



Tardigrades : Natures' Survivor and Biomedical Pioneer

Aniket Kumar Singh¹, Poushali Roy¹, Tamali Das¹, Neelabh Datta¹
All authors contributed equally

¹Department of Biochemistry, Asutosh College, Affiliated to University of Calcutta.

Introduction

Tardigrades (also called **water bears**) are microscopic water-dwellers, ranging in size from 50-1000µm, belonging to *Phylum Tardigrada* in *Kingdom Animalia*. They have a unique characteristic of surviving in environmental extremities as drastic as the vacuum of outer space which can help in the development of more robust materials for a variety of applications.

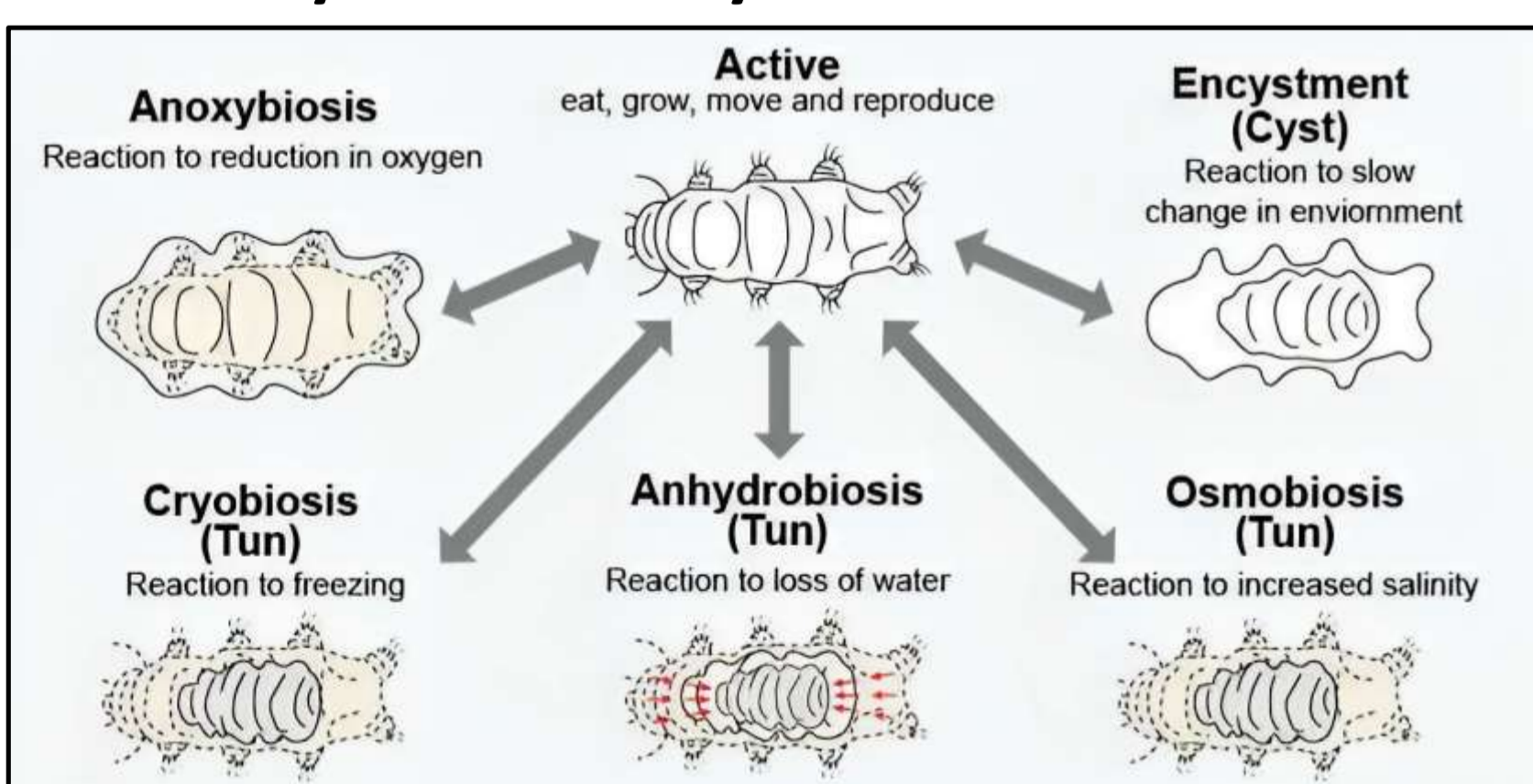


SEM image of [Milnesium tardigradum](#) in active form. (Schokraie E, et al. (2012). *PLoS ONE* 7(9): e45682. doi:10.1371/journal.pone.0045682)

Biological Resilience

- Tardigrades are able to enter a quiescent state of life called **Cryptobiosis**, due to a combination of protective mechanism, DNA repair mechanism and unique proteins that shield their cells from damage.
- The most common types exhibited are **Anhydrobiosis** (lack of water), **Cryobiosis** (low temperature), **Anoxybiosis** (lack of oxygen) and **Osmobiosis** (change of osmotic conditions).

They are basically indestructible.



Anoxybiosis and encystment are responses seen in a variety of organism along with three states of cryptobiosis, in which metabolism is suspended. (Figure- Miller, W. R., *American Scientist*. Sept-Oct 2011. Illustration by Tom Dunne)

Tardigrades in are capable of surviving:

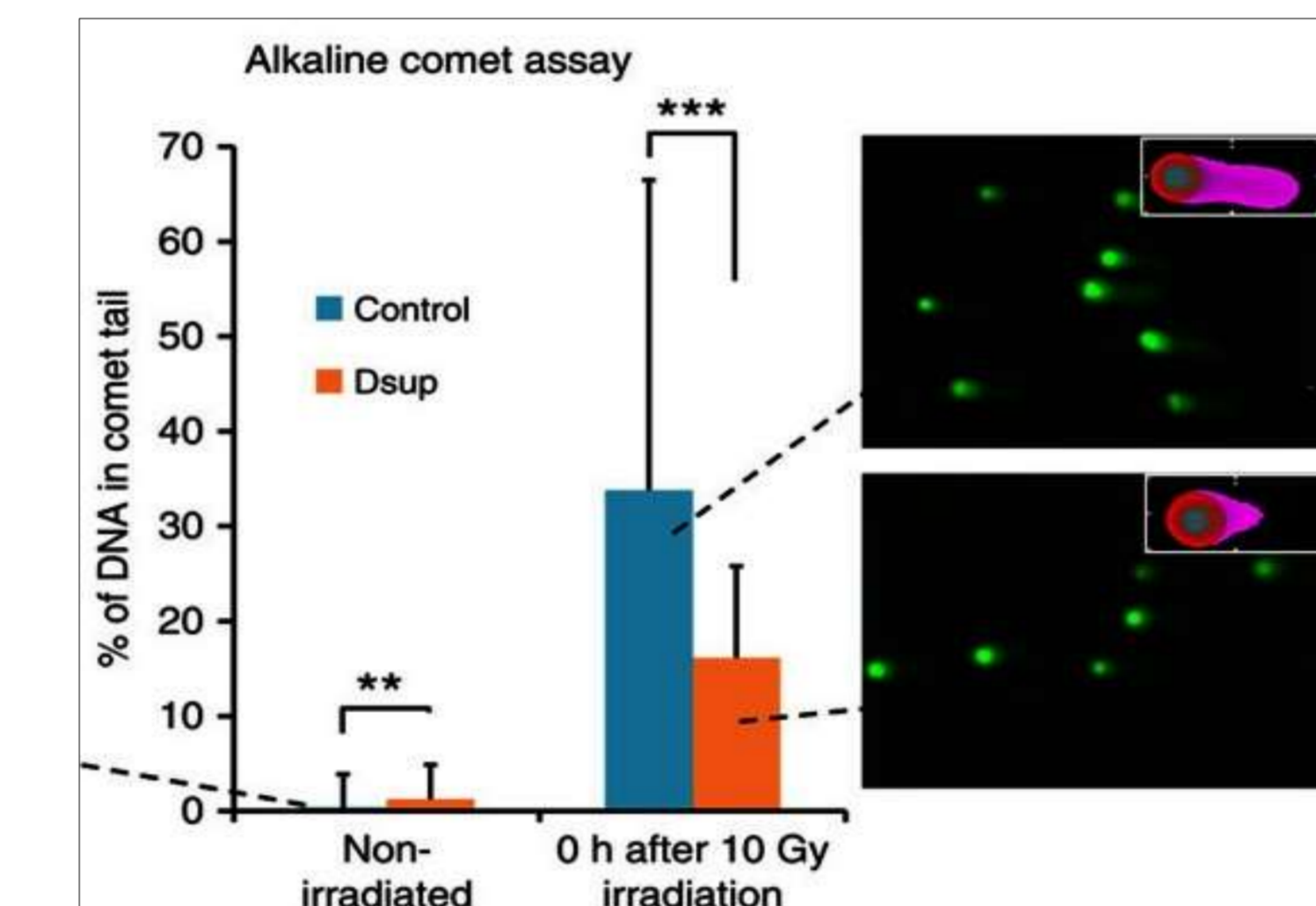
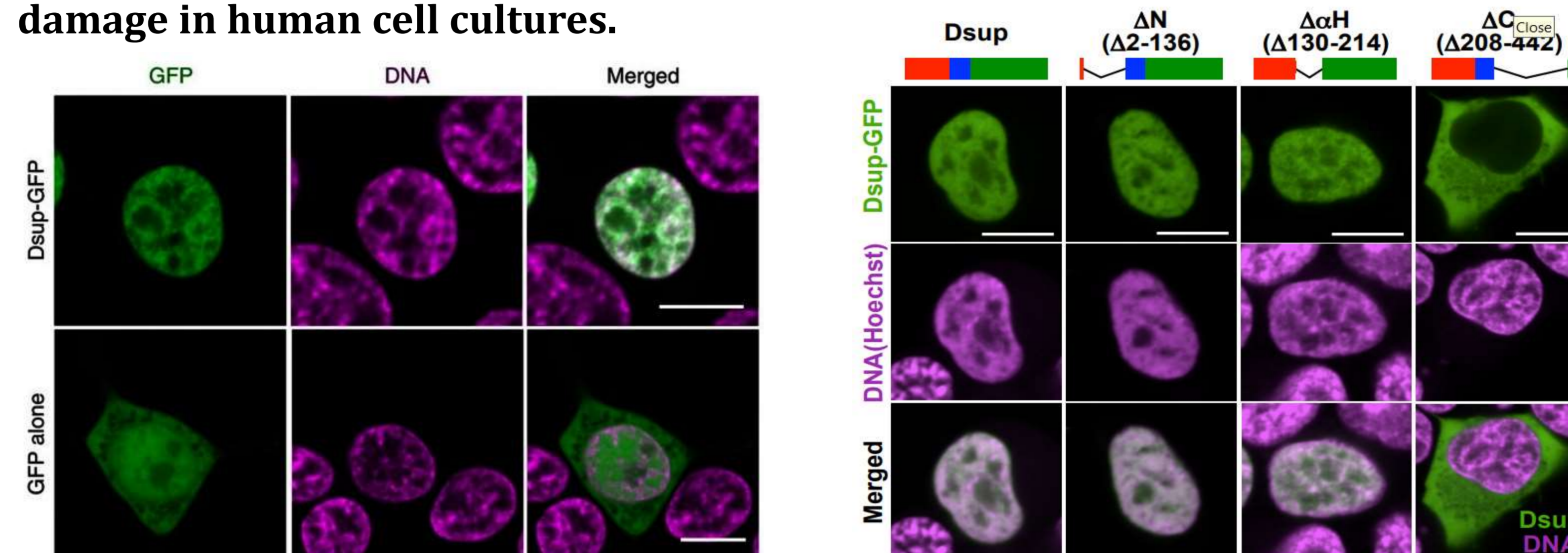
- 20 hours at -273°C(-459°F)
- 20 months at -200°C(-328°F)
- +150°C (+302°F)
- 6,000 atmospheres of pressure
- X-ray and Ultraviolet radiation
- Excessive concentration of Carbon dioxide, Carbon monoxide, nitrogen and Sulphur dioxide.
- Pure vacuum
- Over 125 years(possibly).

Reference:-

- Hashimoto, T., Horikawa, D., Saito, Y. et al. Extremotolerant tardigrade genome and improved radiotolerance of human cultured cells by tardigrade-unique protein. *Nat Commun* 7, 12808 (2016).
- Hesgrove, C., Boothby, T.C. The biology of tardigrade disordered proteins in extreme stress tolerance. *Cell Commun Signal* 18, 178 (2020).
- Kasianchuk N, Rzymiski P, Kaczmarek Ł. The biomedical potential of tardigrade proteins: A review. *Biomed Pharmacother*. 2023 Feb;158:114063.
- Neves, R. C., Hvidepil, L. K. B., Sørensen-Hygum, T. L., Stuart, R. M., & Møbjerg, N. (2020). Thermotolerance experiments on active and desiccated states of *Ramazzottius varieornatus* emphasize that tardigrades are sensitive to high temperatures. *Scientific reports*, 10(1), 94
- Miller, W. R., *American Scientist*. Sept-Oct 2011

Proteomic Analysis of tardigrades

Proteins such as *Tardigrade intrinsically disordered proteins (TDPs)* and *Late embryogenesis-abundant proteins (LEA)* are involved in enabling tardigrades to survive extremities. Some of the well known TDPs are: *Cytoplasmic abundant heat soluble (CAHS) proteins*, *Secreted abundant heat soluble (SAHS) proteins* and *Mitochondrial abundant heat soluble (MAHS) proteins*. *Damage Suppressor Protein (Dsup)* has shown to **reduce the effects of radiation damage in human cell cultures**.



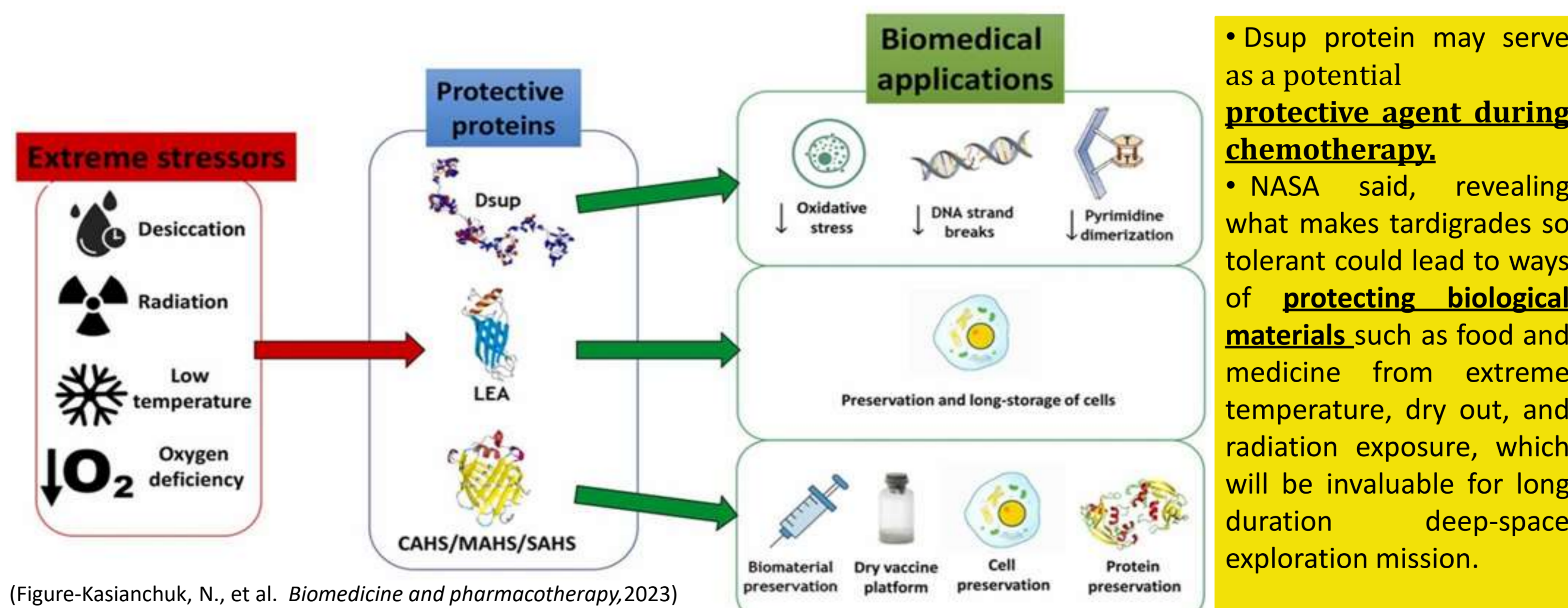
(Figures—Hashimoto,T., et al., *Nat Commun*. 2016 Sep 20)

—When tested in-vitro, it was found that pre-incubation with Dsup protein slowed down the movement of linearized plasmid DNA in dose dependent manner and when mixed with DNA at a specific ratio, the DNA's movement was significantly inhibited due to the formation of large complexes between DNA and Dsup protein.

—The C-terminal region of Dsup is crucial for its interaction with DNA, as removing this region caused a loss of its ability to affect DNA mobility. It is responsible for the co-localization of Dsup protein with nuclear DNA in transfected cells.

—Dsup protein was tested for its protective effect against DNA damage caused by X-ray irradiation and hydrogen peroxide. It was found that cells expressing Dsup had significantly fewer DNA breaks compared to untransfected cells.

Biomedical Importance



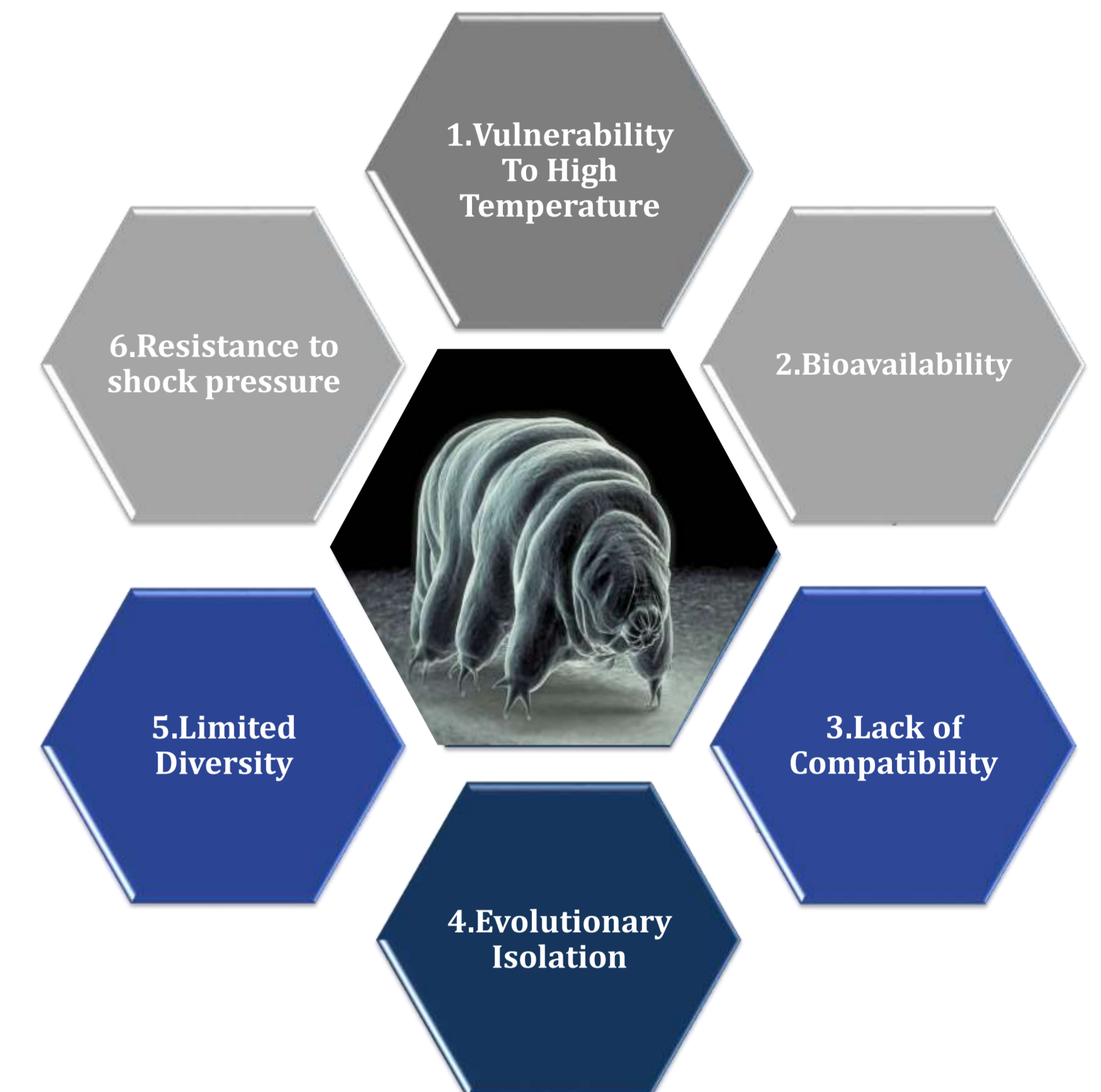
(Figure-Kasianchuk, N., et al. *Biomedicine and pharmacotherapy*,2023)

Dsup protein may serve as a potential **protective agent during chemotherapy**.

NASA said, revealing what makes tardigrades so tolerant could lead to ways of **protecting biological materials** such as food and medicine from extreme temperature, dry out, and radiation exposure, which will be invaluable for long duration deep-space exploration mission.

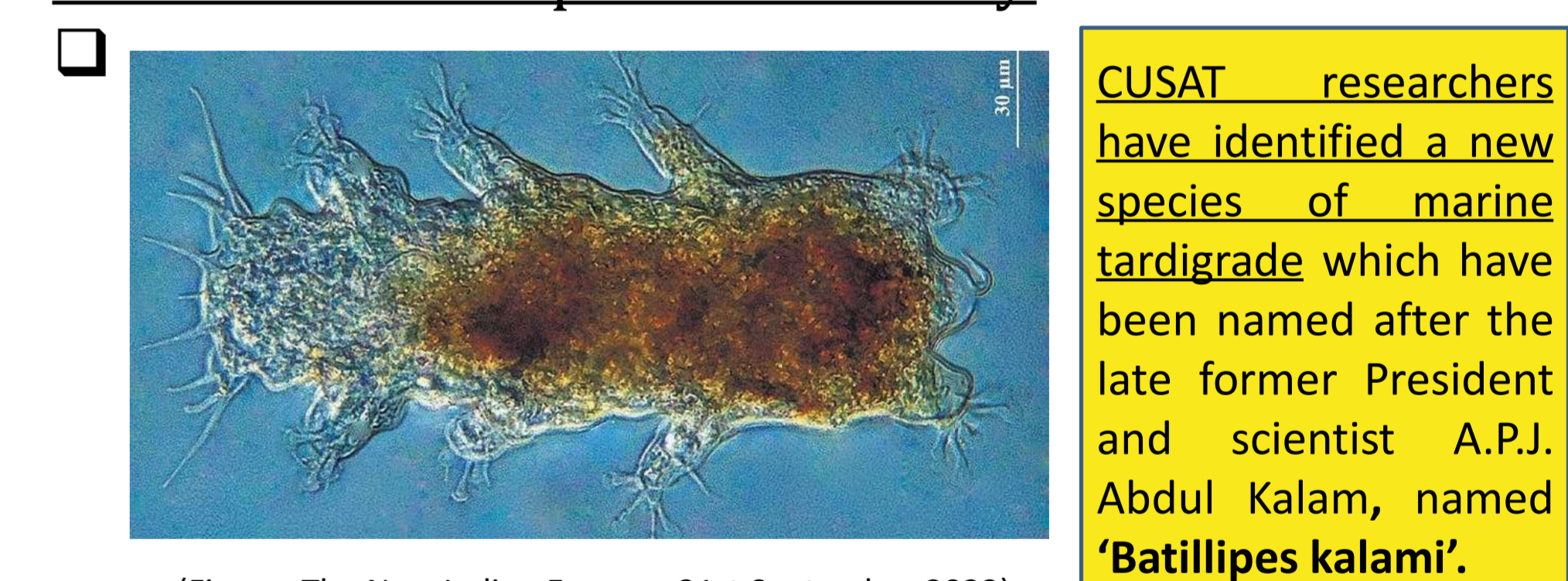
- It is hypothesized that inserting a gene from tardigrade into a human embryonic stem cell **can increase the cells' ability to withstand irradiation**.
- TDPs can be used to designing **dry vaccines** resulting in a longer shelf life and improved portability.
- Increasing the viability of cells and tissues such as blood in blood banks. Blood platelets after infusing them with sugars found in tardigrades can be dehydrated up to 2 years. **90% of the platelets were viable after rehydration**.
- Dsup-expressing cells when exposed to UV-C radiation, these cells showed **an increased expression of some genes (XRCC6, ERCC6, ATR, and BRCA1) involved with DNA repair**.
- DARPA created **Biostasis program** which could save humans from bleeding out or stop the progression of sepsis or damage from a stroke or heart attack.

Limitations



Current Researches and Future Prospects

- Current researches showed that **instead of dying during a drought, crops would hibernate until the water returns and can resist extreme temperatures**.
- If **human and plant cells possessed the same properties as tardigrades, space colonization could take one more step towards reality**.



(Figure- The New Indian Express, 21st September 2023)

CUSAT researchers have identified a new species of marine tardigrade which have been named after the late former President and scientist A.P.J. Abdul Kalam, named 'Batillipes kalami'.

- In the near future human genetics can be altered with tardigrades', which will put us in an entire new world of science.
- "Will the tardigrades ever go extinct?"

Conclusion

In conclusion, tardigrades have not only expanded our understanding of extremophiles and the limits of life on Earth but also hold potential implications for biotechnology, space exploration and life beyond our planet. With new tardigrade species identified every year, new opportunities for research and more understanding regarding their use are becoming possible, opening new doors for future use.

Acknowledgment

We would like to thank the Professors of Biochemistry Department of Asutosh College for assisting and commenting on the manuscript as well as the event organizers for co-operating with us.