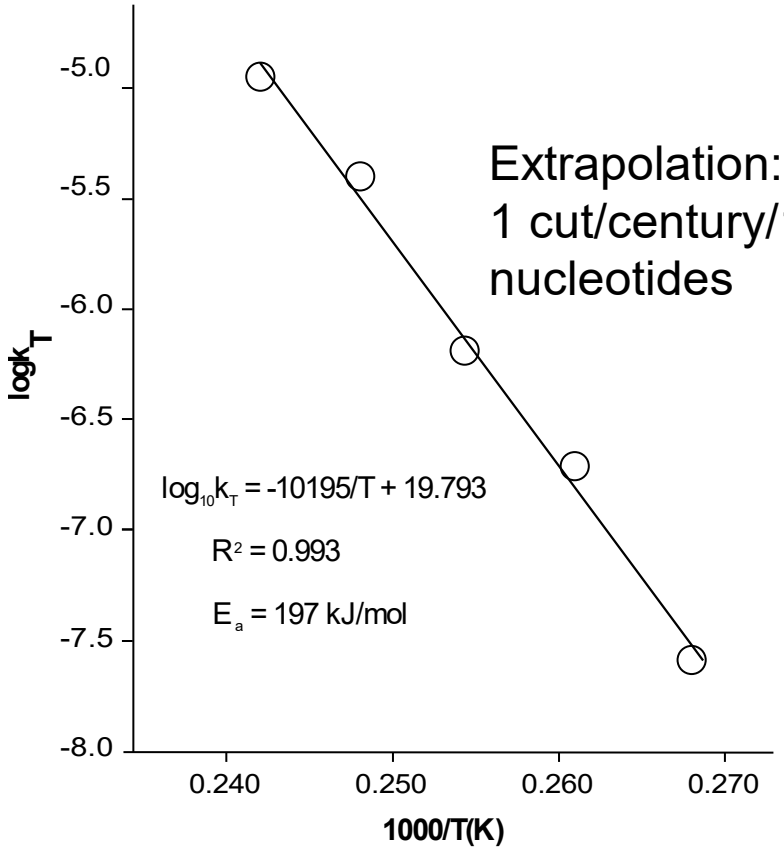
- Accelerated ageing on 29,000 DNA sequences
  - qPCR
  - Sequencing
- DNAshell® brings the best stability (higher half lives)



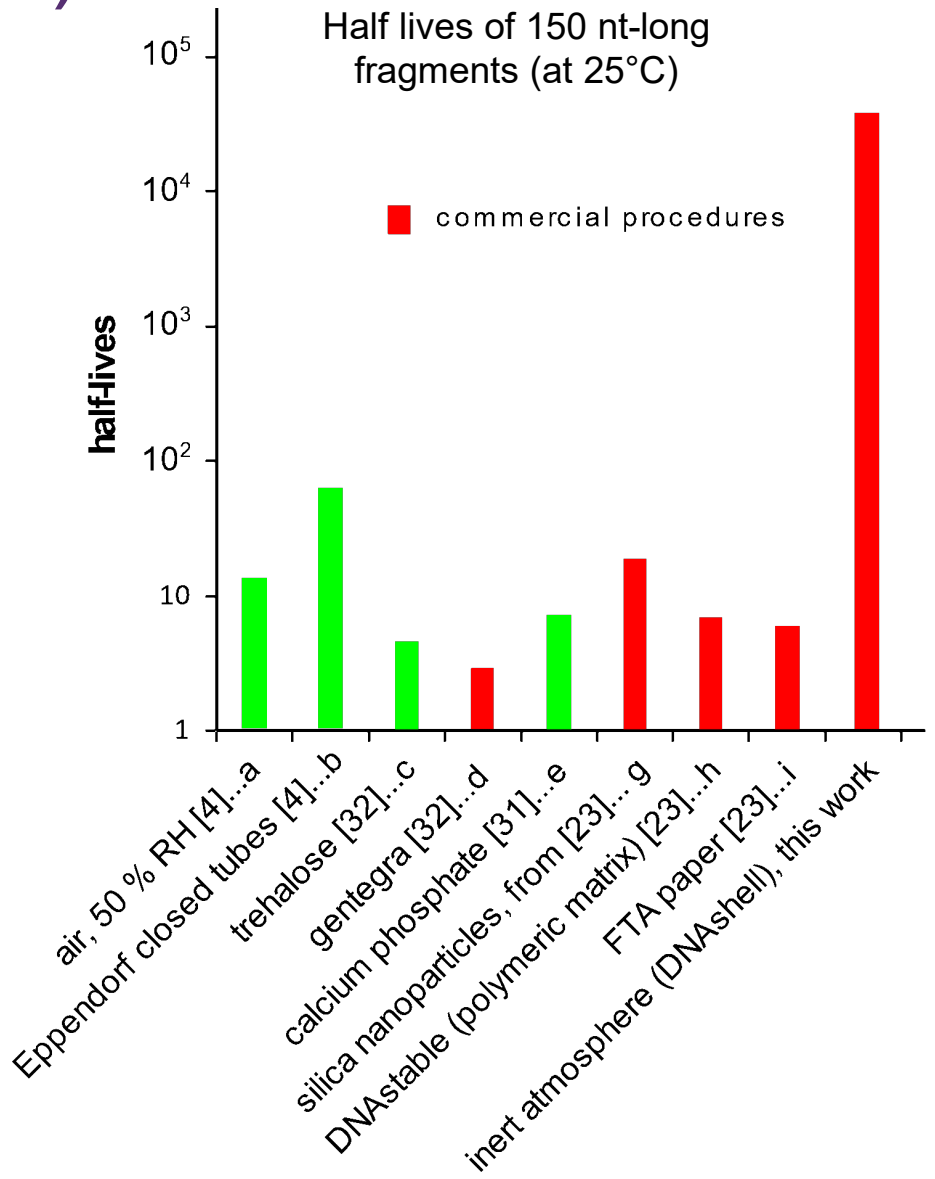


Arrhenius plot (DNAshell®)

With a 2-size amplicon qPCR system, determination of k_T at each temperature T



Extrapolation:
1 cut/century/100,000 nucleotides



First application to DNA data storage

UNICEF Norway initiative

To celebrate the 30-year anniversary of the *United Nations Convention on the Rights of the Child*

- Text encoded by *EMBL-EBI*, UK
- DNA synthesis by *Twist Bioscience*, CA
- DNA encapsulation by *Imagene*, FR
- Storage in Norway

Conclusions

- Technical superiority concerning DNA stability
- The technology is mature, extensively validated, and industrialized
- Already usable and used for DNA data storage (cold data, large amounts,…)

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