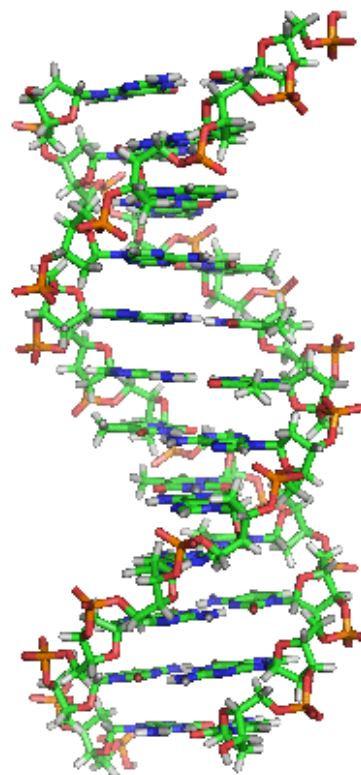
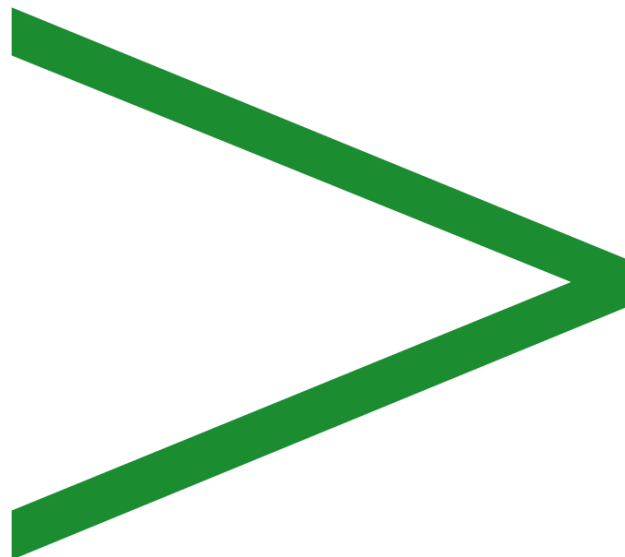
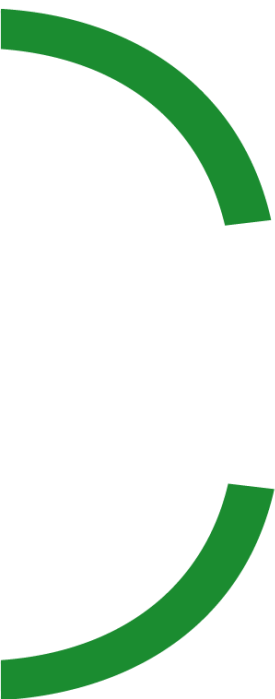


# L'ADN : une solution pour la préservation à long terme des publications et données de la recherche



# Introduction



Tablette Babylonienne au [British Museum](https://www.britishmuseum.org/) , décrivant la [Comette de Halley](https://en.wikipedia.org/wiki/Halley's_comet) en 164 av. J.-C.

[https://en.wikipedia.org/wiki/History\\_of\\_astronomy](https://en.wikipedia.org/wiki/History_of_astronomy)

Que restera-il des publications ou données de recherche Dans 1000 ans ?

# Archivage numérique

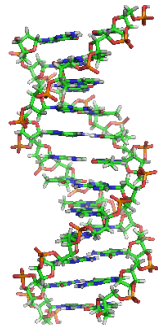
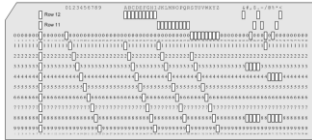


Torre de Pisa

préservation numérique  
=  
édifice complexe  
(ISO 14721...)

stockage  
=  
fondation

# Obsolescence technologique



« Tout ce qui est vrai pour  
le colibacille est vrai pour  
l'éléphant »

Jacques Monod

Prix Nobel Biologie, 1965

# Durabilité du stockage

Disques / bandes: durée de vie de 5-7 ans



- Dépend d'énergie (continu)
- Dépend du minage (continu)
- Sensible champs magnétiques (p.ex. éruptions solaires)





Energie et émissions CO2



Mines terres rares



E-décharege (Ghana)



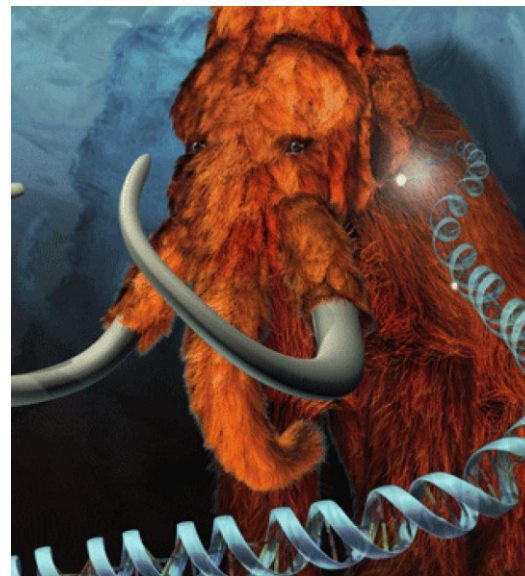
Datacenter (Phoenix, USA)

# Durabilité de l'ADN



Demi-vie d'environ 500 ans dans les cadavres d'insectes.

<https://www.futura-sciences.com/sante/actualites/genetique-demi-vie-adn-parle-dinosaures-ne-reviendront-pas-41796/>




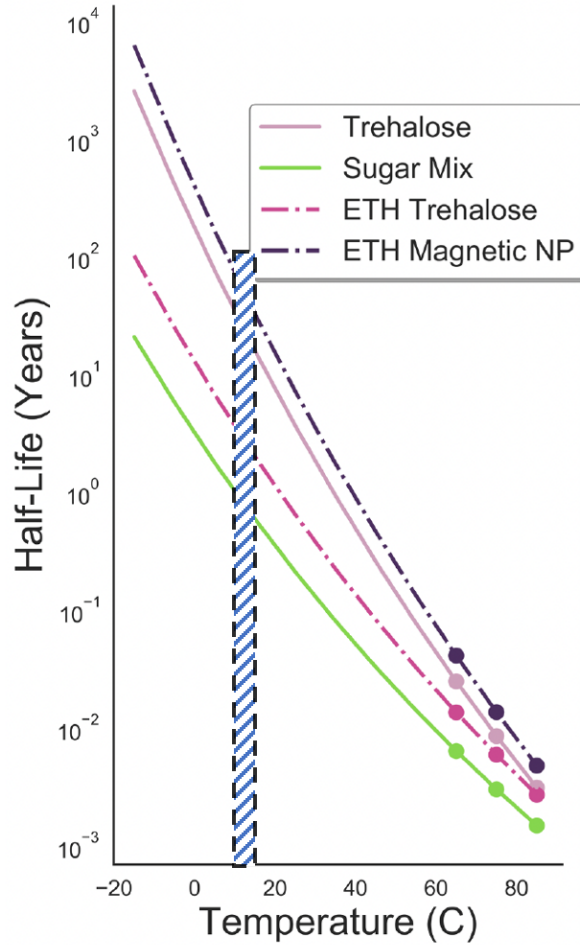
L'ADN des mammoths, disparus il y a 5000 ans, a été reconstitué.

[https://www.sciencesetavenir.fr/fondamenta/l-adn-du-mammoth-laineux-reconstitue\\_6142](https://www.sciencesetavenir.fr/fondamenta/l-adn-du-mammoth-laineux-reconstitue_6142)

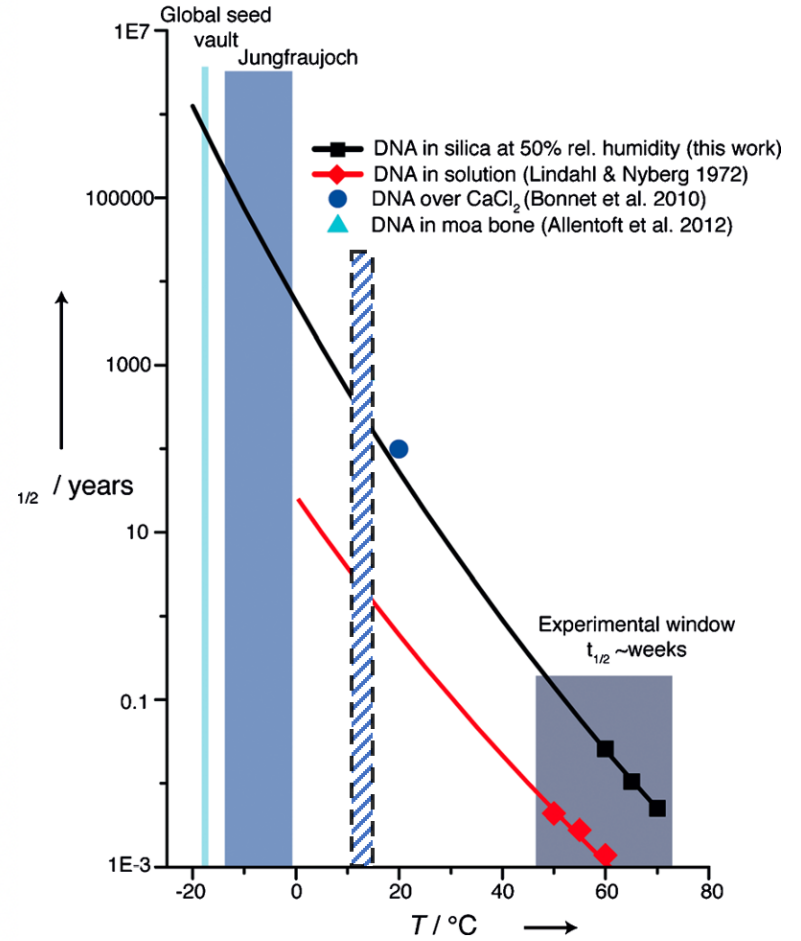


# Storage preservation: Depends on process & temperature

 Target temperature range



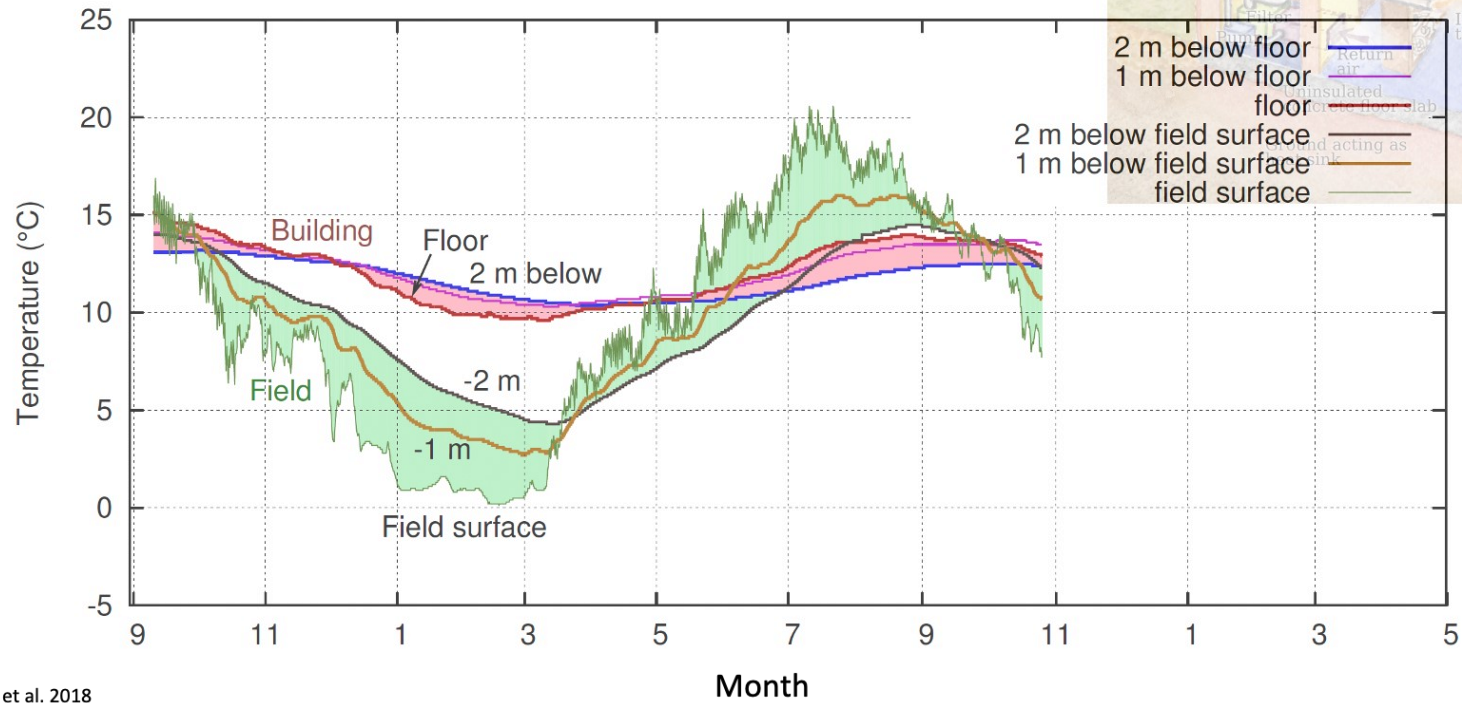
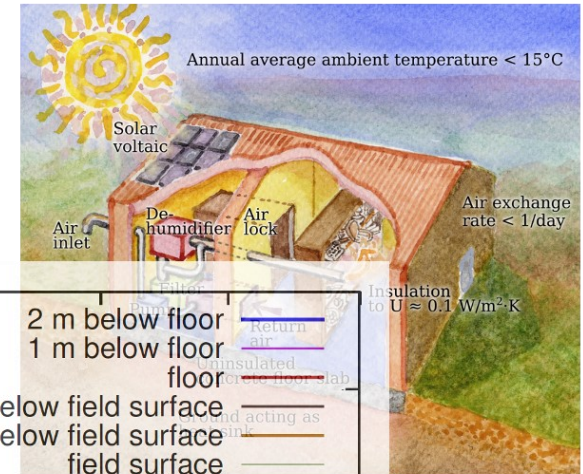
Organick et al. 2020



Grass et al. (2015)

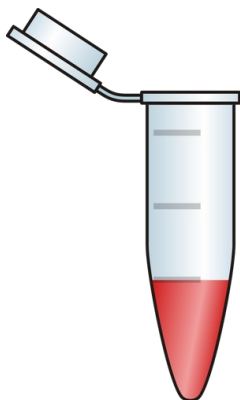


# No energy to keep information



From Padfield et al. 2018

# Densité de stockage



1 gramme d'ADN peut contenir 215 Pétaoctets.  
(215'000 Téractets = 215 millions de Gigaoctets)



Quelques grammes suffisent pour couvrir les besoins de l'ensemble de la Suisse en terme de données de recherche, publications et archives patrimoniales.

# Science fiction?



[Why DNA](#) [About Us](#) [Members](#) [Resources](#) [News & Events](#) [Contact Us](#)



## SNIA Announces DNA Data Storage Technology Affiliate

DNA Data Storage Alliance Joins SNIA and Begins Technical Work to Create an Interoperable DNA Data Storage Ecosystem.

[READ MORE](#)



## The DNA Data Storage Alliance releases their first whitepaper

We are thrilled to share with you our first whitepaper – **Preserving our Digital Legacy: An Introduction to DNA Data Storage.** The whitepaper covers all the basics and more of DNA data storage.

[READ MORE](#)



## Webinar: Archival Storage Futures

On November 20th, 2020 we participated in a webinar hosted by Small Data Industries to talk about the future of digital storage, DNA Data Storage, and decentralized storage. Click to see what's new and what's next in digital storage.

[WATCH NOW](#)

# illumina®

## Illumina

Illumina is improving human health by unlocking the power of the genome. Our focus on innovation has...



## Twist Bioscience

At Twist Bioscience Corporation, we work in service of customers who are changing the world for the better...

# Microsoft

## Microsoft

Microsoft (Nasdaq "MSFT" @microsoft) enables digital transformation for...

## Western Digital

## Western Digital

About the company: Western Digital creates environments for your data to thrive. As a leader...

# La question n'est pas de savoir *si* mais *quand* le stockage ADN sera largement utilisé.



Archives Cantonales Vaudoises

<https://dnastoragealliance.org/>

 <b>imagine</b> Imagine offers a distinctive technology for custom targeted preservation of DNA-based... <a href="#">READ MORE</a>	 <b>Molecular Assemblies</b> Molecular Assemblies, Inc. is a private biotech company developing an enzymatic DNA synthesis technology... <a href="#">READ MORE</a>	 <b>OLO5</b> OLO5 is a fully integrated data management system designed for researchers and institutions. Powerful yet easy to use... <a href="#">READ MORE</a>	 <b>Quantum</b> Quantum technology and services help customers capture, create and share digital content... <a href="#">READ MORE</a>
 <b>Seagate</b> Seagate is creating the solutions with game-changing technology. Seagate is at the... <a href="#">READ MORE</a>	 <b>MilliporeSigma</b> MilliporeSigma is a global life science leader with solutions and services for research, biotechnology, development and... <a href="#">READ MORE</a>	 <b>MISL</b> Molecular Information Systems Lab @ UW <a href="#">READ MORE</a>	 <b>Oligo Archive</b> Oligo Archive is a data management solution for oligo synthesis... <a href="#">READ MORE</a>
 <b>Los Alamos National Laboratory</b> Los Alamos National Laboratory is a premier research and development organization... <a href="#">READ MORE</a>	 <b>Cinématique Suisse</b> Cinématique Suisse is the national film archive in Switzerland. It preserves, archives and... <a href="#">READ MORE</a>	 <b>21eS</b> 21eS is a pioneering computational platform - competitive with leading... <a href="#">READ MORE</a>	 <b>DNALI</b> DNALI Data Technology is a private biotech company working on... <a href="#">READ MORE</a>
 <b>ICMS @ Eindhoven University</b> The Institute for Complex Molecular Systems (ICMS) at the Eindhoven University of Technology focuses on... <a href="#">READ MORE</a>	 <b>Information Storage &amp; Memories @ Technion</b> The Information Storage and Memories (ISM) at the Technion - Israel Institute of Technology is... <a href="#">READ MORE</a>	 <b>BioMemory</b> BioMemory is working with the customers to meet the challenge of... <a href="#">READ MORE</a>	 <b>Gupta Lab @ DA-ICT</b> Research in our lab currently focuses on aspects of information processing... <a href="#">READ MORE</a>
 <b>Lab4ISC</b> Lab For Intelligent Storage & Computing @ OSU The lab for Intelligent Storage and Computing at Ohio State University focuses on the emerging storage and computing... <a href="#">READ MORE</a>	 <b>Yakubovskiy Group @ Technion &amp; Reichman IIS</b> The Yakubovskiy research group is an active information and data science research group. Our current research includes computational aspects of... <a href="#">READ MORE</a>	 <b>eurEARE</b> eurEARE is a company dedicated to meeting the bio-coding edge... <a href="#">READ MORE</a>	 <b>cacheDNA</b> Cache DNA provides a unique solution for multi-user editing and... <a href="#">READ MORE</a>
 <b>DNAalgo</b> DNAalgo is the leader in the Application of the most sophisticated tools of the Information Theory to the DNA... <a href="#">READ MORE</a>	 <b>DIGITAL BEDROCK</b> Digital Bedrock provides digital preservation services. Complete... <a href="#">READ MORE</a>	 <b>BIO ECHO</b> BioEcho Life Sciences is a specialized provider for the extraction and analysis of nucleic acids... <a href="#">READ MORE</a>	 <b>ICOS Research Group - Newcastle University</b> We conduct research at the interface of computational science and... <a href="#">READ MORE</a>
 <b>Dell Technologies</b> Dell Technologies <a href="#">READ MORE</a>	 <b>Digital Preservation Coalition</b> Digital Preservation Coalition <a href="#">READ MORE</a>	 <b>PFU</b> PFU America, Inc. <a href="#">READ MORE</a>	 <b>CATALOG</b> Catalog <a href="#">READ MORE</a>
 <b>University of Marburg</b> Forward-looking together with high academic standards... <a href="#">READ MORE</a>	 <b>Fujifilm</b> The Fujifilm Group of companies averages the depth of... <a href="#">READ MORE</a>	 <b>University of Antwerp</b> The research conducted at the University of Antwerp... <a href="#">READ MORE</a>	 <b>University of Arizona Center For Applied Nanobiotechnology and Medicine</b> The University of Arizona Center for Applied Nanobiotechnology and... <a href="#">READ MORE</a>
 <b>IBM</b> IBM is a leading global hybrid cloud and AI and consulting provider... <a href="#">READ MORE</a>	 <b>DNA Script</b> Founded in 2014 by DNA Script... <a href="#">READ MORE</a>	 <b>Lenovo</b> Lenovo is a leading global technology company... <a href="#">READ MORE</a>	



# Application prochaine



Stockage ADN pour datacenter  
(pour dans 1-2 ans)  
(avec protocoles standards p.ex. S3)

<https://dnastoragealliance.org>



# Projet local



Archives  
Cantoniales  
Vaudoises

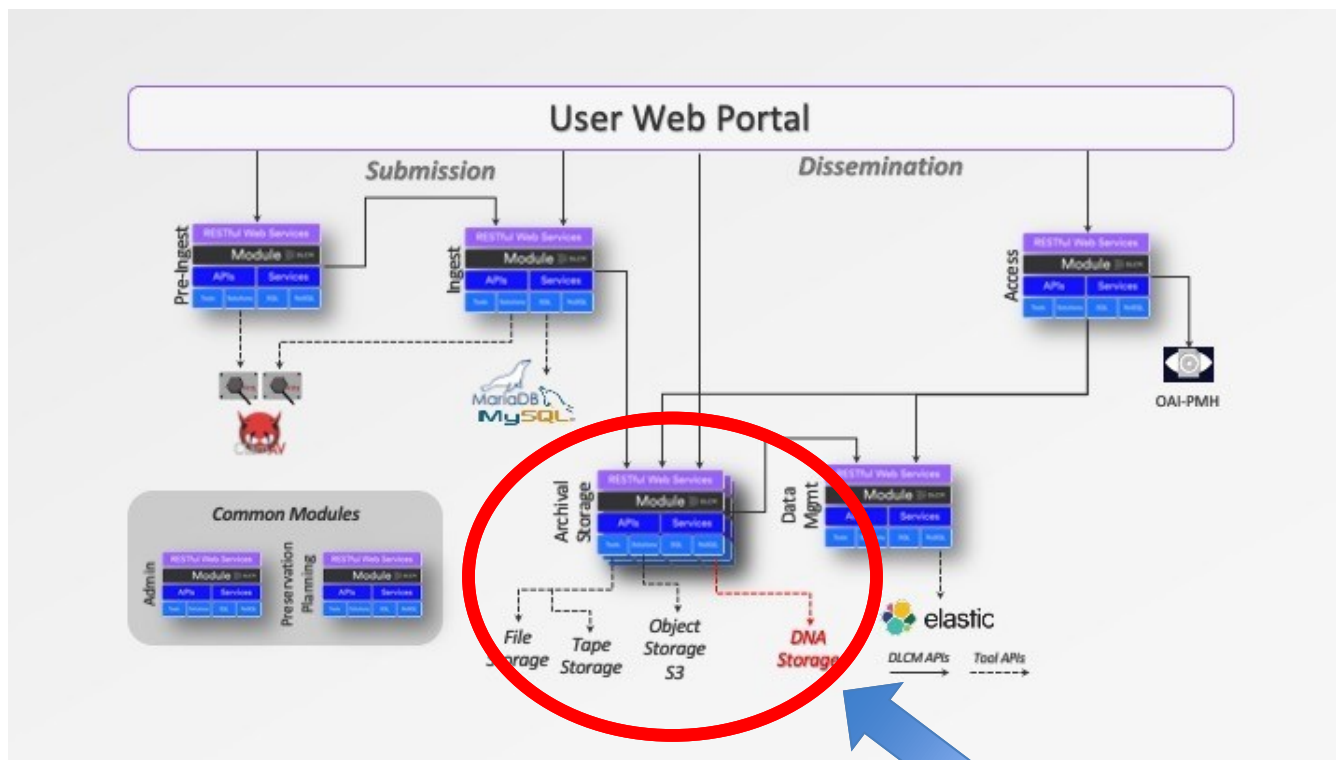


UNIVERSITÉ  
DE GENÈVE

h e g

Haute école de gestion  
Genève

haute école **arc**<sup>+</sup>  
neuchâtel berne jura



Archives  
Cantoniales  
Vaudoises

<https://olos.swiss>

**Idée**  
Stockage hybride  
ADN / magnétique

# Encodage / Décodage



## Bases scientifiques

- Heckel & al. *A Characterization of the DNA Data Storage Channel*. Scientific Reports. 2019.
- Meiser & al. *Reading and writing digital data in DNA*. Nature Protocols. 2020.



## Code durable

- Pur python
- Pas de dépendences
- Reed-solomon error correcting codes (CD, DVD, BlueRay, RAID-6, ADSL...)
- Documenté



## Open source

- <https://github.com/jbkrause/archive2dna>





# Application – demandes finiacements



Archives  
Cantoniales  
Vaudoises



UNIVERSITÉ  
DE GENÈVE

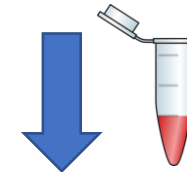
h e g

Haute école de gestion  
Genève

haute école **arc**<sup>+</sup>  
neuchâtel berne jura

- ⇒ Mico-usine
- ⇒ Synthèse et séquençage
- ⇒ Tubes contenant les données
- ⇒ Stockage en dépôt d'archives

<https://olos.swiss>



# Approche alternative

—G—Y—O—C

Grow Your Own Cloud

=> Produit de l'oxygène

=> Utilise énergie solaire

<https://growyourown.cloud>



# Cultiver les données pour les préserver



Le plus grand potager historique de Suisse – Musée national, Château de Prangins





Tour de l'Ale, Lausanne.  
Construction: 1340

«Édifice» de  
préservation  
numérique  
stable et durable,  
incluant un média  
pérenne.

