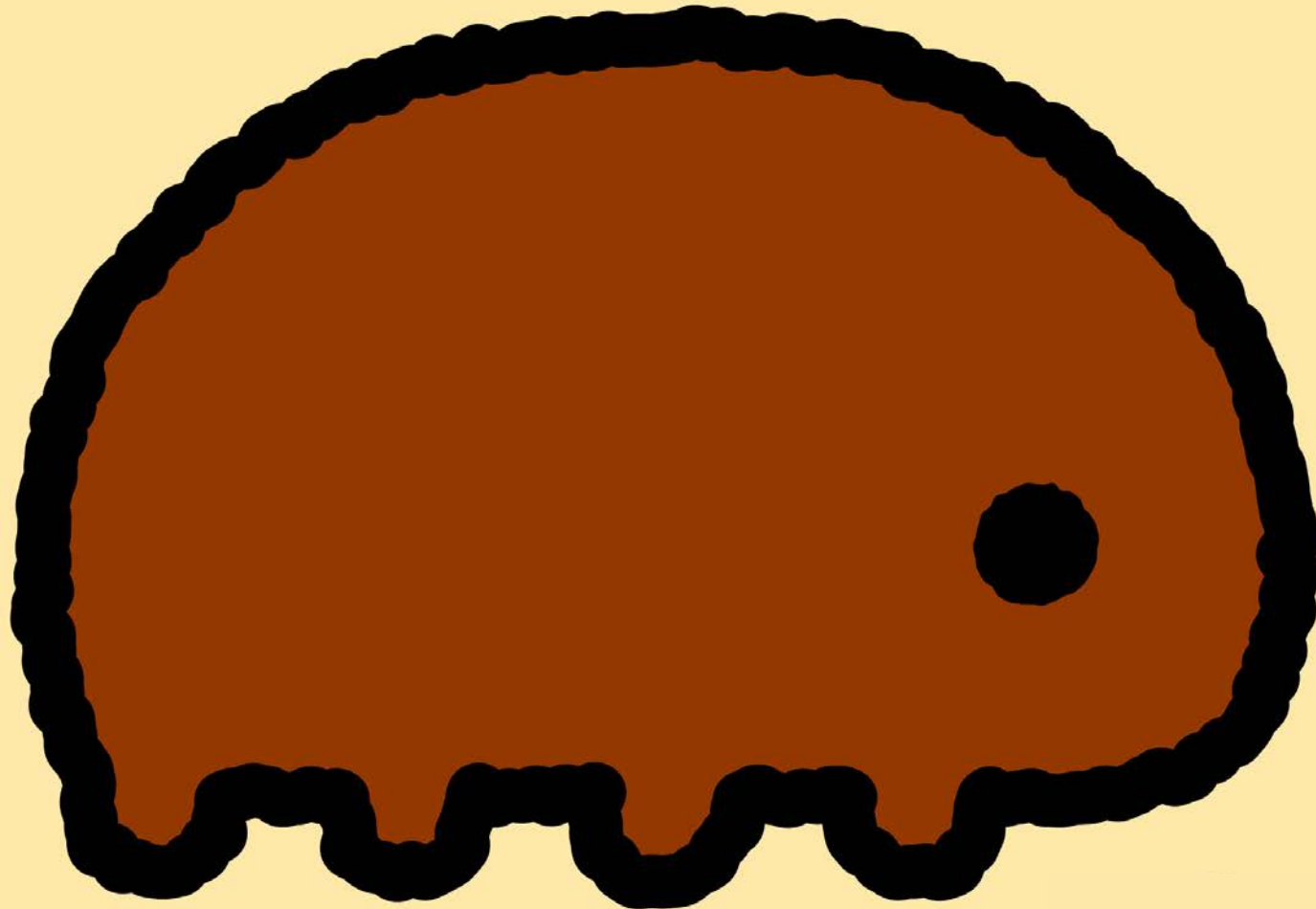
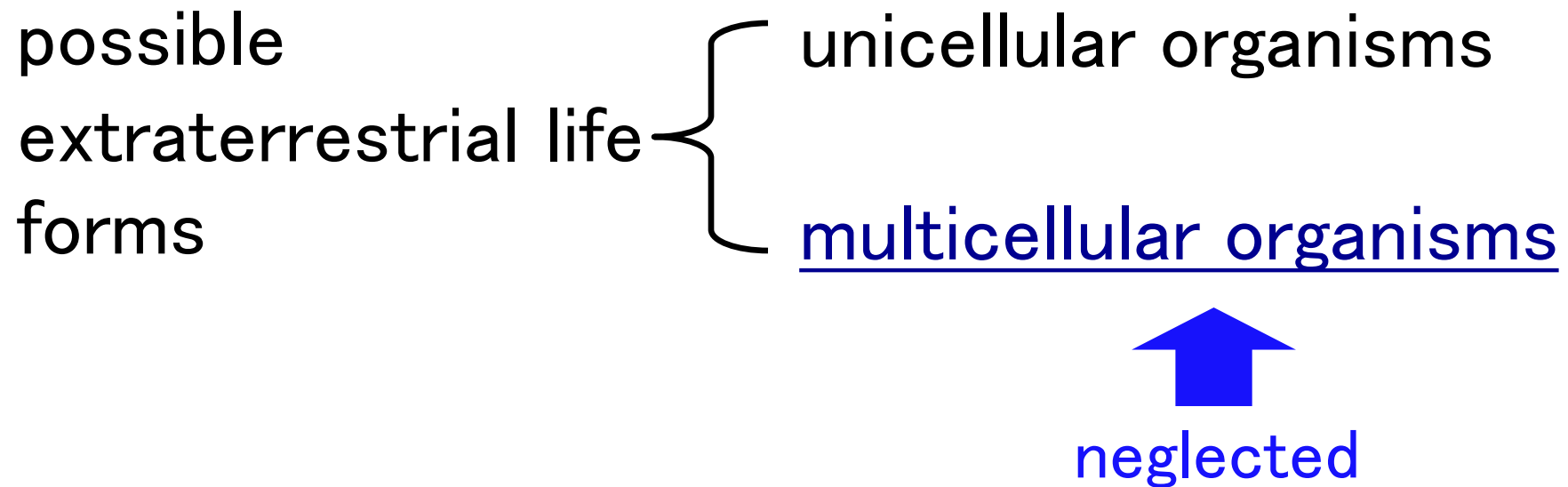


Astrobiological Research on Tardigrades: Implications for Extraterrestrial Life Forms



Daiki D. Horikawa
Paris University Descartes

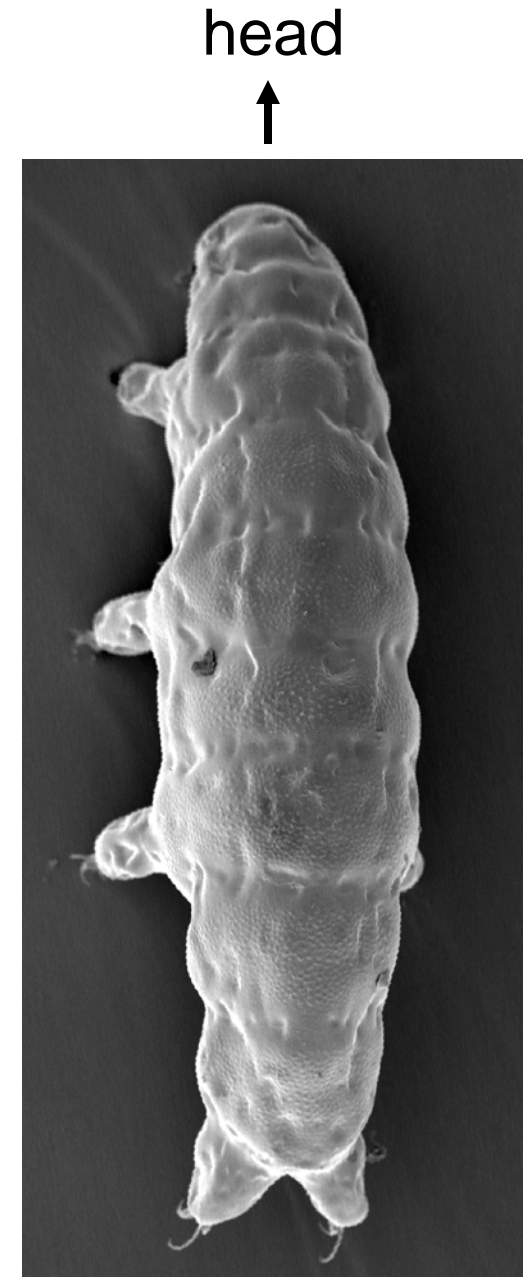
Are we alone in the univers?



Tardigrades

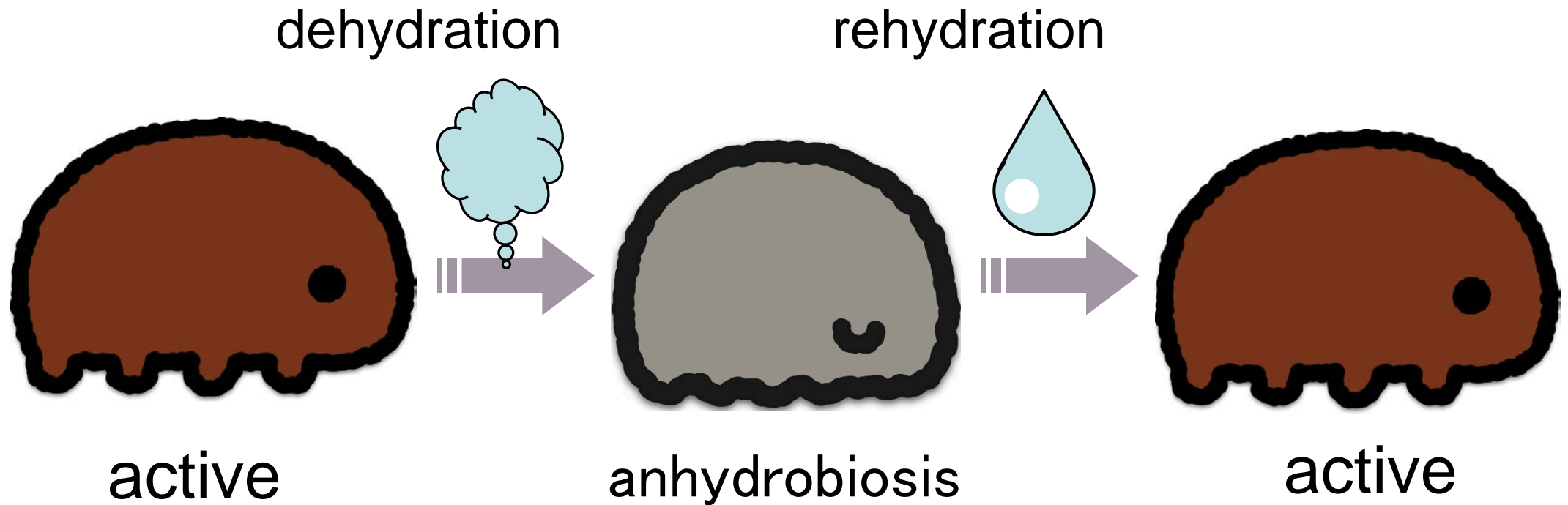
-well known examples of extremotolerant animals-

- Classification - Phylum Tardigrada
>1000 species
- Body length - 0.05 ~ 1mm
- Habitats - Various environments
- Characteristics - Anhydrobiosis,
Tolerance to extreme
environments



Anhydrobiosis

Anhydrobiosis - an ametabolic dry state induced by desiccation



- 1~3% body water content
- ametabolic

Anhydrobiosis



Tolerance to extreme environments

■ High temperature	+151°C	(Rahm, 1921)
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■ Low temperature	−273°C	(Becquerel, 1950)
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■ High pressure	7.5 GPa	(Ono <i>et al.</i> , 2008)
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■	X-rays	10 kGy	(May <i>et al.</i> , 1964)
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Radiation

	γ-rays	7 kGy	(Jonsson <i>et al.</i> , 2005)
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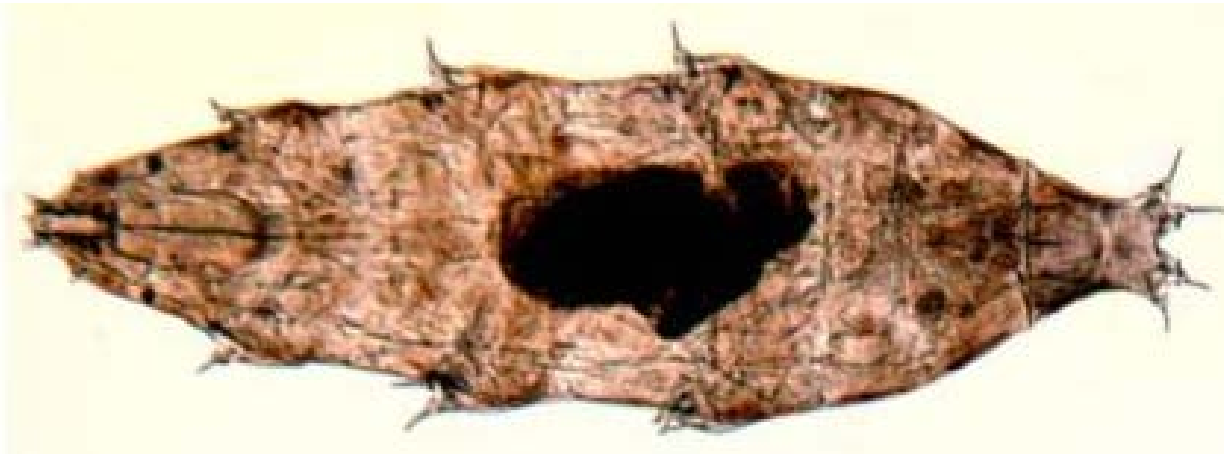
	Heavy ions	8 kGy	(Horikawa <i>et al.</i> , 2006)
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Tolerance to space environments

Tardigrades survived open space environments that have

- Space vacuum
- Massive UV radiation (7577 kJ/)

at low Earth orbit



Milnesium tardigradum



Jonsson et al. 2008

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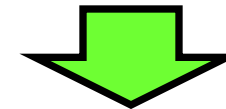
Model species: *Ramazzottius varieornatus*

We have established a culture system for a tardigrade species



Ramazzottius varieornatus

- Collected from mosses in Sapporo, Japan
- Algae as food
- Anhydrobiotic capacity through its whole life history



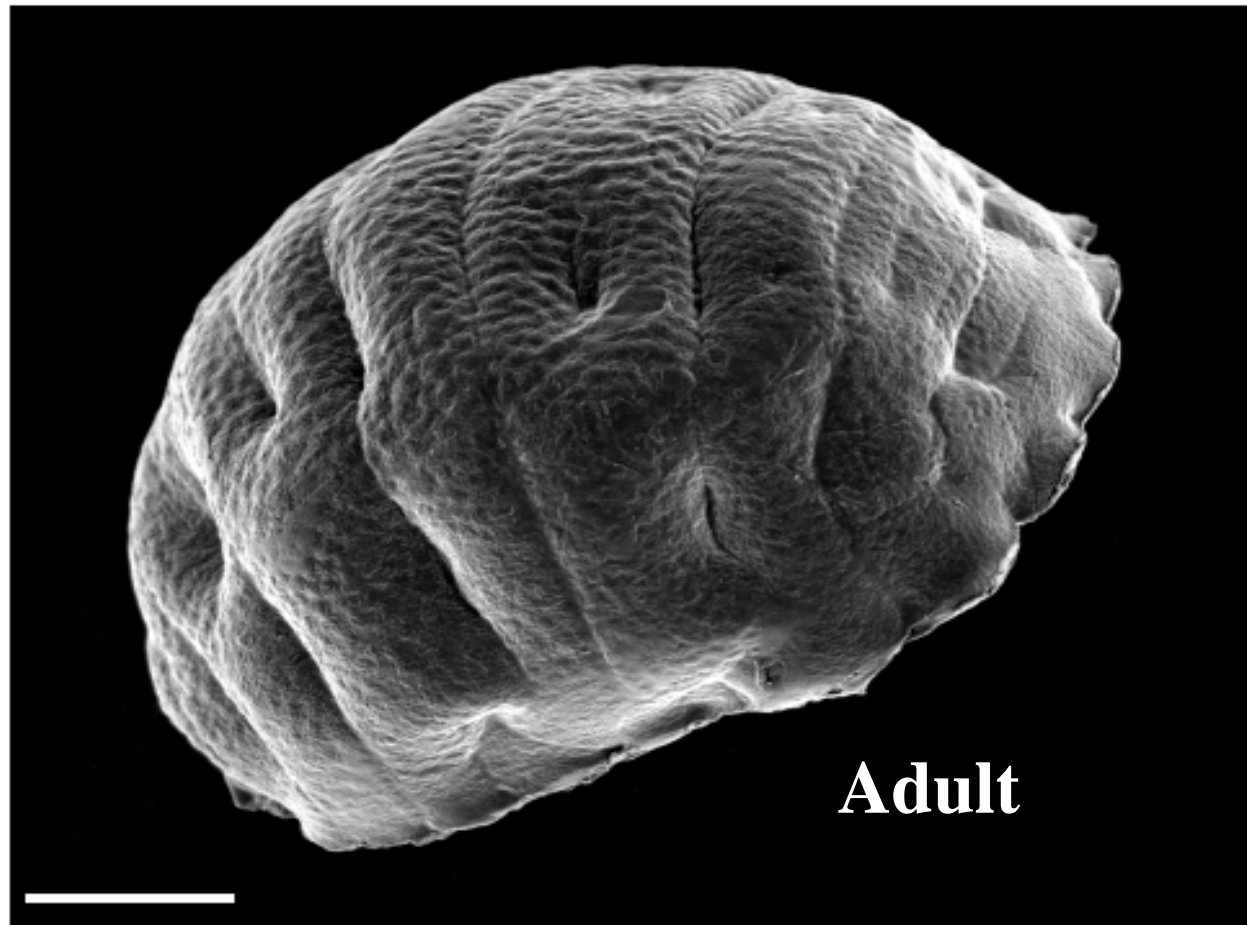
Model for astrobiological research



(Horikawa et al. 2008)

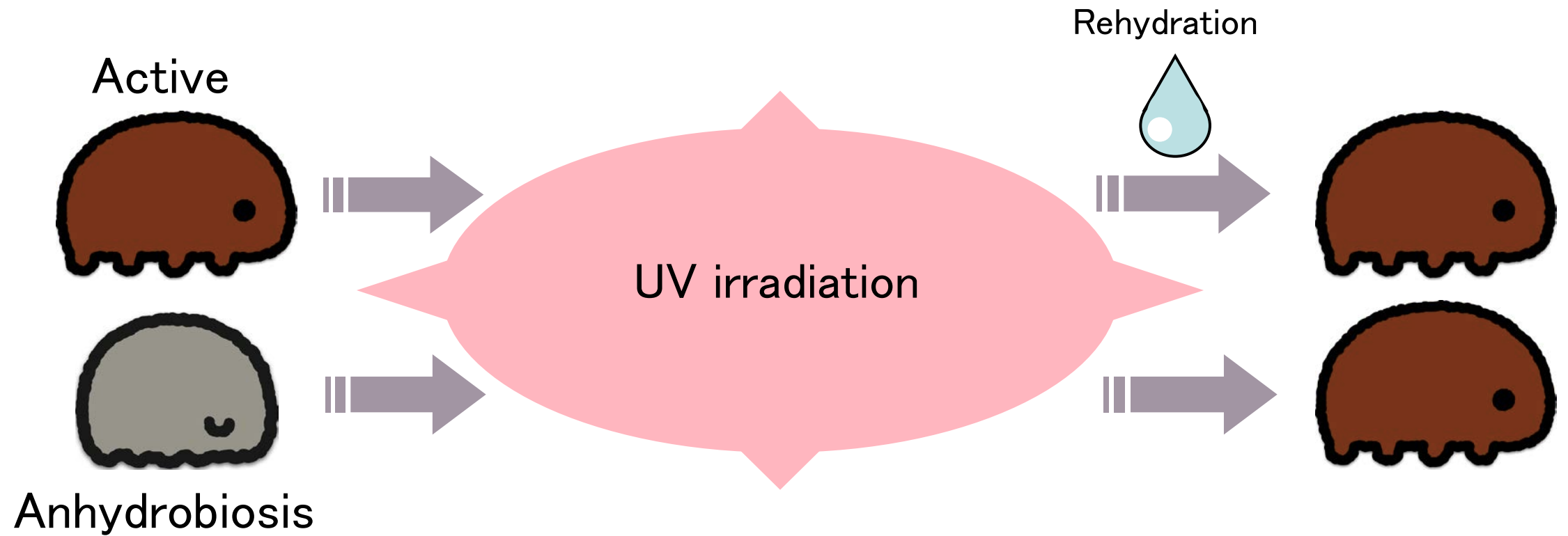
UV radiation tolerance

- Evaluation of UV radiation tolerance
- Mechanisms behind the tolerance



UV radiation tolerance

Procedure



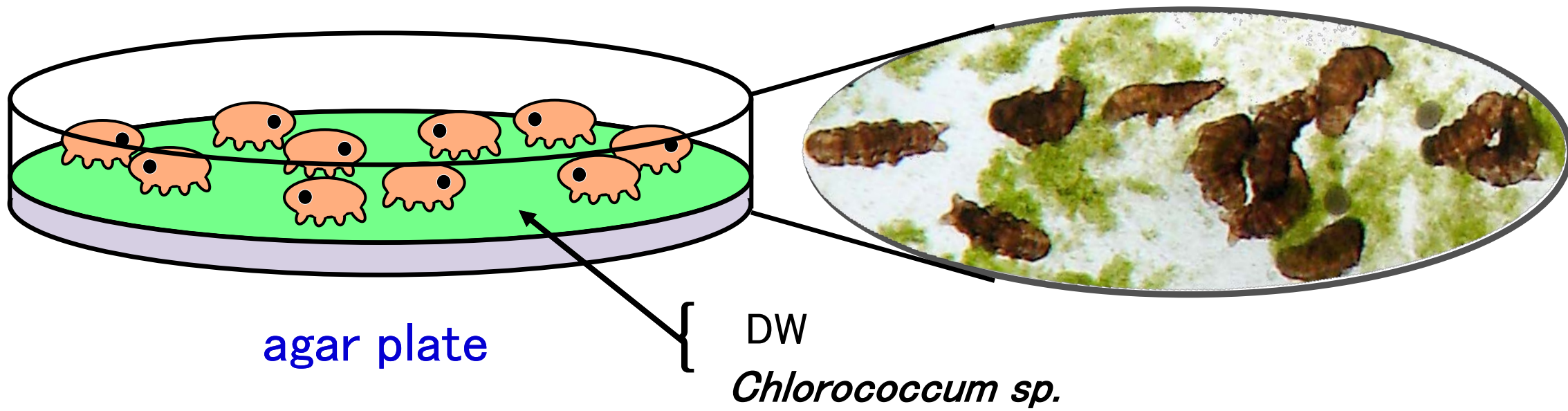
UV radiation tolerance

Post-irradiation culture

Temperature: 22°C

Food: Green alga *Chlorococcum* sp.

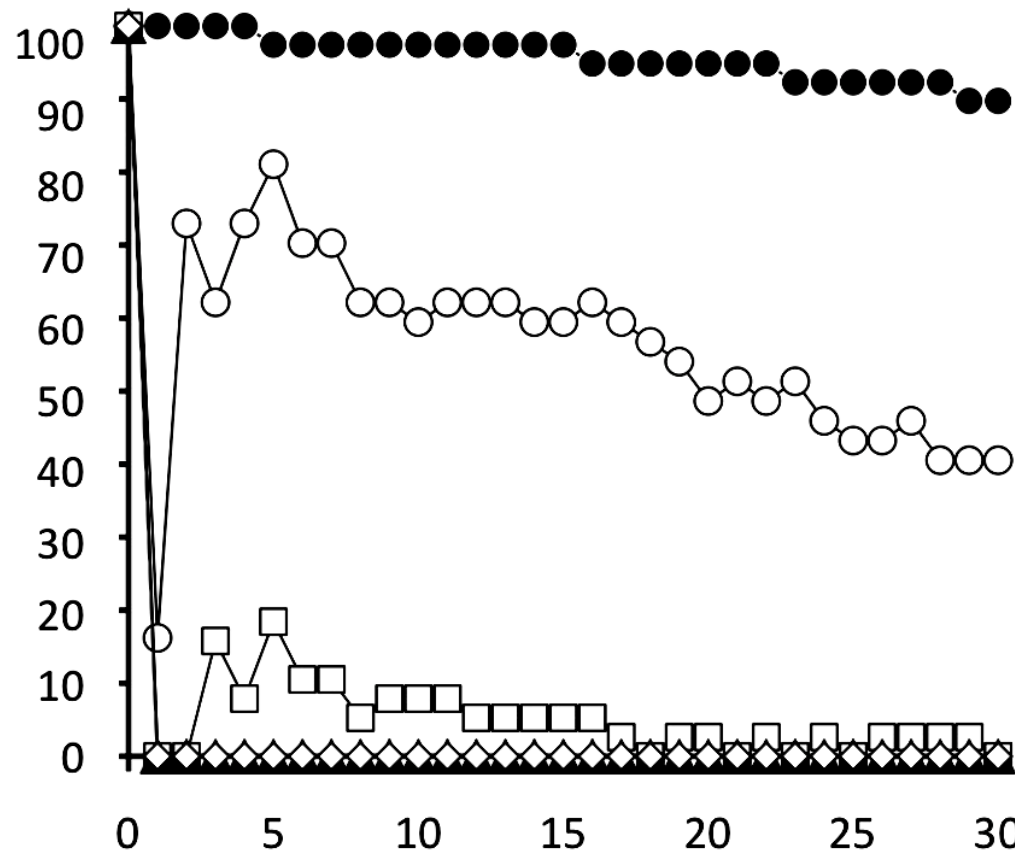
Light conditions: Continuous dark



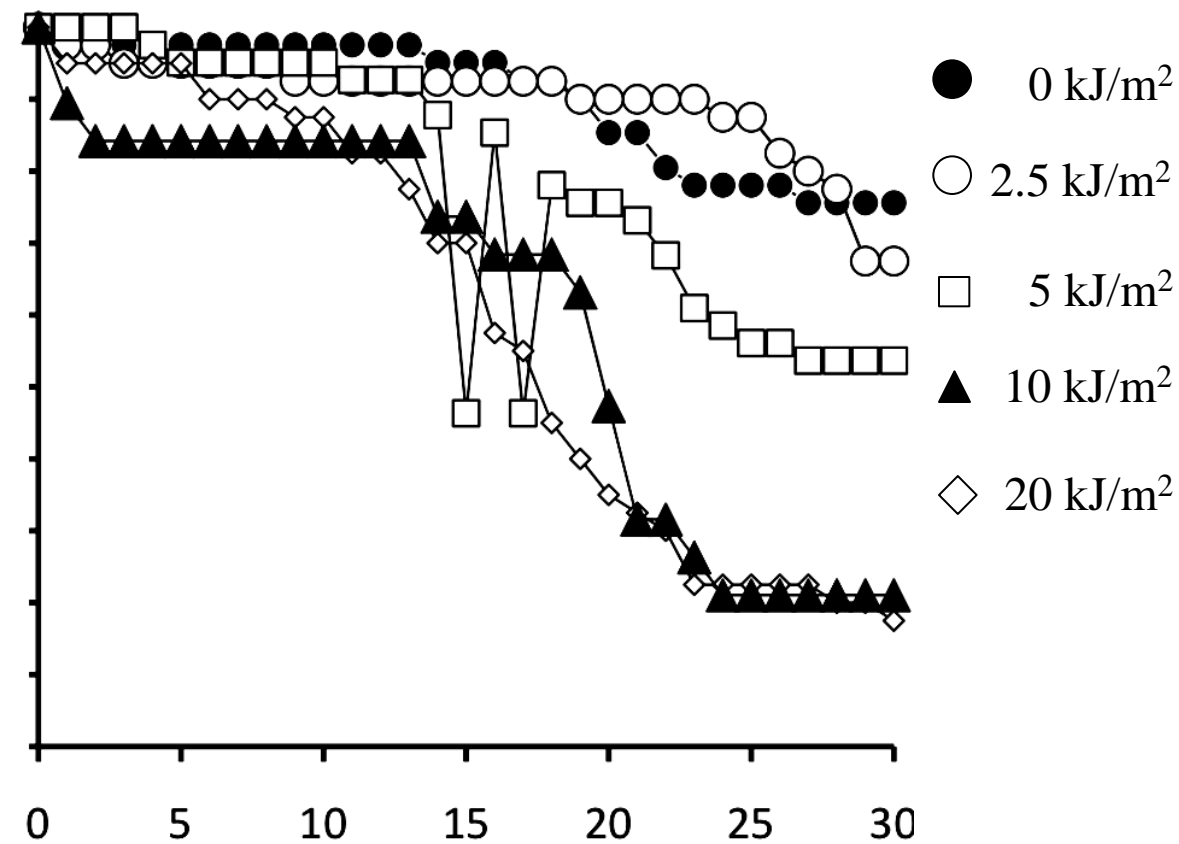
UV radiation tolerance

Survival ability

R. varieornatus



R. varieornatus (Anh.)



Survival ability

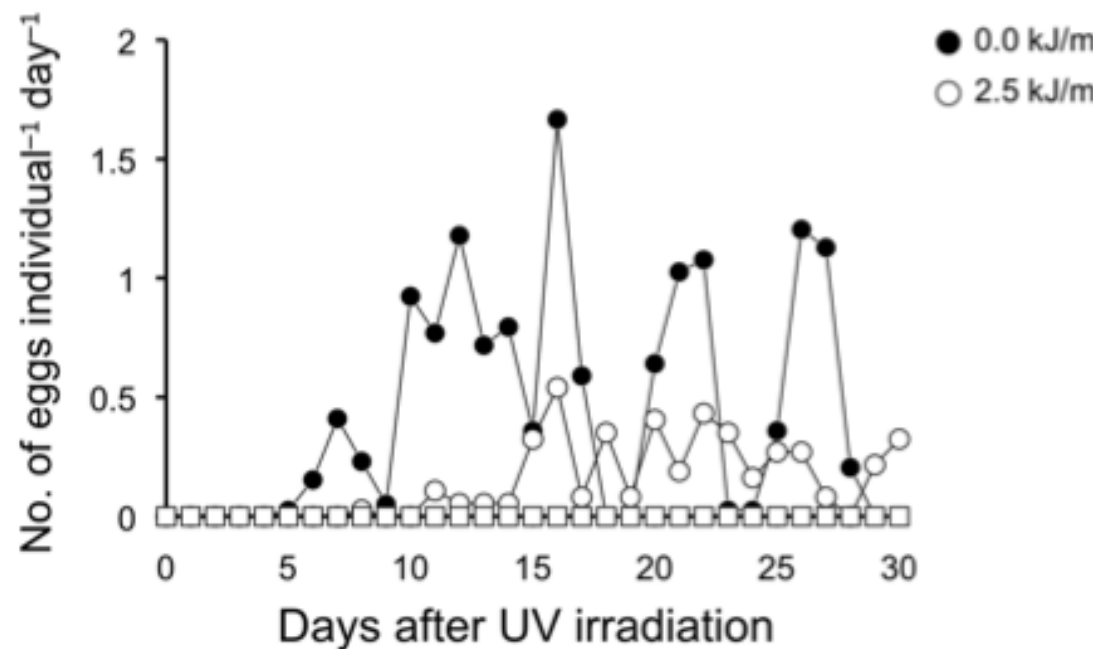
R. varieornatus (Anhydrobiosis) > *R. varieornatus* (Active)

(Horikawa et al. 2013)

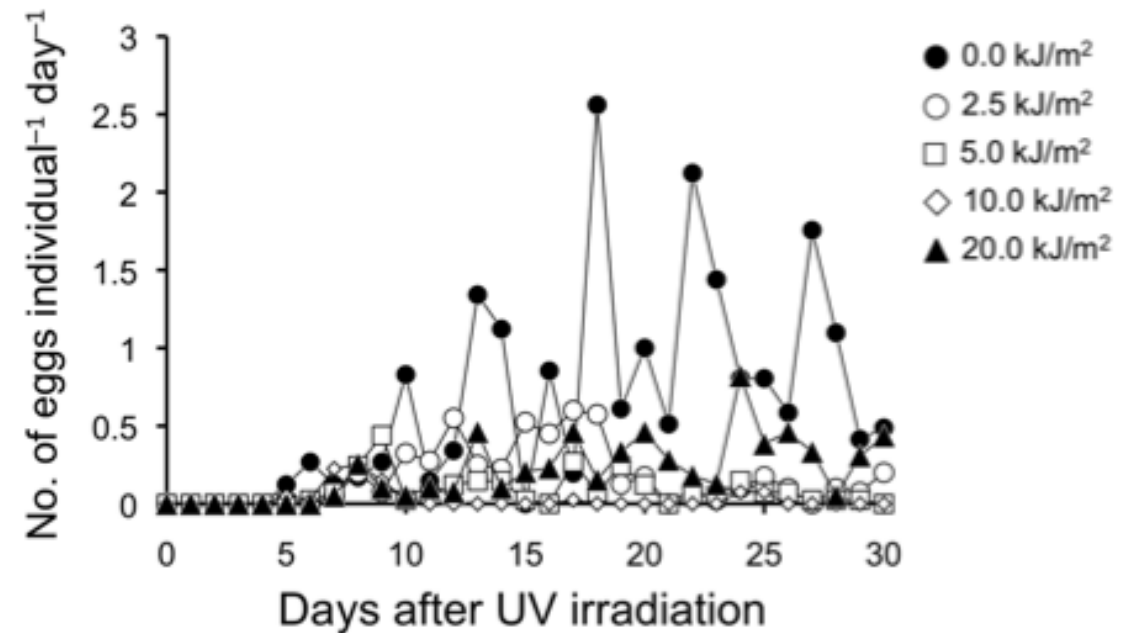
UV radiation tolerance

Reproduction capacity

R. varieornatus



R. varieornatus (anh.)

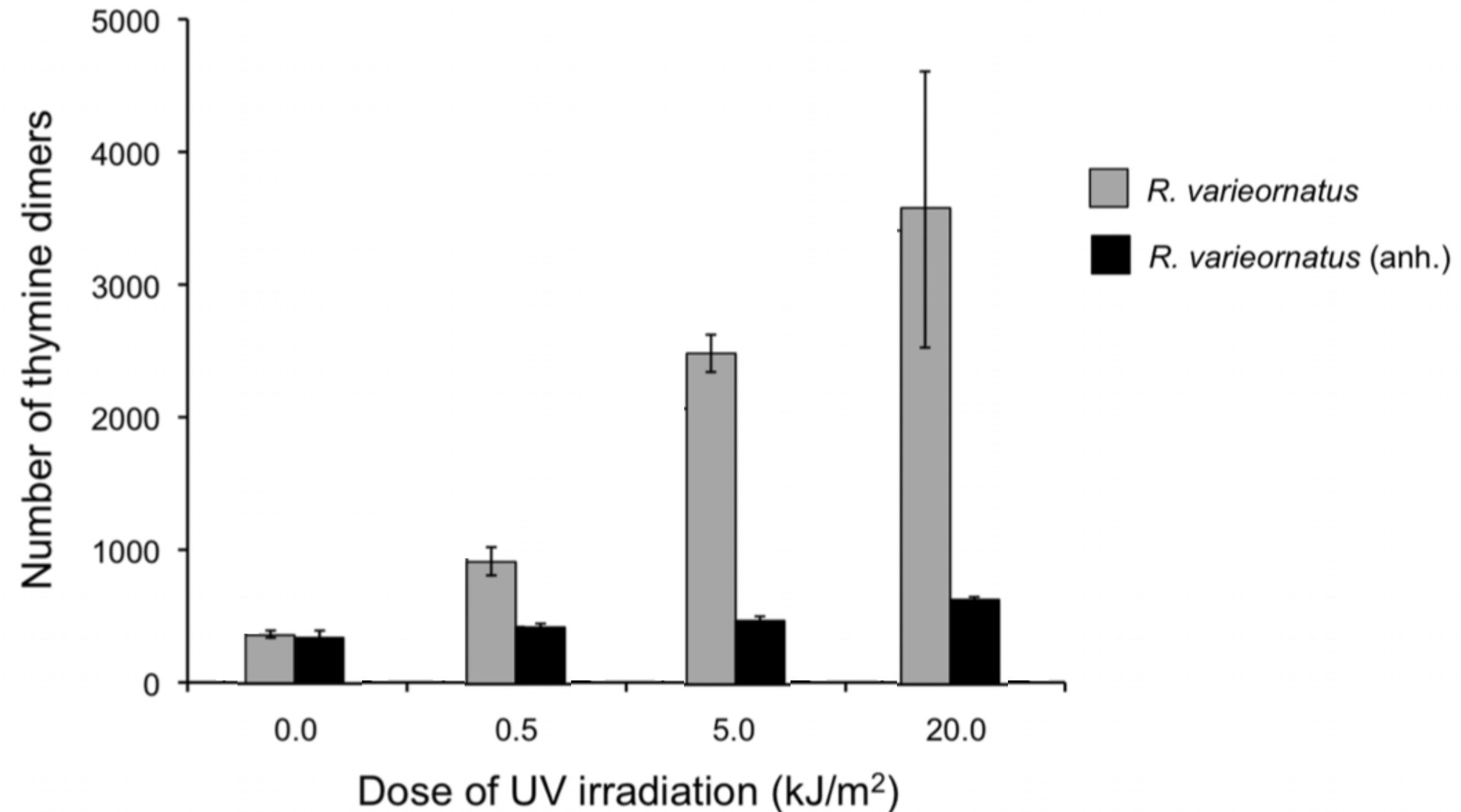


Reproduction capacity

R. varieornatus (Anhydrobiosis) > *R. varieornatus* (Active)

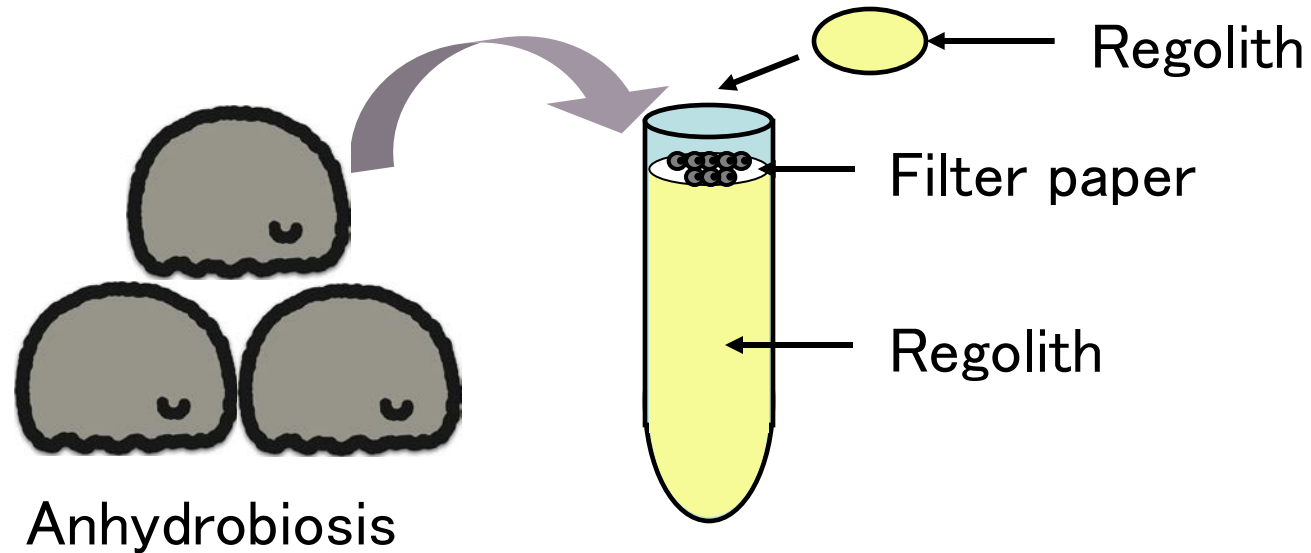
(Horikawa et al. 2013)

UV radiation tolerance: DNA damage

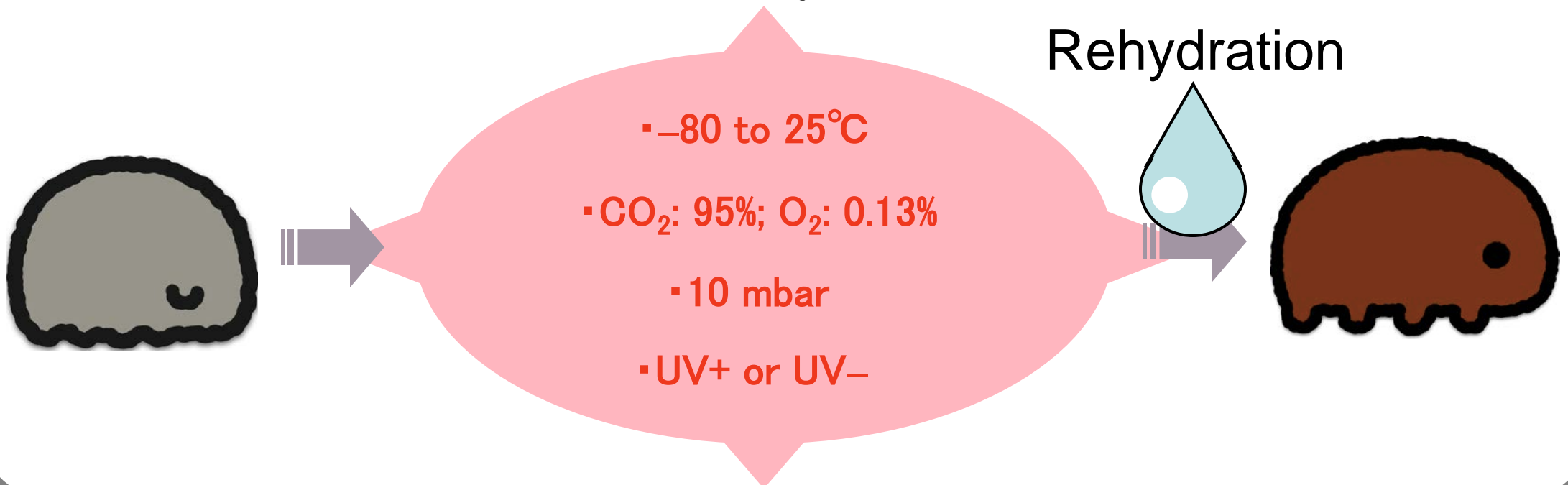


- Anhydrobiosis has protective effects on DNA against UV radiation

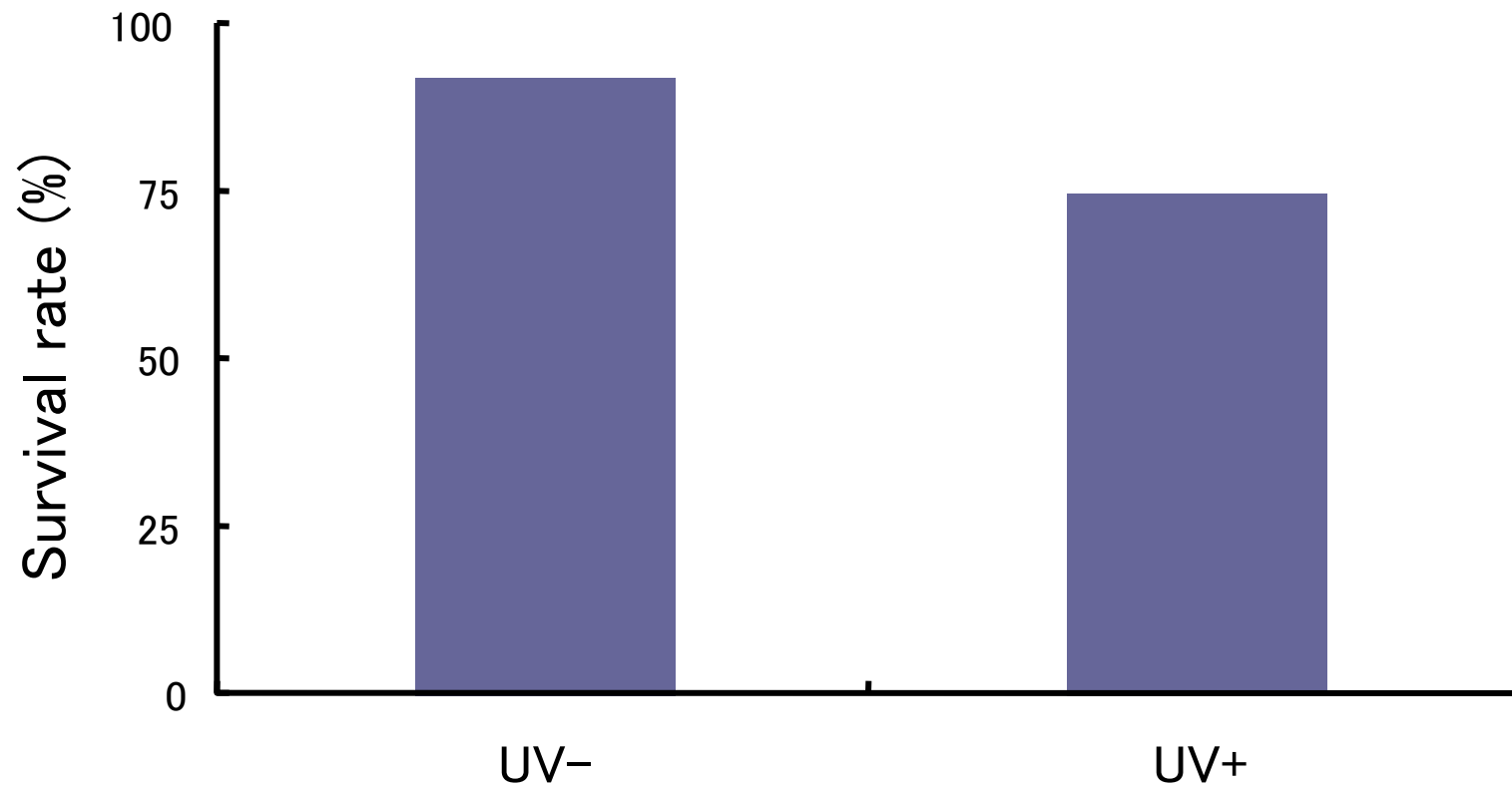
Mars Environmental Chamber Experiment



Mars Environmental Chamber (41 days)



Mars Environmental Chamber Experiment

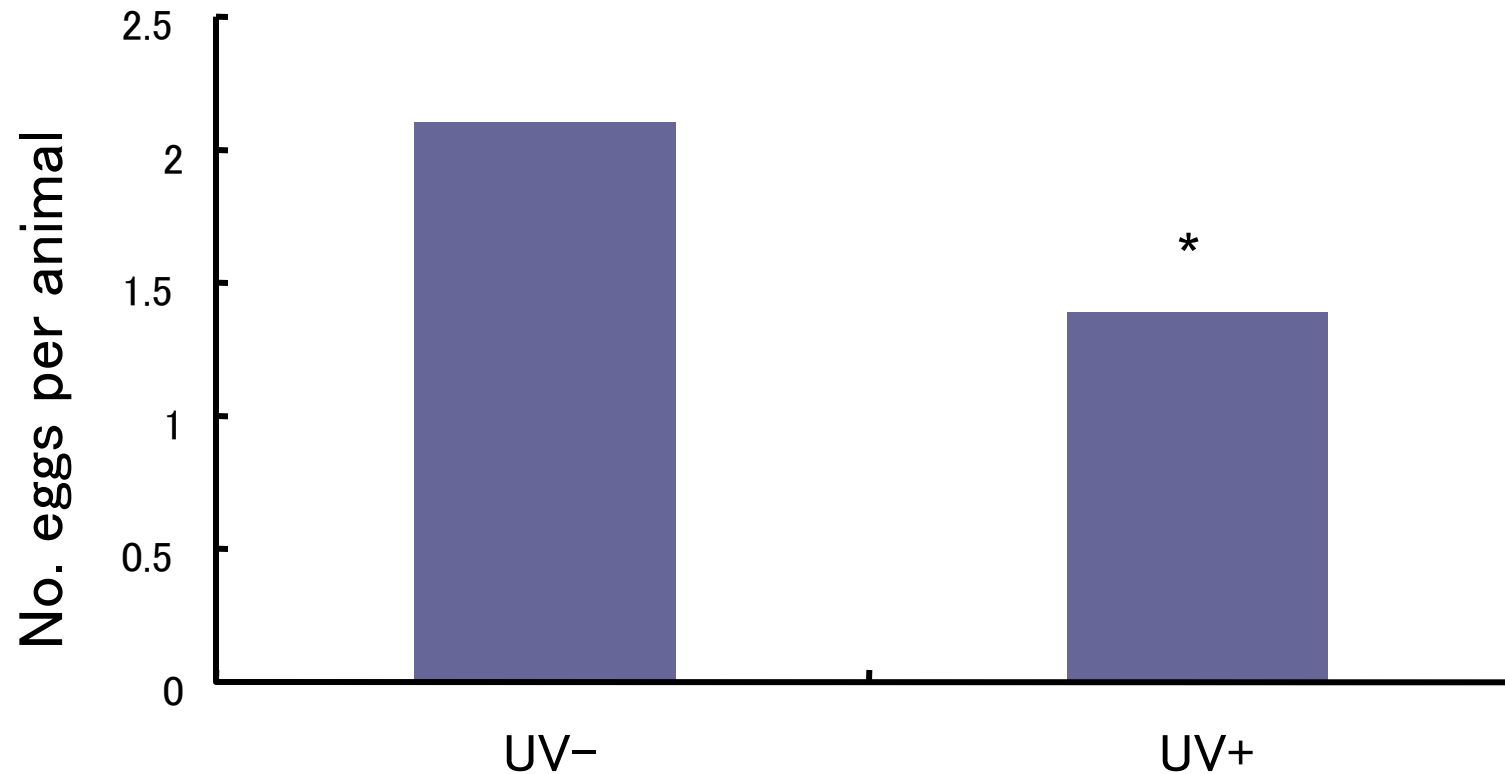


More than 70% of the animals survived after exposure to simulated Martian environments.

(Johnson et al. 2011)

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Mars Environmental Chamber Experiment



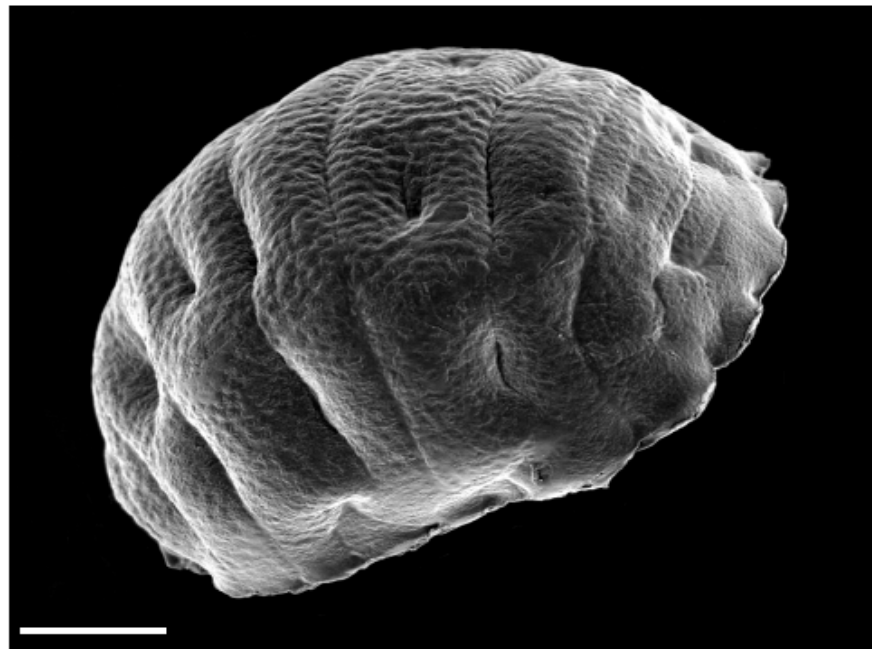
The animals exposed produced new generation.

(Johnson et al. 2011)

This document is provided by JAXA.

Summary

- Anhydrobiosis has protection effects on DNA against UV radiation.
- Tardigrades could survive in Mars surface environments for 41 d if they are covered with thin layer of regolith.
- There are possibilities that there are some multicellular-like organisms on the Mars-like environments.



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Mars Environmental Chamber Experiment Team

NAI Postdoctoral Program

Camo Sakamoto (Illustration)



Thank you.