Everything you wish you were: A Tardigrade!

Daniele Mattei, PhD

What Are Tardigrades?

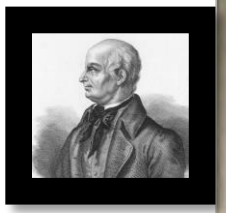
They are small**, opportunistic organisms.**

•Microscopic, invertebrate, water-dwelling organisms

they are typically 0.3 to 0.5 mm (0.012 to 0.020 in) in length.

•Discovered in 1773 by German zoologist Johann Goeze who named them “Kleiner Wasserbär” (small water bear).

•In 1776 Italian biologist Lazzaro Spallanzani called them Tardigrada from Latin tardi (slow) gradi (step) because of their slow-moving behavior.



Where do we place Tardigrades?
What kind of creature are they?

- **Kingdom**: Animalia

Multicellular organisms with differentiated tissues and heterotrophic lifestyles (relying on external food sources).

- **Phylum**: Tardigrada

Tardigrada is their unique phylum, making them distinct from all other organisms. More than 1,300 described species.

- **Superphylum**: Ecdysozoa

Tardigrades are grouped with other molting animals (e.g., arthropods and nematodes). This shared characteristic links them evolutionarily.


Why are we talking about tardigrades?

JOURNAL ARTICLE

Highlight: Tardigrades and the Science of Extreme Survival

Casey McGrath

Genome Biology and Evolution, Volume 16, Issue 1, January 2024, evad234,
https://doi.org/10.1093/gbe/evad234
Published: 19 January 2024 **Article history**

ANNUAL REVIEW OF ANIMAL BIOSCIENCES Volume 10, 2022

Review Article | Free

Examples of Extreme Survival: Tardigrade Genomics and Molecular Anhydrobiology

Kazuharu Arakawa[1,2,3,4]

ELSEVIER

Biomedicine & Pharmacotherapy

Volume 158, February 2023, 114063

Review

The biomedical potential of tardigrade proteins: A review

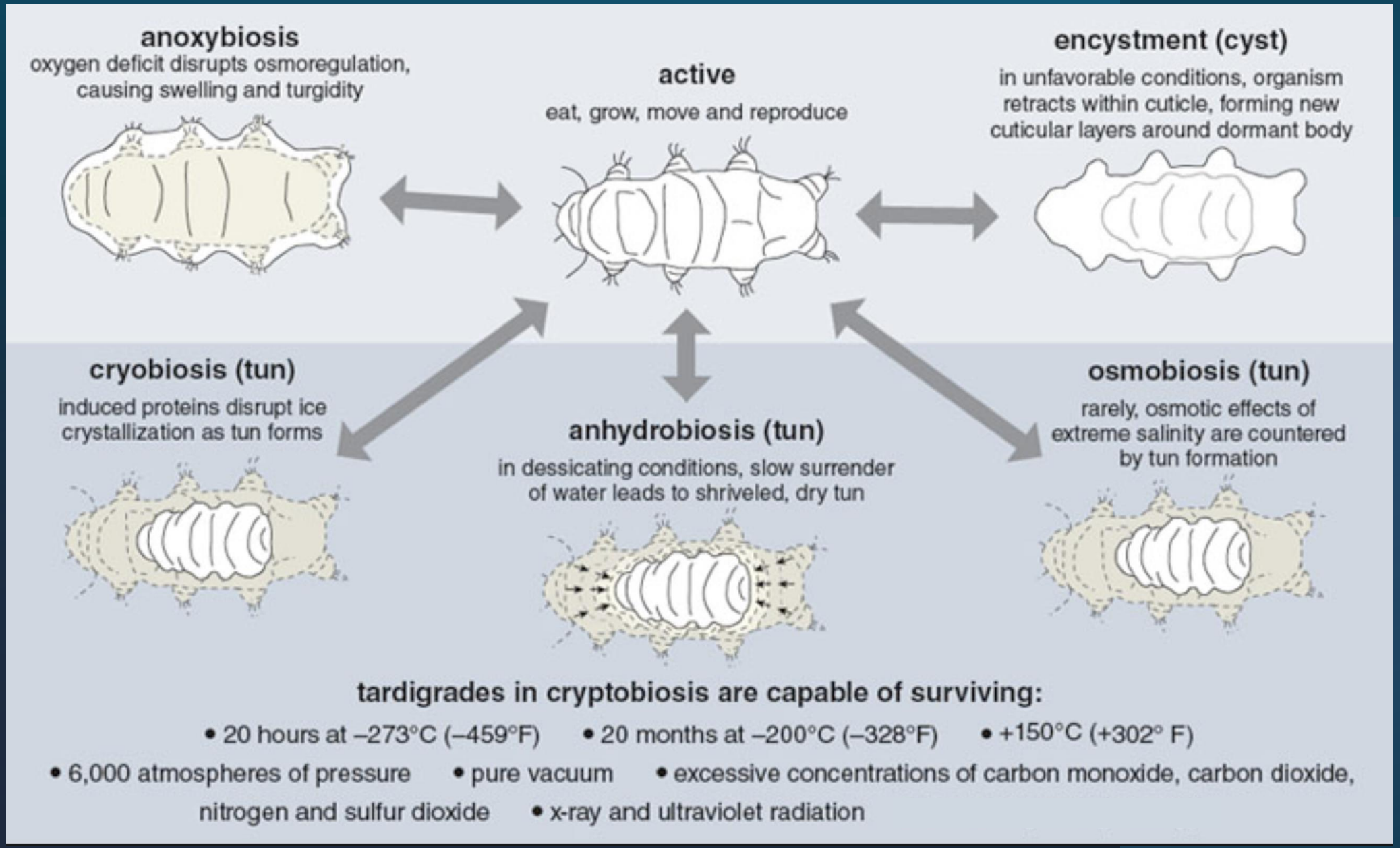
Nadiia Kasianchuk [a b], Piotr Rzymski [c d], Łukasz Kaczmarek [a]

Improvise, Adapt and Overcome

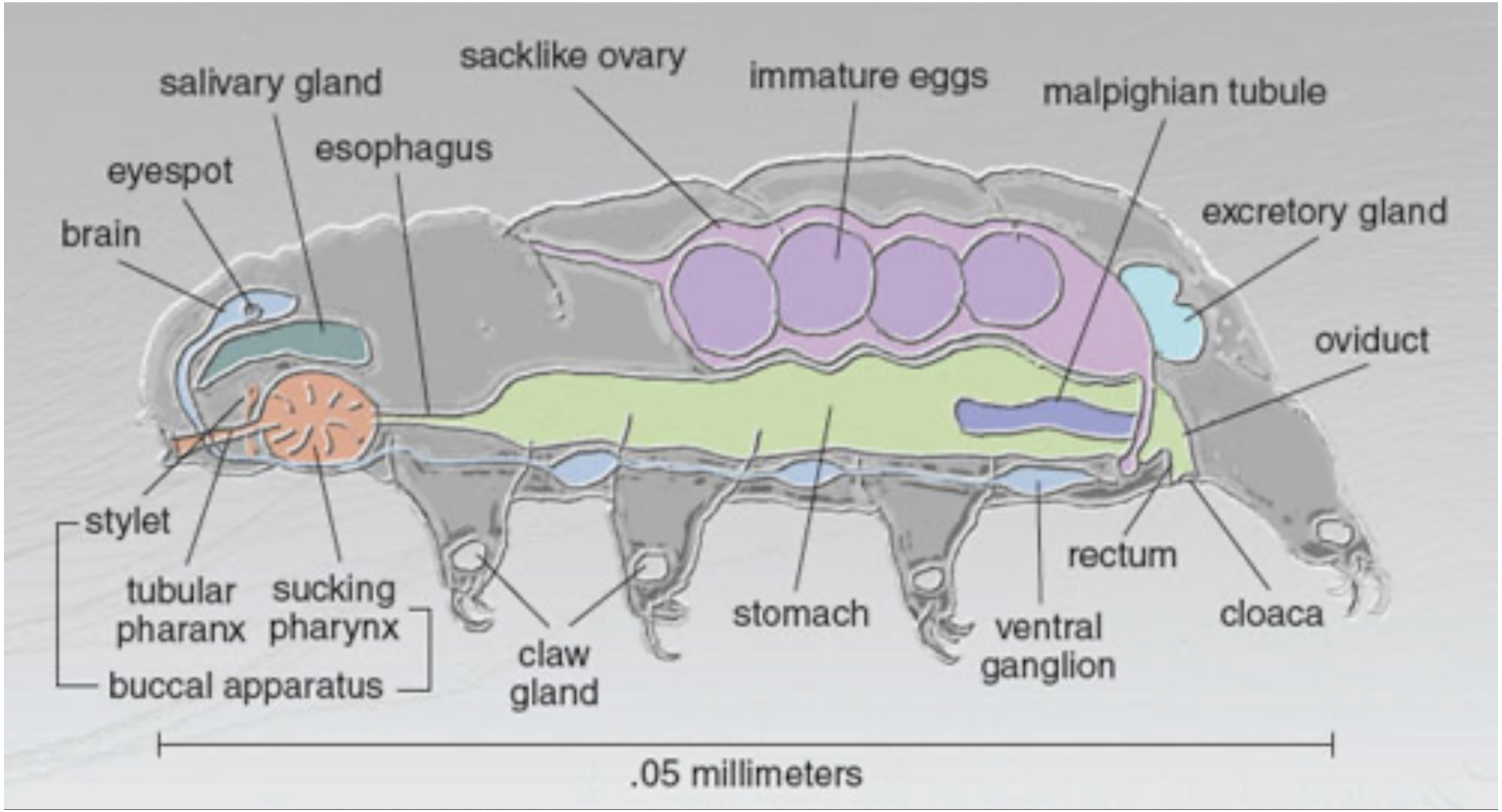
Tardigrades exhibit distinctly different responses, grouped under the general name of cryptobiosis, to different sources of stress. Anhydrobiosis and cryobiosis lead to the formation of tuns, but they are not equivalent—they are different mechanisms for protection against different environmental assaults.

Cryptobiosis: From Greek for “Kryptos (concealed, hidden) and “biosis”: life process

https://www.americanscientist.org/article/tardigrades



https://www.americanscientist.org/article/tardigrades



https://www.americanscientist.org/article/tardigrades


What’s their secret?

(Bio)Hazard!

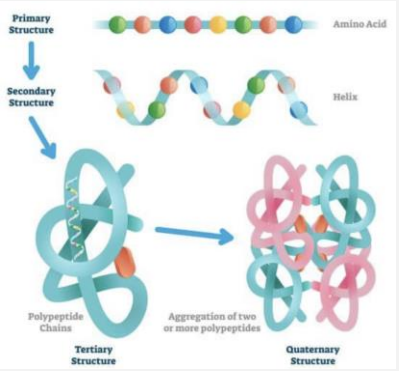
What is a hazard in terms of life and biological systems?

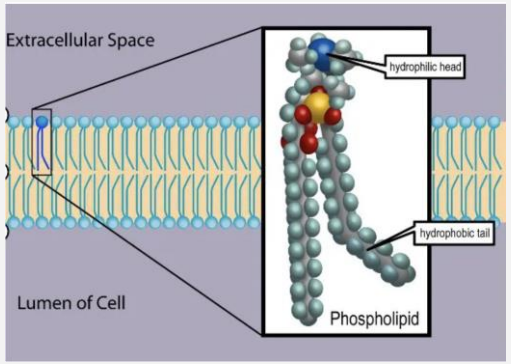
- Extreme temperatures
- Extreme pH (acid/base)
- Extreme pressures
- Dehydration
- Irradiation (γ-radiation/x-rays/uv-light)

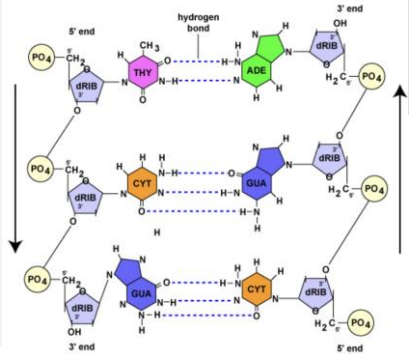
All these hazards pose a threat to our:

- Protein integrity
- Lipid integrity
- Genome integrity

Cells of ALL living organisms depend on proper structural
And functional stability of proteins, lipids and nucleic acids to work







NEWS | 24 October 2024

New species of tardigrade reveals secrets of radiation-resisting powers

Knowing the genes responsible for water bears' radiation tolerance could lead to diverse applications, from cancer treatment to space exploration.

By Miryam Naddaf

Li et al., Science 2024

The secrete is in the genome!

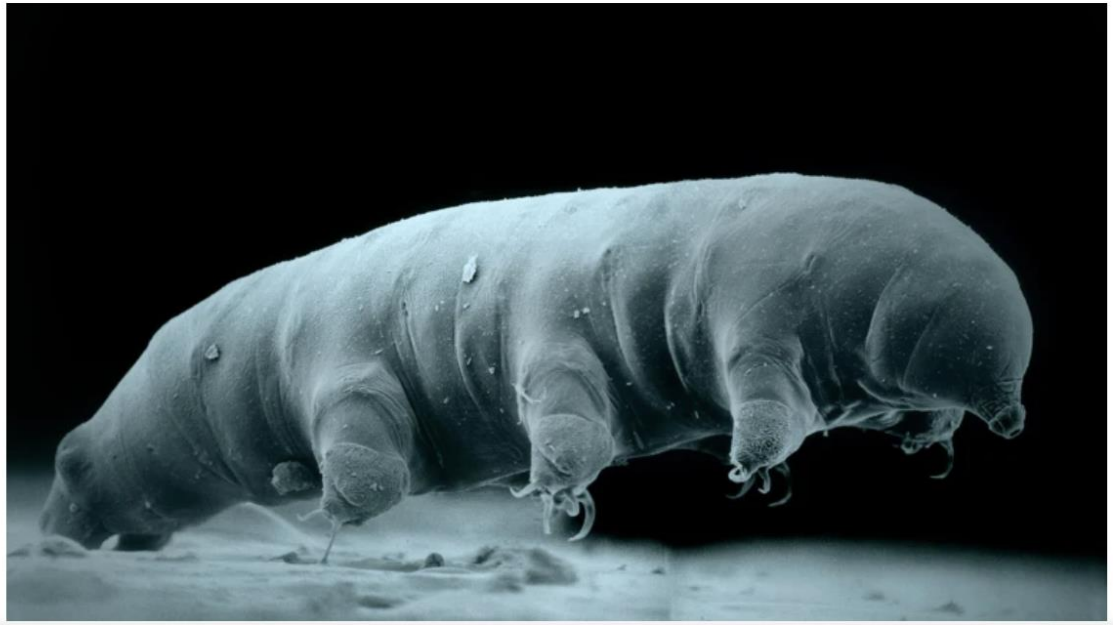
- Genome sequencing revealed that the species had 14,701 genes, 30% of which are unique to tardigrades.
- Researchers exposed Tardigrades to 3000 to 5000 grays (Gy) of gamma rays, which is ~1000 times the lethal dose for humans.
- They found that 2,801 genes involved in DNA repair, cell division and immune responses became active.
- One of the genes, called TRID1, encodes a protein that helps to repair double-strand breaks in DNA by recruiting specialized proteins at sites of damage.
- The researchers also estimate that **0.5–3.1% of the tardigrade's genes** were acquired **from other organisms** through a process known as **horizontal gene transfer.**

NEWS | 24 October 2024

New species of tardigrade reveals secrets of radiation-resisting powers

Knowing the genes responsible for water bears' radiation tolerance could lead to diverse applications, from cancer treatment to space exploration.

By Miryam Naddaf

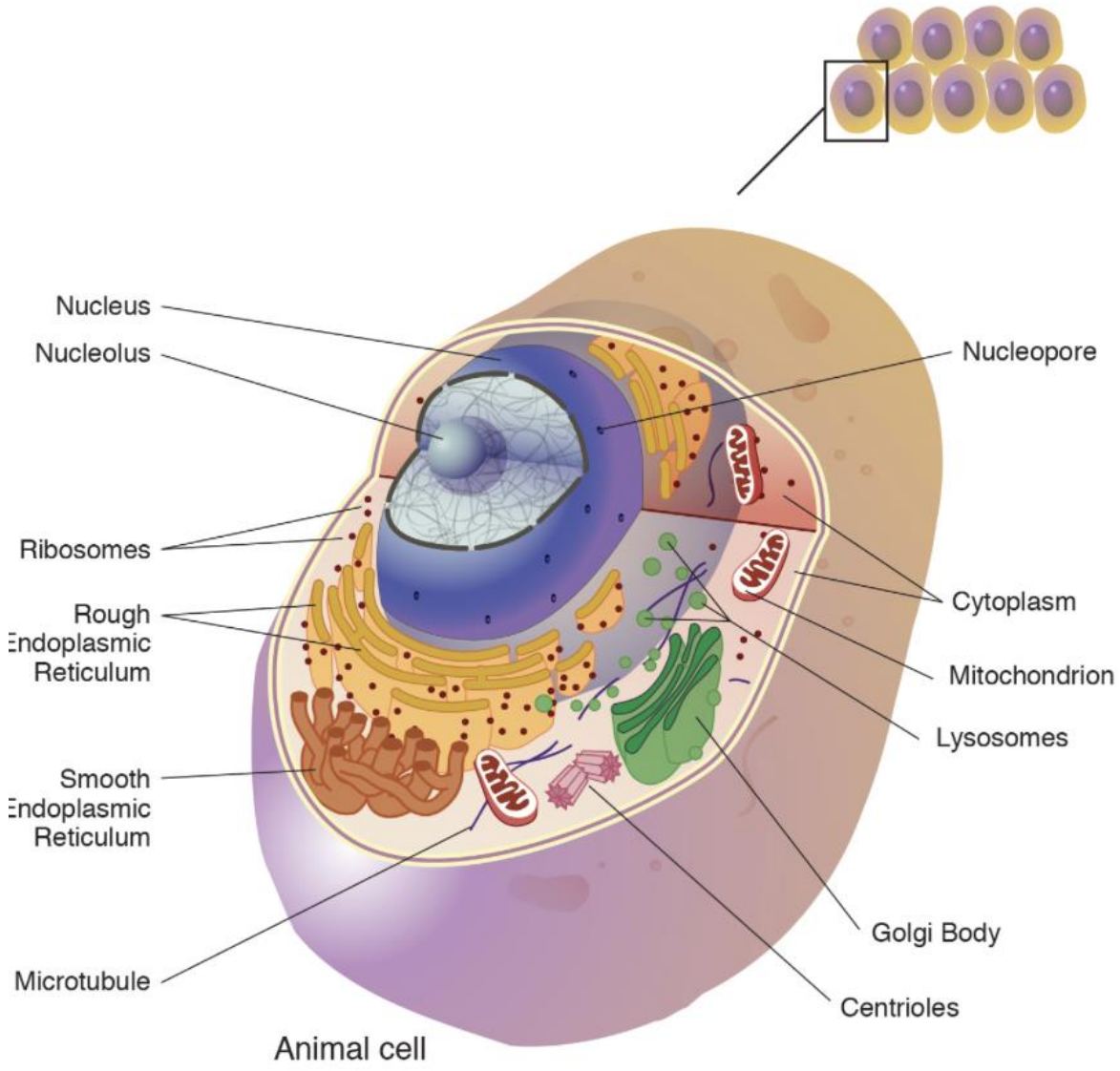


Li et al., Science 2024

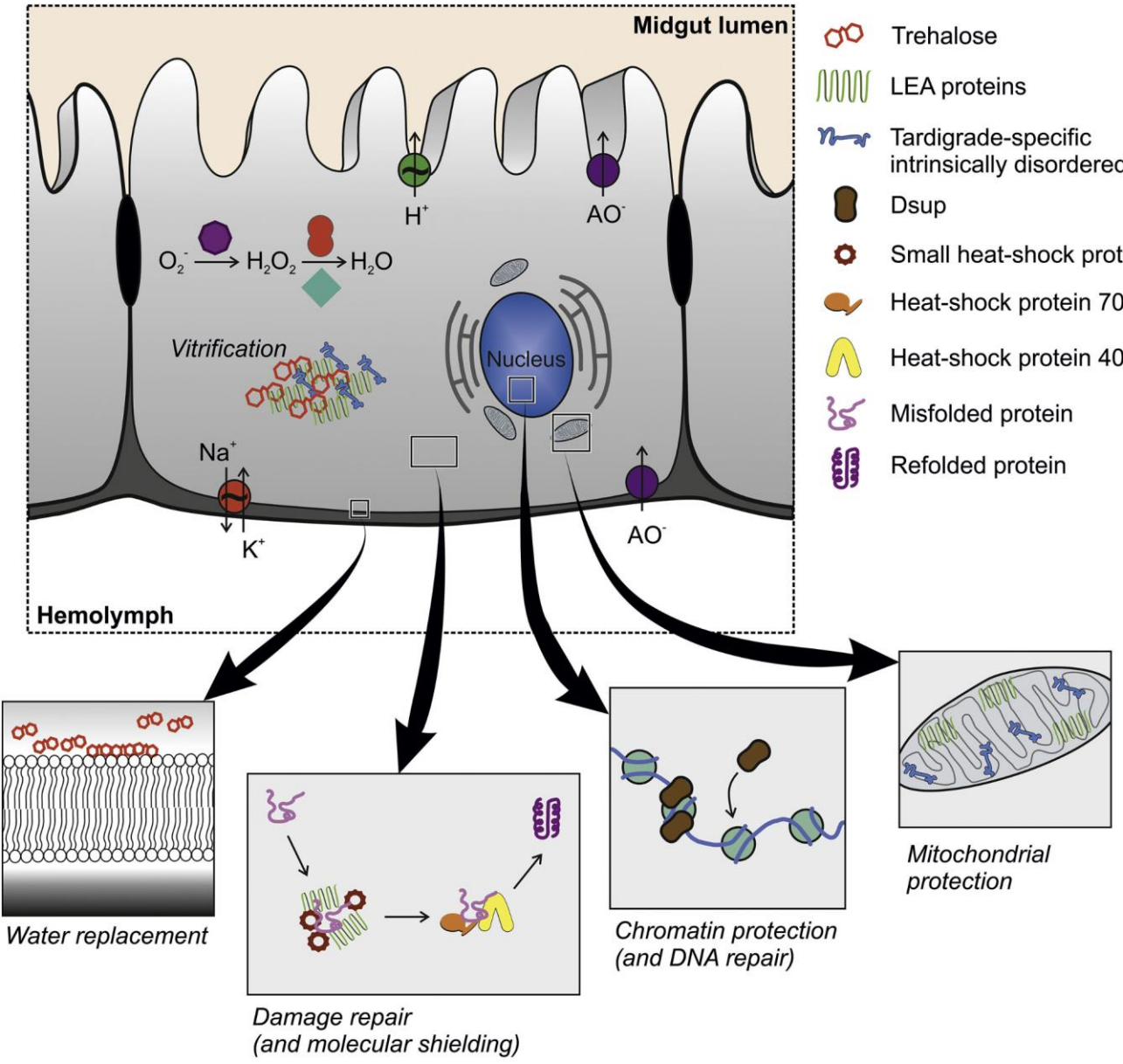
The secrete is in the genome!

- Genome sequencing revealed that the species had 14,701 genes, 30% of which are unique to tardigrades.
- Researchers exposed Tardigrades to 3000 to 5000 grays (Gy) of gamma rays, which is ~1000 times the lethal dose for humans.
- They found that 2,801 genes involved in DNA repair, cell division and immune responses became active.
- One of the genes, called TRID1, accelerates the repair of DNA double-strand breaks by recruiting specialized proteins at sites of damage.
- The researchers also estimate that **0.5–3.1% of the tardigrade's genes** were acquired **from other organisms** through a process known as **horizontal gene transfer.**
- A gene called DODA1, which seems to have been acquired from bacteria, enables tardigrades to produce four types of antioxidant pigments called **betalains -** can mop up harmful reactive chemicals which account for 60–70% of radiation's damaging effects.

Cryopreservation



The secrete is in the genome!



- Tardigrade specific proteins such as TDPs help maintain protein and lipid stability, along with the sugar trehalose.
- Additionally, some TDPs form gels that slow down molecular interactions within cells – thereby slowing metabolism.
- Late Embryogenesis Abundant (LEA) proteins, also found in plant seeds, maintain structural stability during desiccation.
- Trehalose and glycerol act to both preserve osmotic pressure when water and ions are pumped out and as acute, immediate anti-freeze agents.
- Trehalose and glycerol help maintain lipid membrane fluidity.

Nadja Møbjerg, Ricardo Cardoso Neves, Comparative Biochemistry and Physiology, 2021

Cryopreservation

We now routinely cryopreserve cells and embryos (up to 7-8 days post fertilization).

- Trehalose and glycerol can be used to cryopreserve cells.
- Serum albumin is added to provide stability.
- We can apparently also cryopreserve whole humans…

But we don’t know how to wake em up!

We can learn a lot from Tardigrade at the cellular and molecular level!

Potential Future Applications

nature › communications biology › articles › article

Article | Open access | Published: 25 May 2024

Tardigrade secretory proteins protect biological structures from desiccation

Samuel Lim, Charles B. Reilly, Zeina Barghouti, Benedetto Marelli, Jeffrey C. Way & Pamela A. Silver

R.O. Schill, B. Mali, T. Dandekar, M. Schnölzer, D. Reuter, M. Frohme

Molecular mechanisms of tolerance in tardigrades: New perspectives for preservation and stabilization of biological material

Biotechnol. Adv., 27 (2009), pp. 348-352

View PDF View article View in Scopus ↗

Google Scholar ↗

News | Published: 20 September 2016

Tardigrade protein helps human DNA withstand radiation

Jason Bittel

Nature (2016) | Cite this article

13k Accesses | **1** Citations | **1124** Altmetric | Metrics

Experiments show that the tardigrade's resilience can be transferred to cultures of human cells.

Open Access Article

Proteomics Reveals How the Tardigrade Damage Suppressor Protein Teaches Transfected Human Cells to Survive UV-C Stress

by **Enxhi Shaba** [1,†], **Claudia Landi** [1,*,†], **Carlotta Marzocchi** [2], **Lorenza Vantaggiato** [1], **Luca Bini** [1], **Claudia Ricci** [2,‡] and **Silvia Cantara** [2,‡]

[1] Functional Proteomics Lab, Department of Life Sciences, University of Siena, 53100 Siena, Italy
[2] Department of Medical, Surgical and Neurological Sciences, University of Siena, 53100 Siena, Italy
[*] Author to whom correspondence should be addressed.
[†] These authors contributed equally to this work.
[‡] These authors contributed equally to this work.

Int. J. Mol. Sci. **2023**, *24*(14), 11463; **https://doi.org/10.3390/ijms241411463**

PROTEIN SCIENCE

RESEARCH ARTICLE | Open Access

Labile assembly of a tardigrade protein induces biostasis

S. Sanchez-Martinez, K. Nguyen, S. Biswas, V. Nicholson, A. V. Romanyuk, J. Ramirez, S. Kc, A. Akter, C. Childs, E. K. Meese, E. T. Usher, G. M. Ginell, F. Yu, E. Gollub, M. Malferrari ... See all authors

First published: 19 March 2024 | **https://doi.org/10.1002/pro.4941** | Citations: 1

Int J Mol Sci. 2019 Mar 15;20(6):1322. doi: 10.3390/ijms20061322

Modulation of Disordered Proteins with a Focus on Neurodegenerative Diseases and Other Pathologies

Anne H S Martinelli [1,†], Fernanda C Lopes [2,3,†], Elisa B O John [2,3], Célia R Carlini [3,4,5,*], Rodrigo Ligabue-Braun [6,*]

IS RESILIANCE = LONGEVITY?

Not necessarily

- Tardigrades live up to 2 years in their hydrated form and decades in their tun-form.
- This is still long compared to similar organisms like nematodes who live several months-1y.

The Planarian flatworms are not as resilient to stressors but the can potentially live forever
- **Constant rejuvenation and repair.**

Thank You!
Questions?