

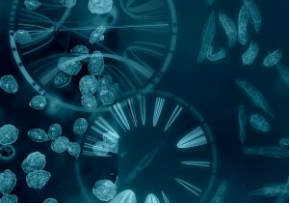
UNIVERSITÉ
LIBRE
DE BRUXELLES



Bdelloid rotifers as model system for space research: what can we learn from them?

Prof. Karine Van Doninck

Switch to Space 2, October 6th 2020



Bdelloid rotifers

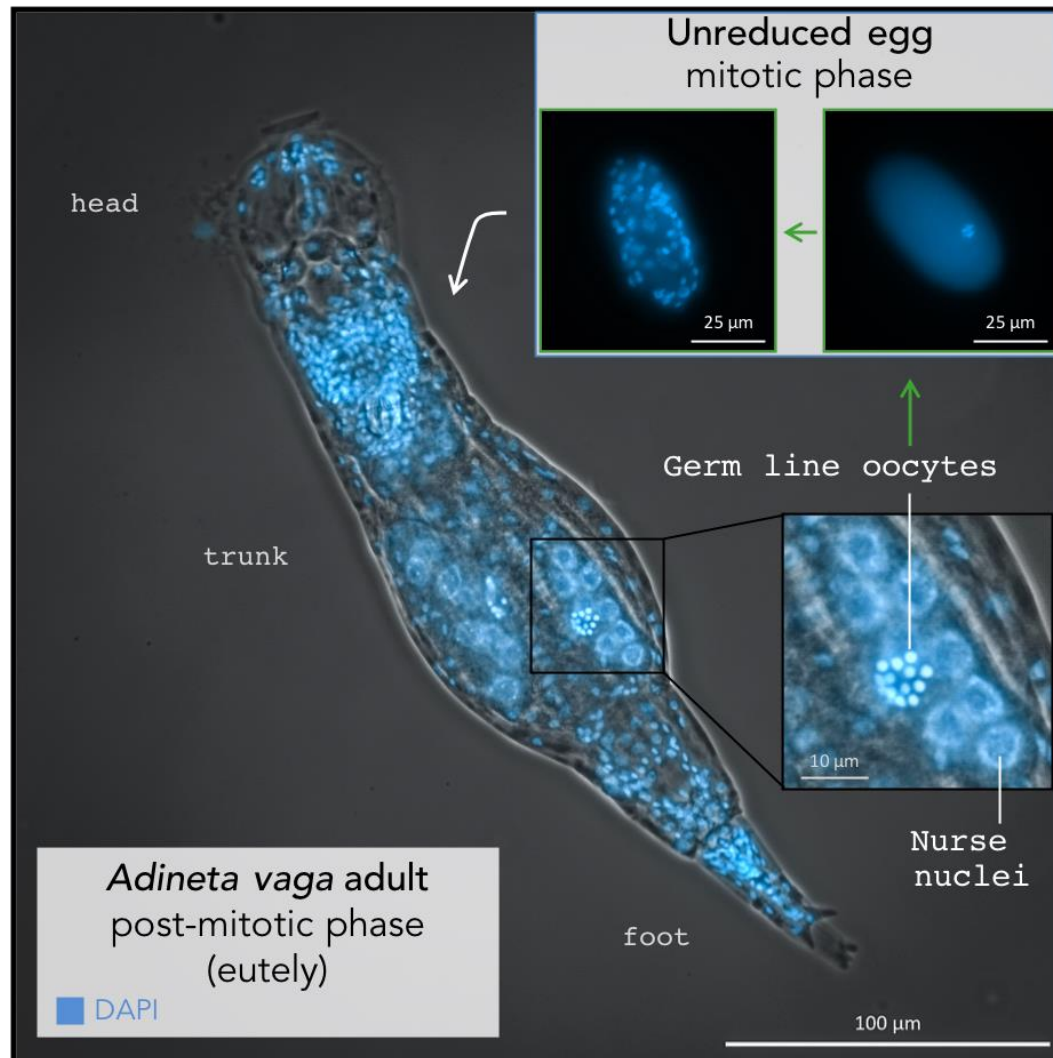
The most notorious putative ancient asexuals:

⇒ The bdelloid rotifers: a fascinating microscopic world discovered here by an artist



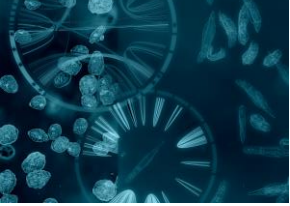
Credits to artist Wim van Egmond

Strict asexual reproduction?

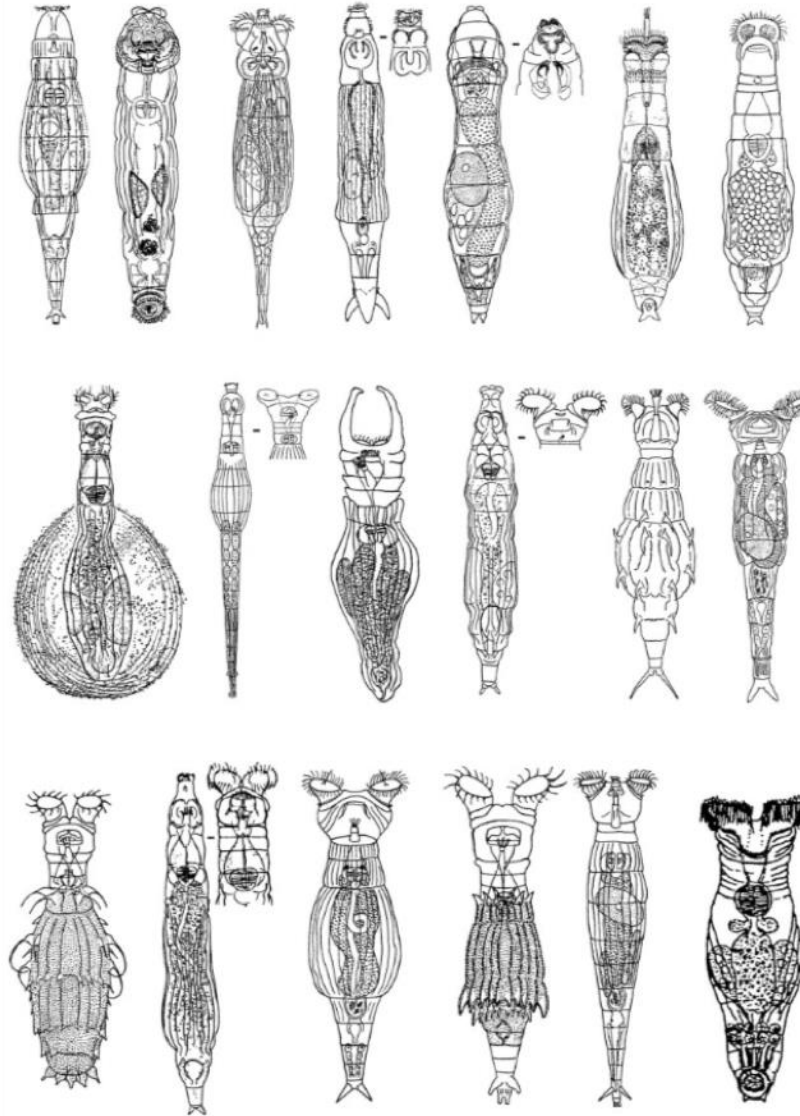


Postdoc
Matthieu Terwagne

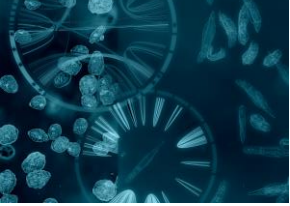
Easy to clone in the laboratory



> 400 morphospecies



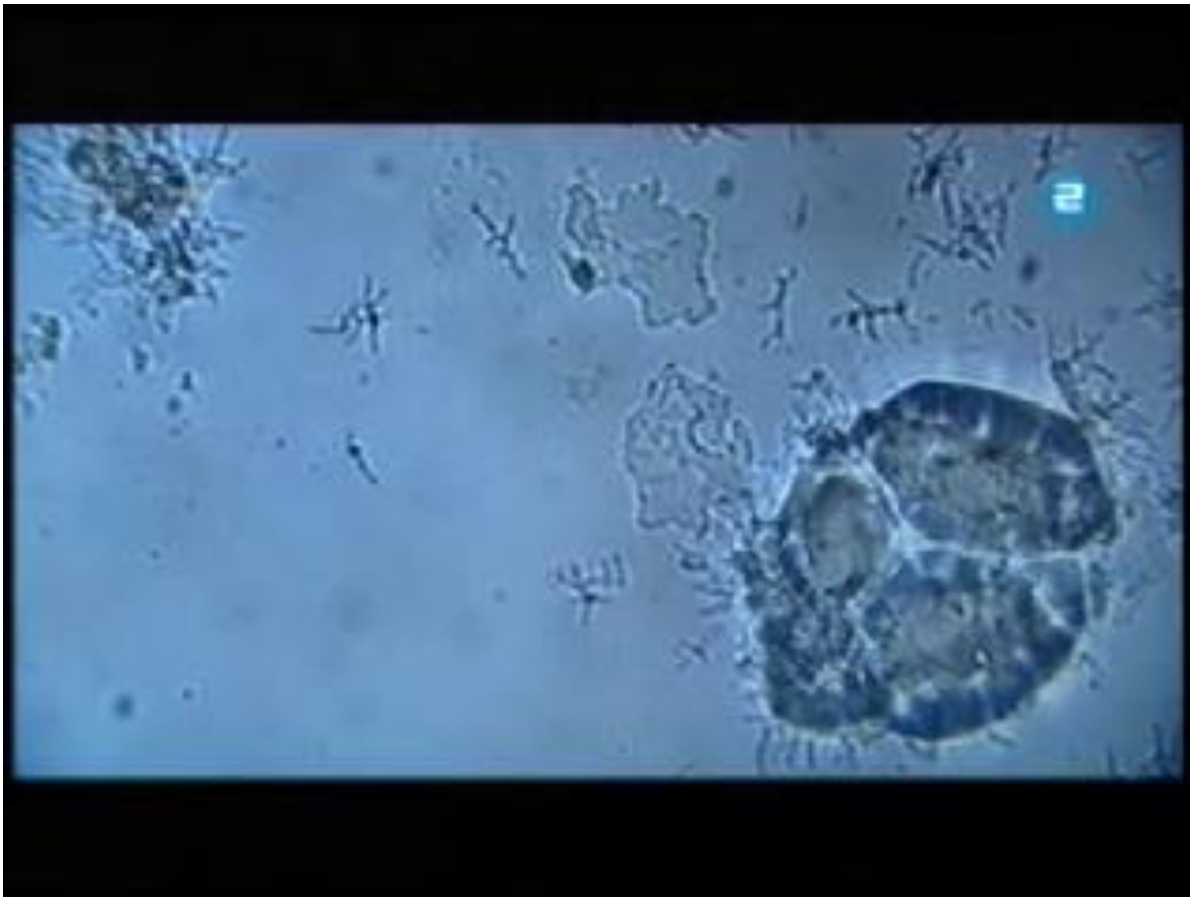
An evolutionary scandal

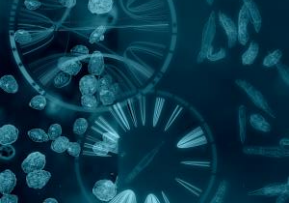


Desiccation resistance

One of the most notorious extremophile animals:

⇒ The bdelloid rotifers: a fascinating microscopic world already discovered by van Leeuwenhoek (1702)





Desiccation resistance

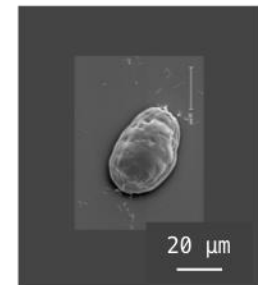
Hydrated



Contracted



Desiccated

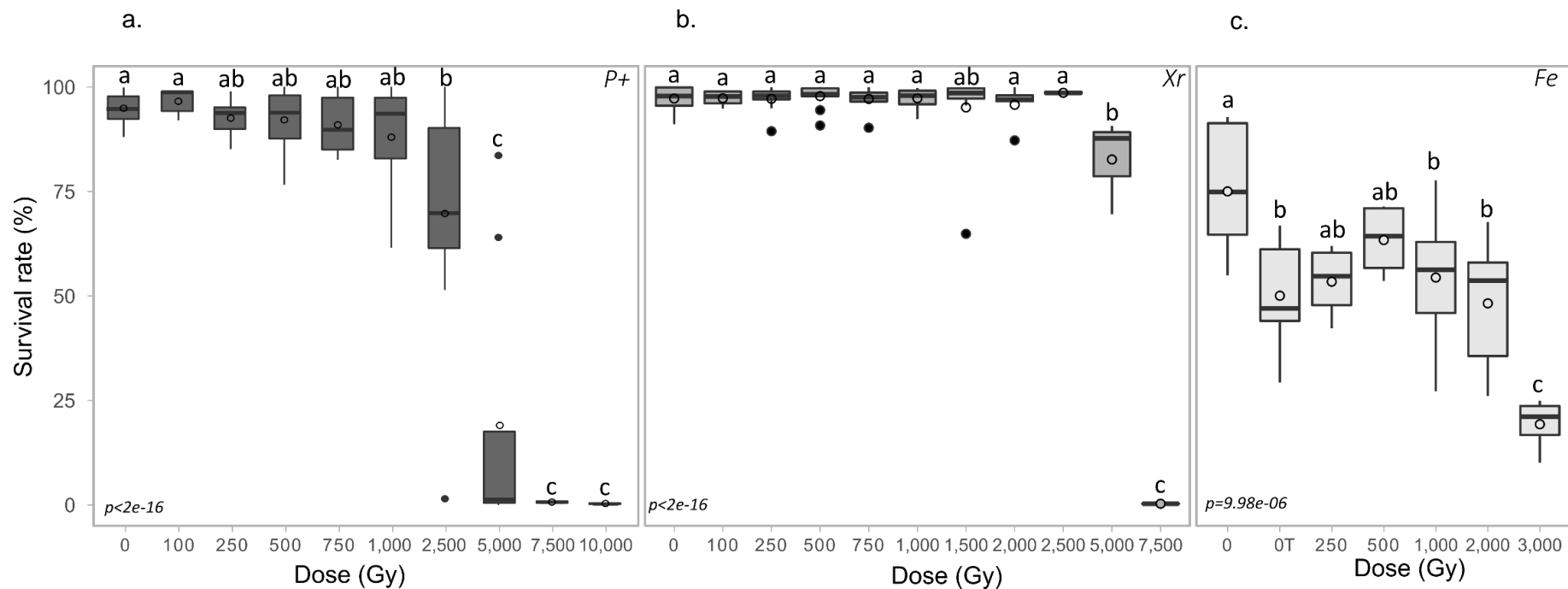


water
=
6.5% of dry weight ⁽¹⁾

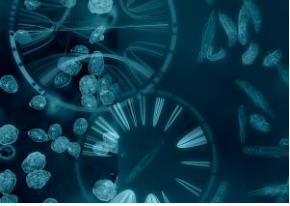
metabolism

Ionizing radiation resistance

Desiccated bdelloid rotifer *Adineta vaga* exposed to IR:



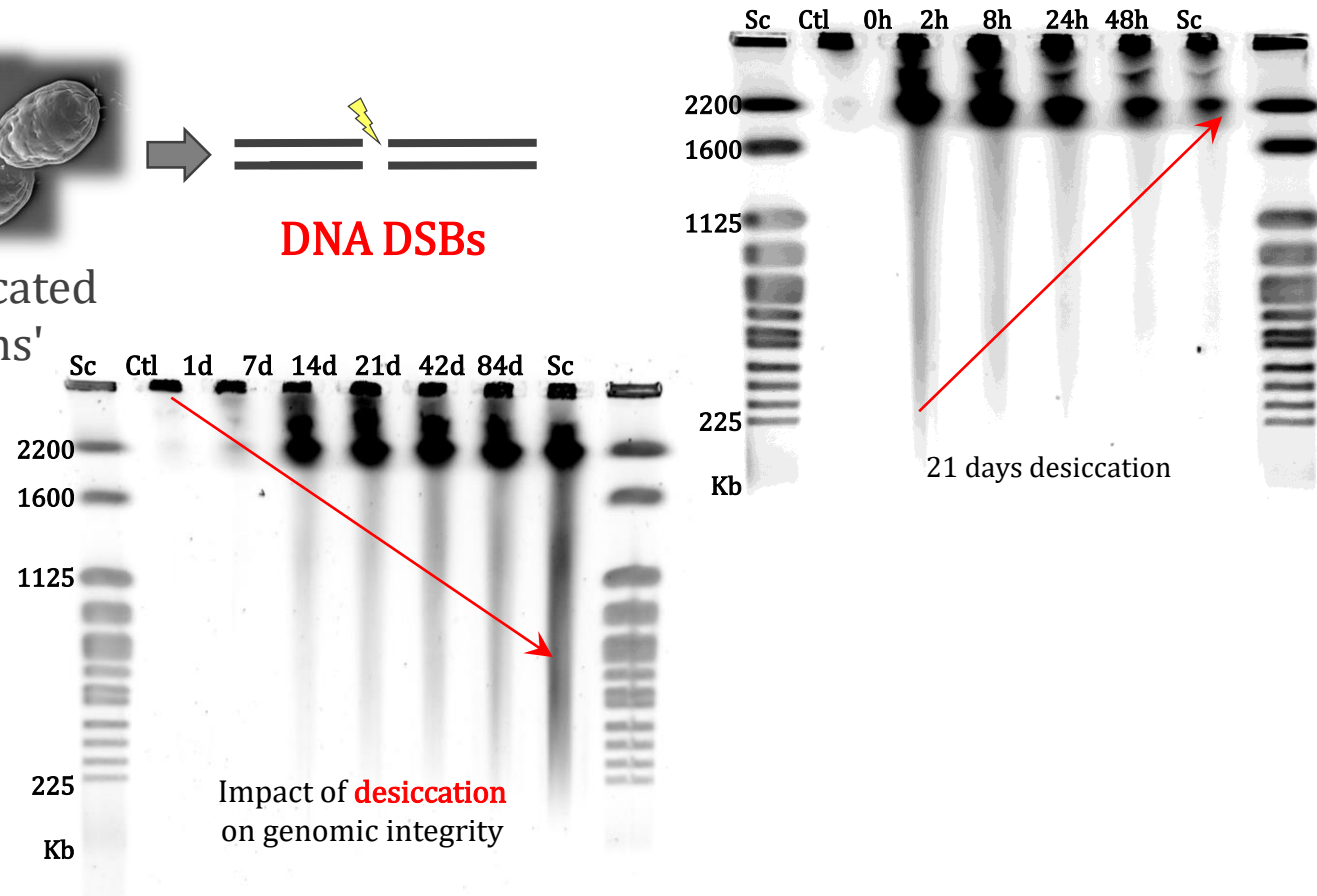
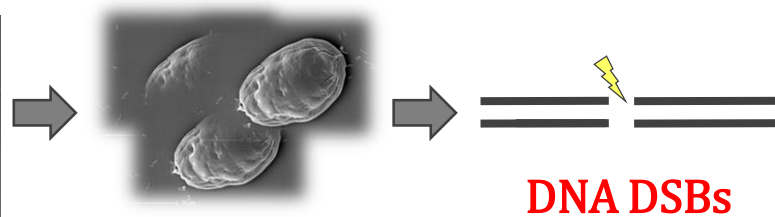
Postdoc
Boris Hespeels



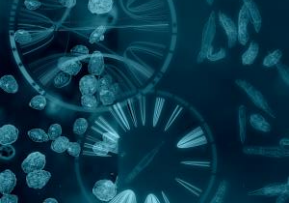
Genomic integrity following desiccation



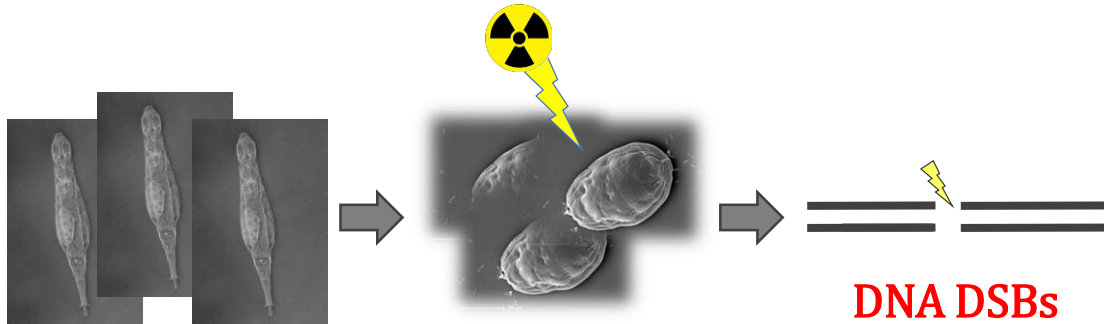
Hydrated
bdelloid clone



Postdoc
Boris Hespeels

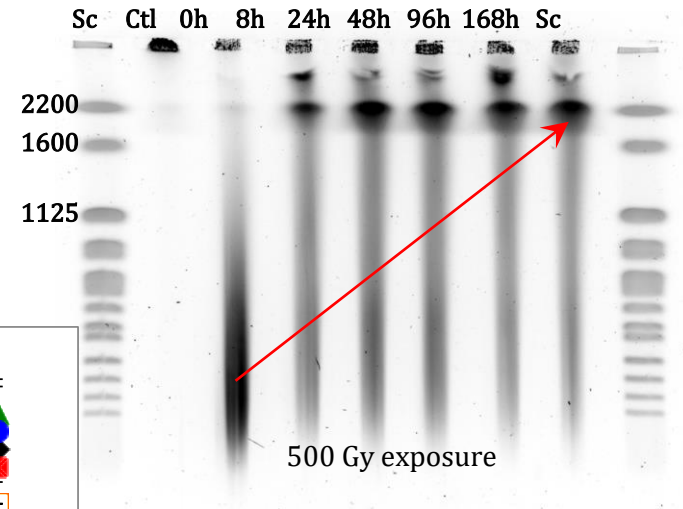
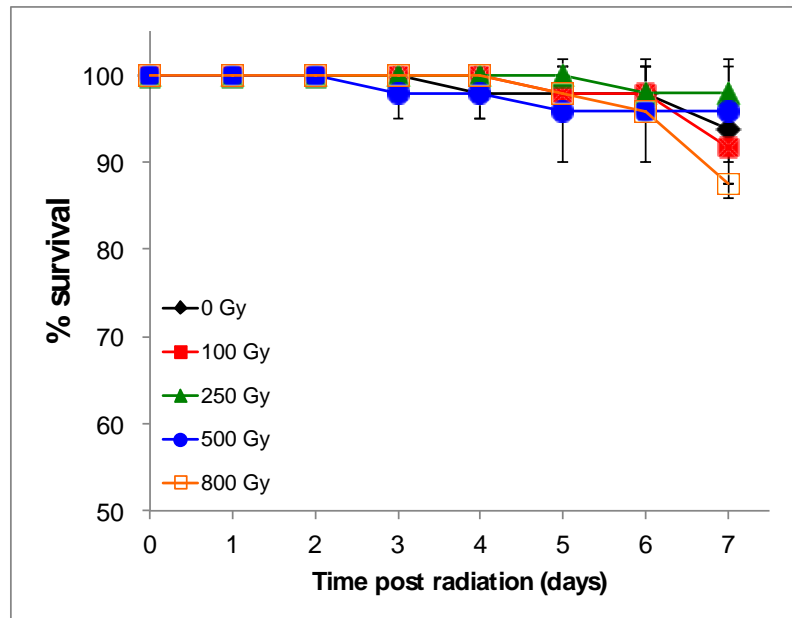


Genomic integrity following radiation



Hydrated
bdelloid clone

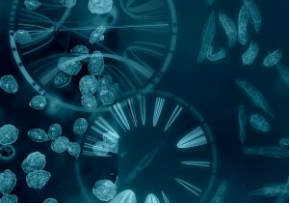
Desiccated



Postdoc
Boris Hespeels



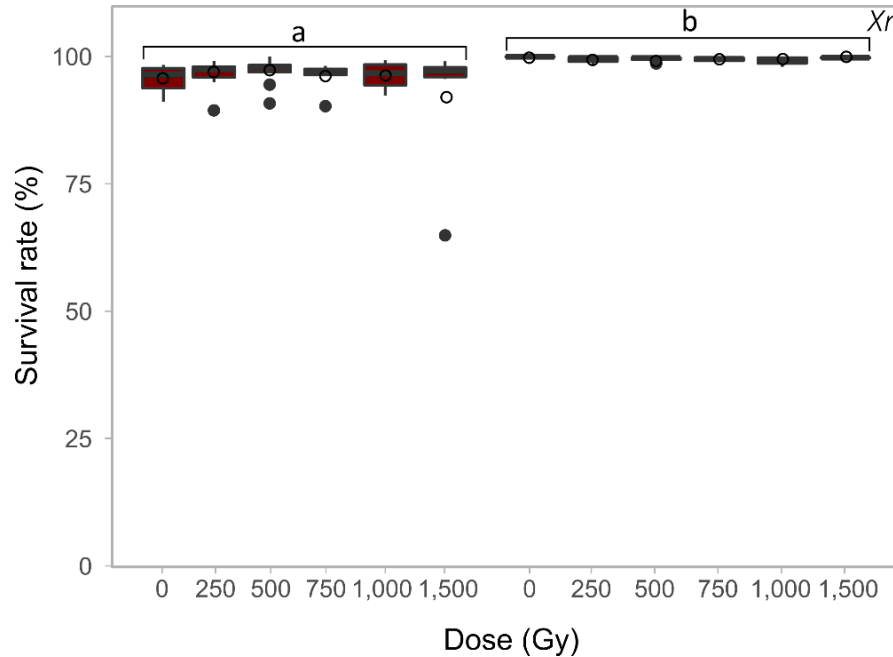
Postdoc
Matthieu Terwagne



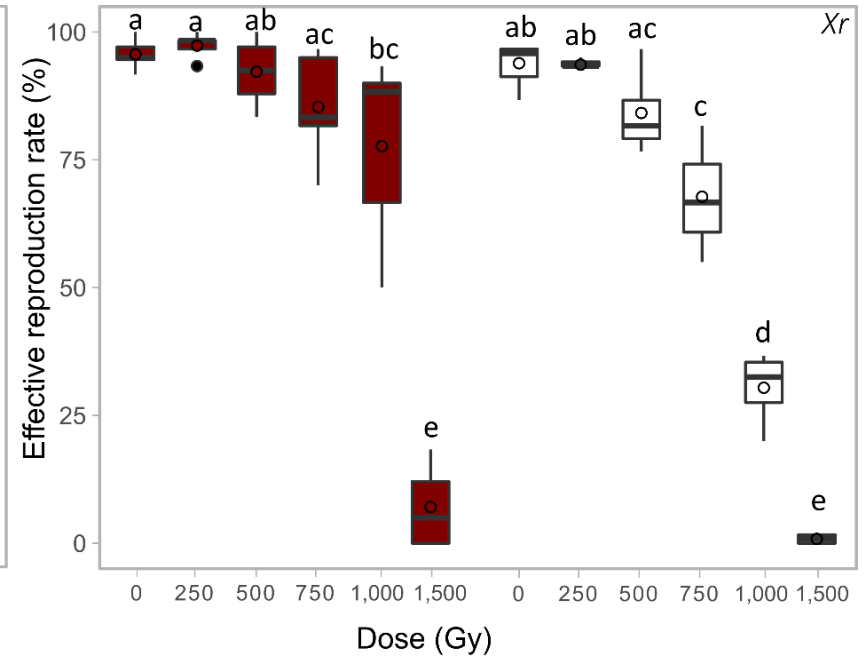
Ionizing Radiation: different impact on survival and fertility

Desiccated and hydrated bdelloid rotifer *A. vaga* exposed to X-rays:

a.



b.

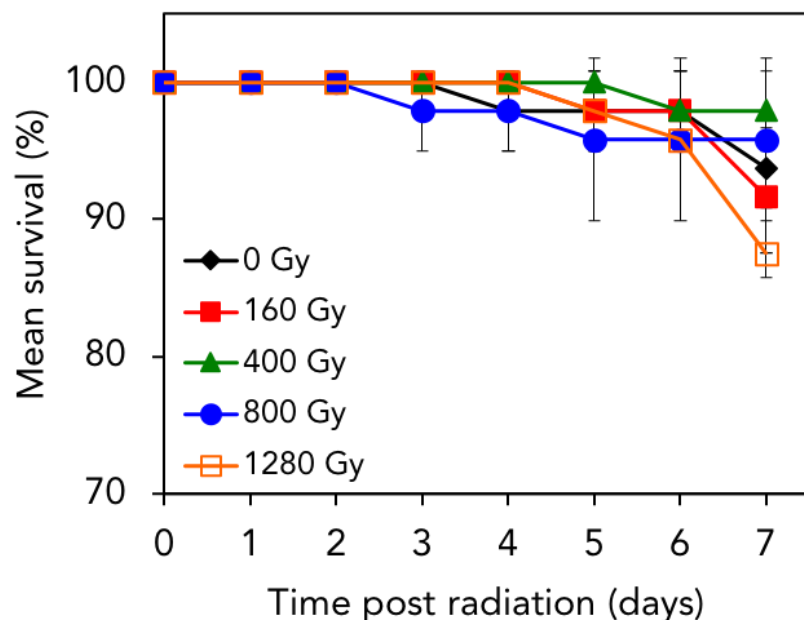


Postdoc
Boris Hespeels

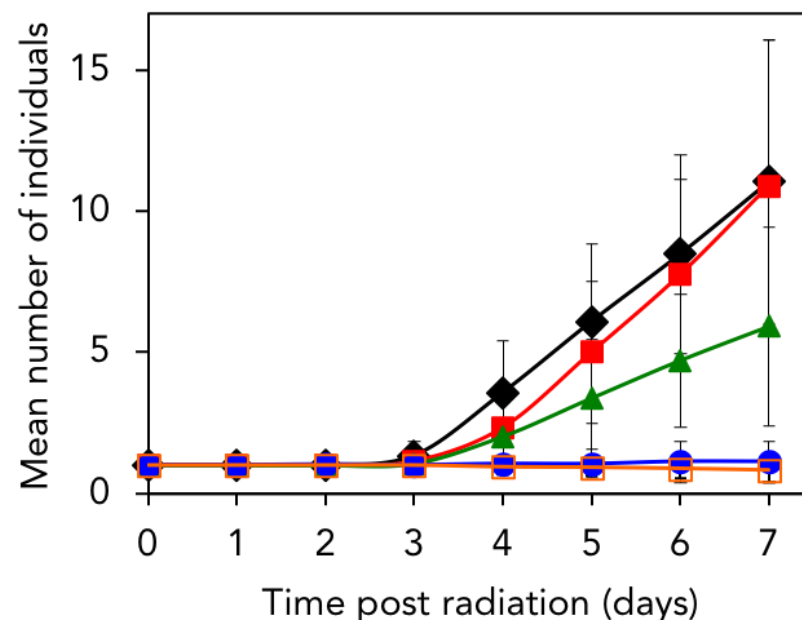


Ionizing Radiation: different impact on survival and fertility

A. vaga survival



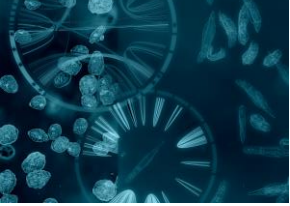
A. vaga reproduction (pop. growth)



Lower tolerance of germ-line cells than somatic cells to IR-induced damage

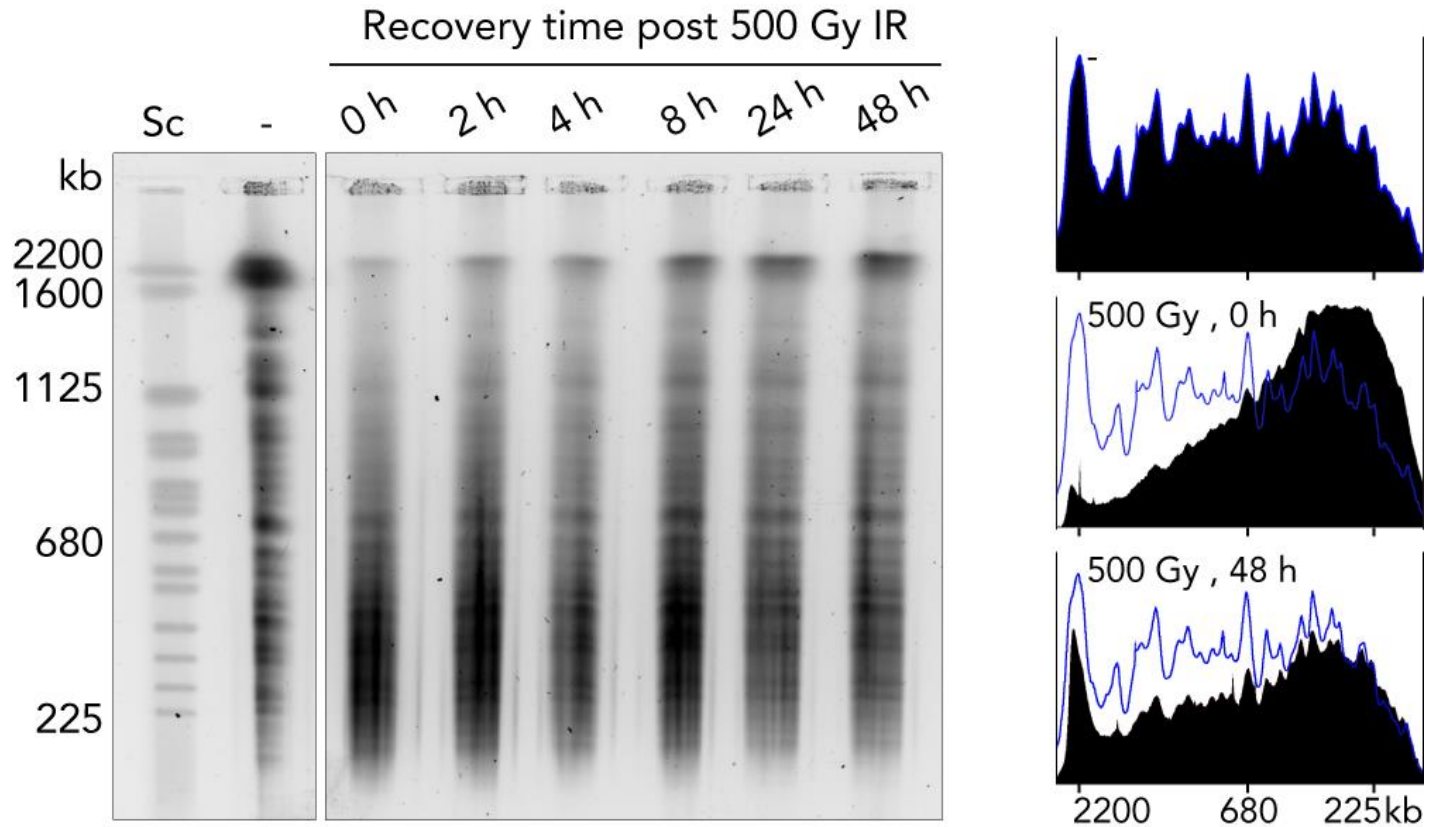
Postdoc
Matthieu Terwagne





Massive genomic DNA breakage: incomplete repair in somatic cells

SbfI restriction



DNA DSB repair within 48h

Postdoc
Boris Hespeels

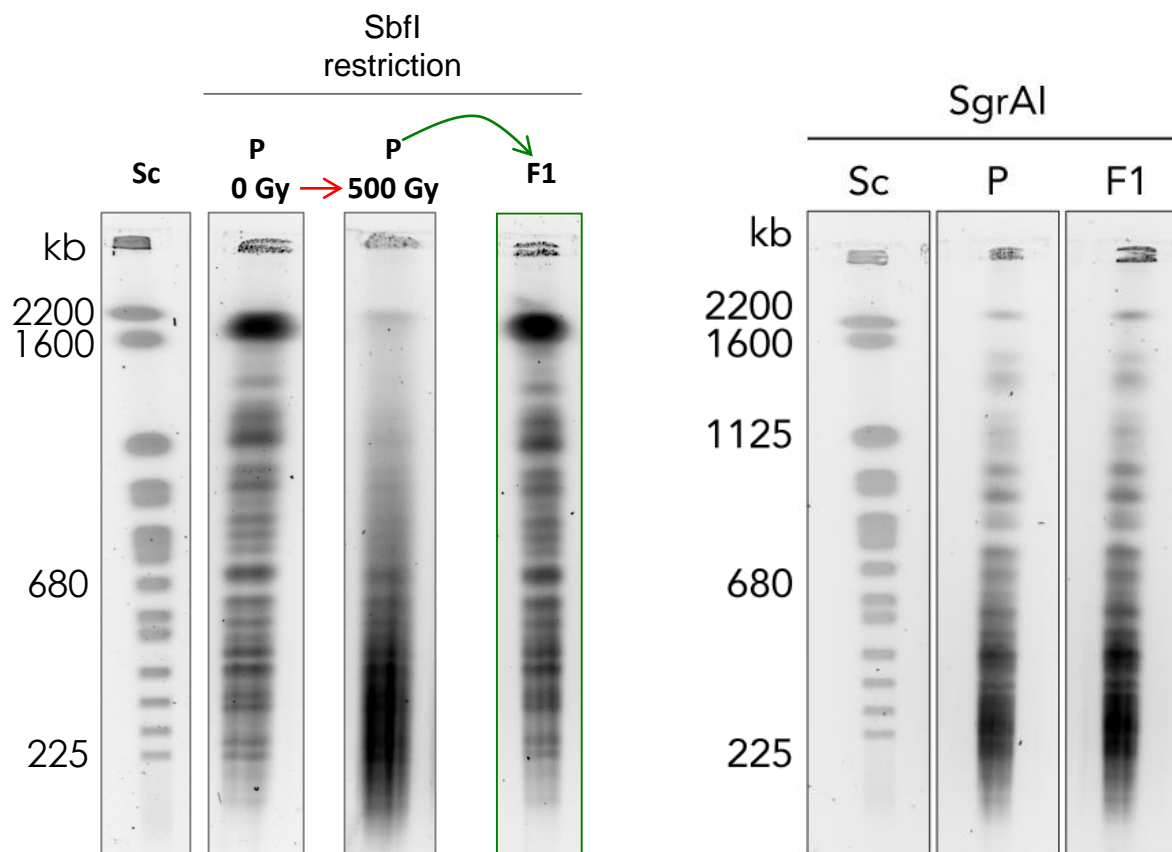


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Matthieu Terwagne





Massive genomic DNA breakage: genome integrity recovered in F1



Complete restoration of the parental profile in the F1 of irradiated individuals based on RE-coupled PFGE

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Boris Hespeels

Postdoc
Matthieu Terwagne



RISE (Rotifer In SpaceE)

The space environment is
hostile

Bdelloid rotifers as model
system for space research



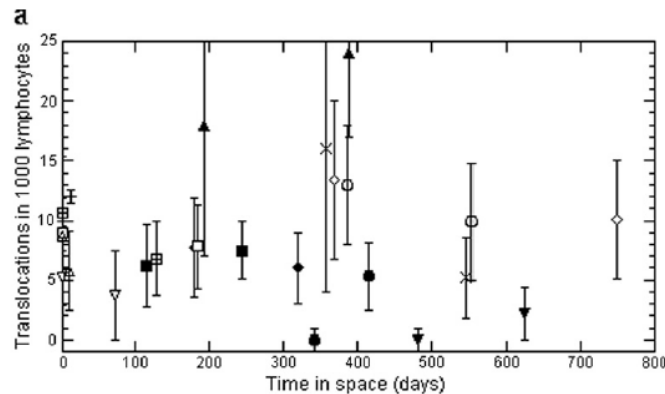
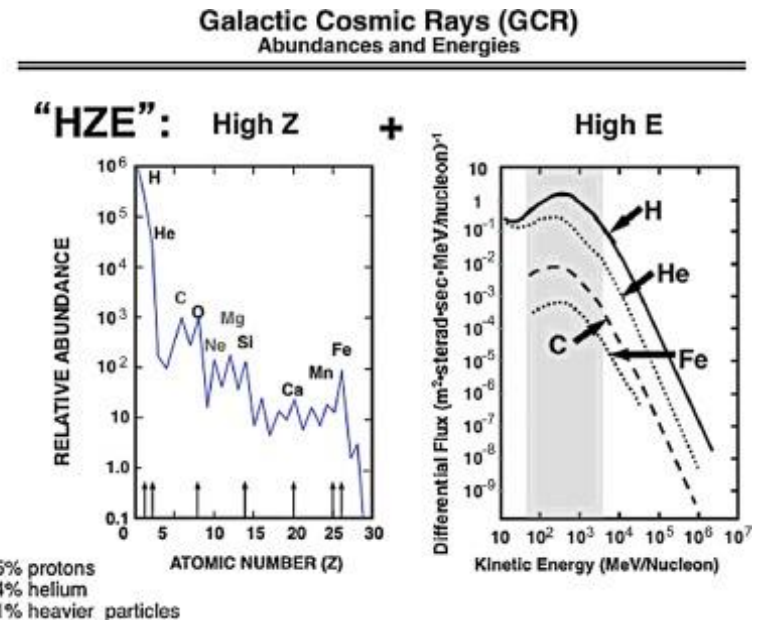
Space challenges

Long-term human space missions or long periods on ISS can have impacts on human health due to:

- ⇒ Microgravity
- ⇒ Higher doses of radiation: UV, X-rays and charged particles (such as galactic cosmic rays)
- ⇒ Confinement, ...



The International Space Station (ISS)
Altitude 400km. Low Earth Orbit (LEO).



Time-course of chromosomal aberration in a study on 22 Russian cosmonauts. Relationship between translocation frequency (WGE) and total duration of space sojourns for cosmonauts involved in multiple space flights. Each symbol represents a different cosmonaut. (George et al., 2007)



ROTIFER-B

Rob-1: how microgravity and space flight affect biological processes, using as model organism *Adineta vaga*.

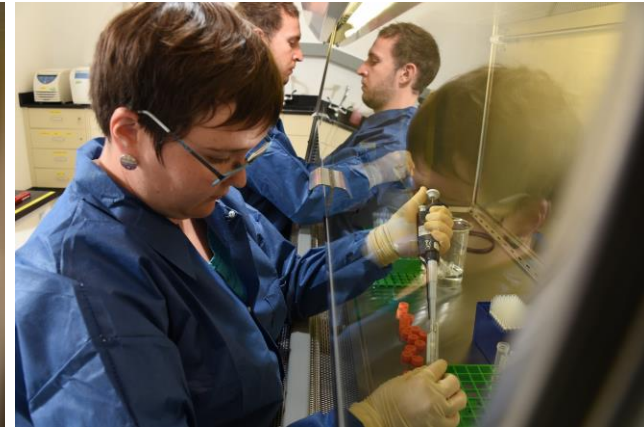
02/12/2019: integration and assembly of Rob-1



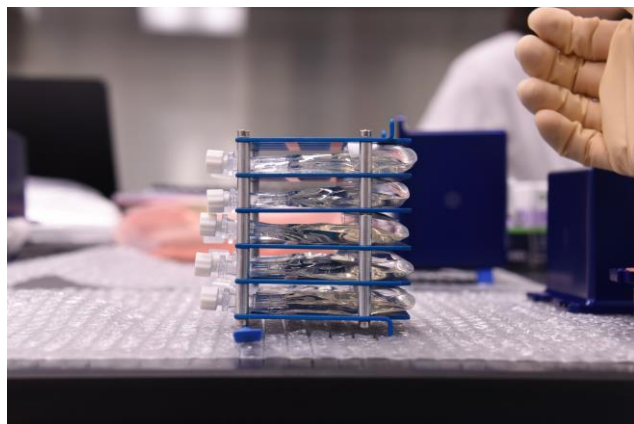
Injection of 10.000 individuals per PL30 bags



Karine Van Doninck & Boris Hespeels



Lucie Bruneau & Richard Coos



Collaboration with Kaiser Italia



Collaboration with ESA

Rob-1: art & science





ROTIFER-B

Rob-1 on ISS

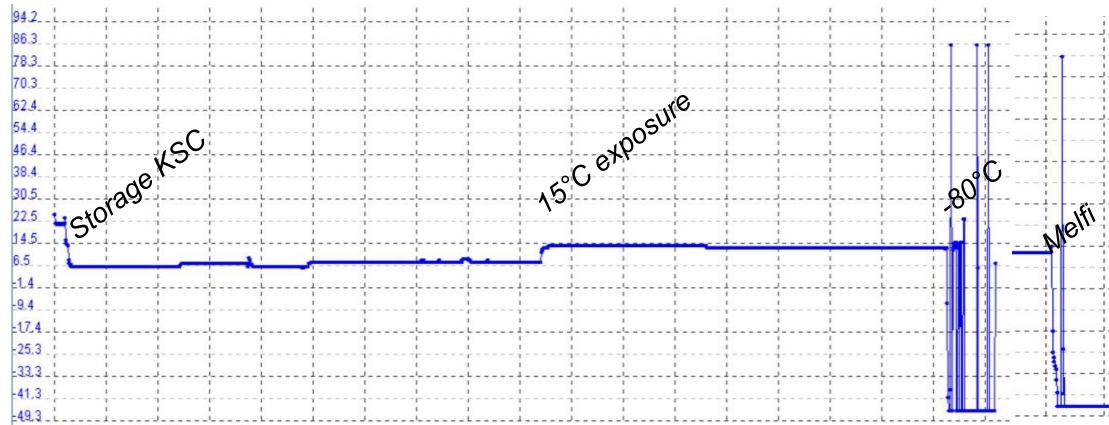
05/12/2019: launch to ISS



Credits to artist Marc Guillaume



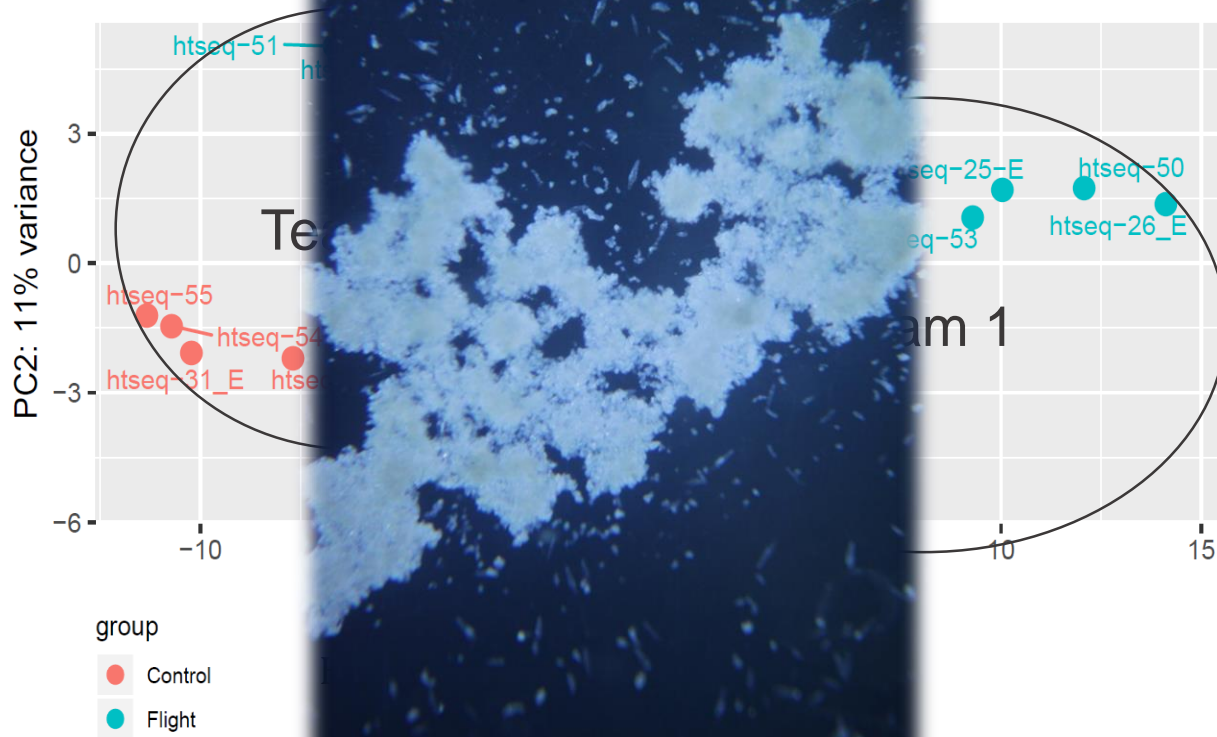
Astronaut Luca Parmitano – Rob 1 – Kubik Incubator





ROTIFER-B

Rob-1: preliminary results



“Flight” has little effect on gene expression

Postdoc
Boris Hespeels

Postdoc
Victoria Moris



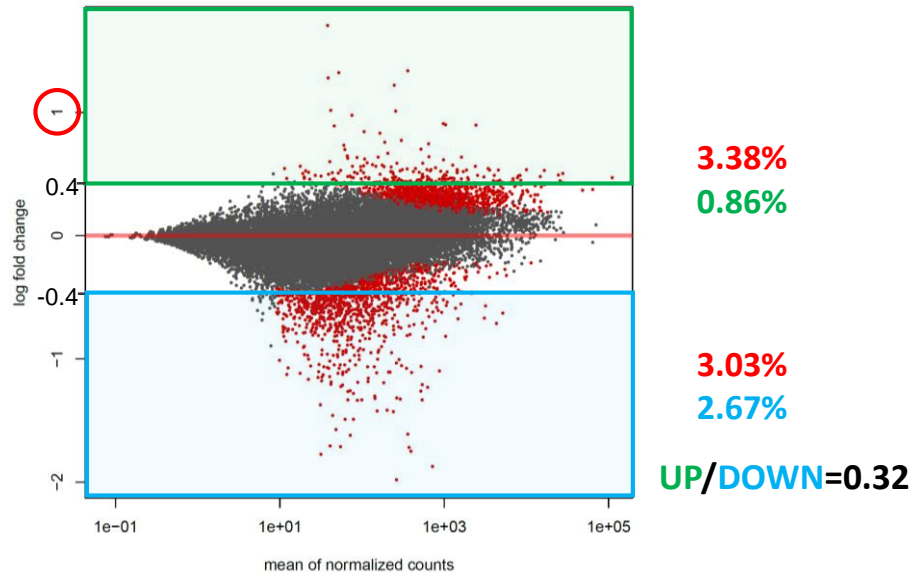


ROTIFER-B

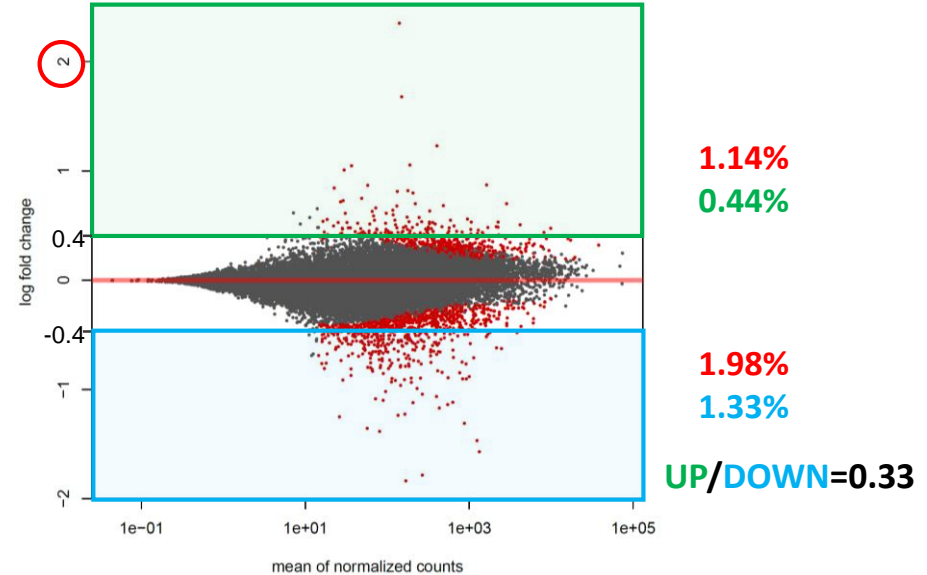
Rob-1: preliminary results

Team 1 vs Team 2

Team 1



Team 2



More genes downregulated (lower expression) in the flight samples when compared to the ground samples.

Postdoc
Victoria Moris

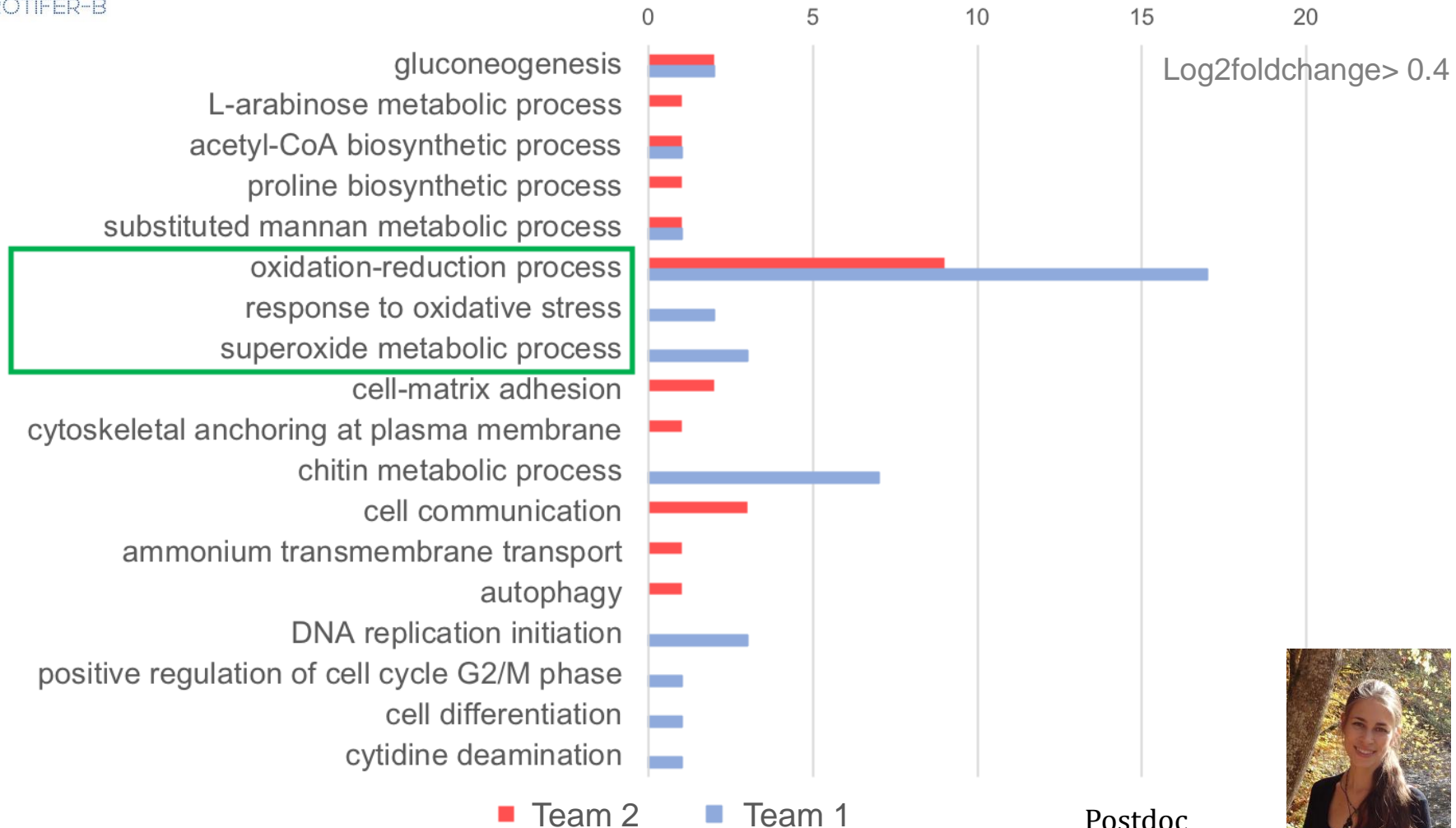




ROTIFER-B

Rob-1: preliminary results

Oxidative stress



Postdoc
Victoria Moris



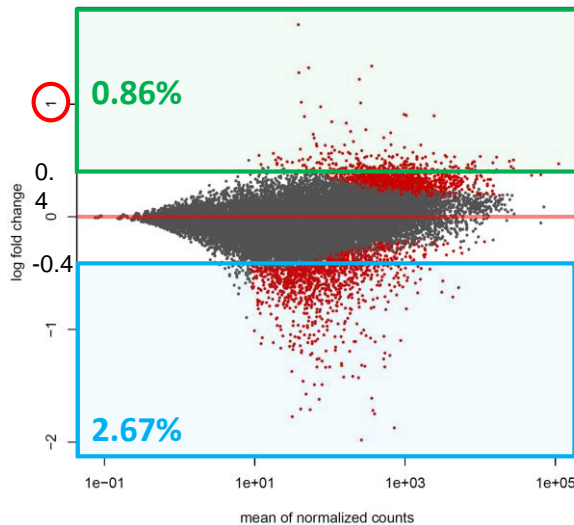


ROTIFER-B

Rob-1: preliminary results

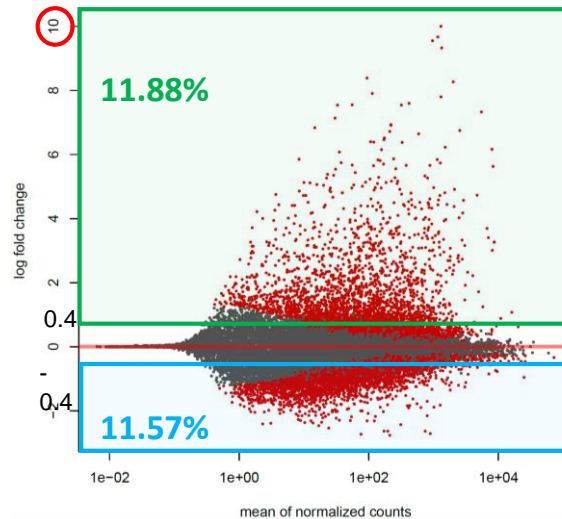
Radiation effect in the laboratory

Team 1



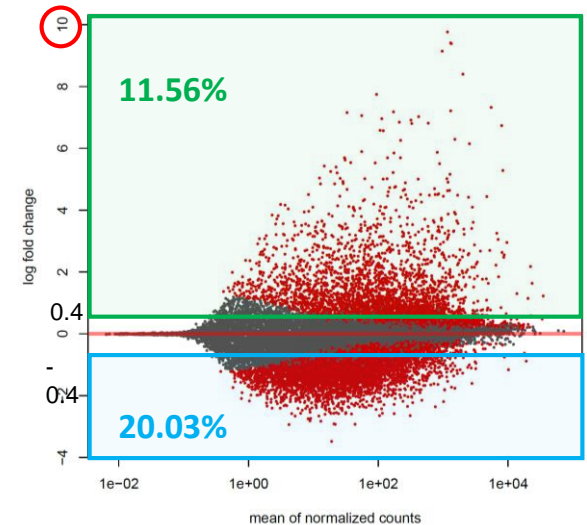
Logfc > 0.4 **UP/DOWN=0.32**
Logfc > 1 **UP/DOWN=0.09**

500 Gy X-rays, hydrated *A. vaga*
Timepoint: 2.5h after radiation



Logfc > 0.4 **UP/DOWN=1.03**
Logfc > 1 **UP/DOWN=1.24**

500 Gy X-rays, desiccated *A. vaga*
Timepoint: 2.5h after rehydration



Logfc > 0.4 **UP/DOWN=0.58**
Logfc > 1 **UP/DOWN=0.54**

Higher log2foldchange (up to 10) for genes being overexpressed
Higher proportion of genes being upregulated

Postdoc
Victoria Moris



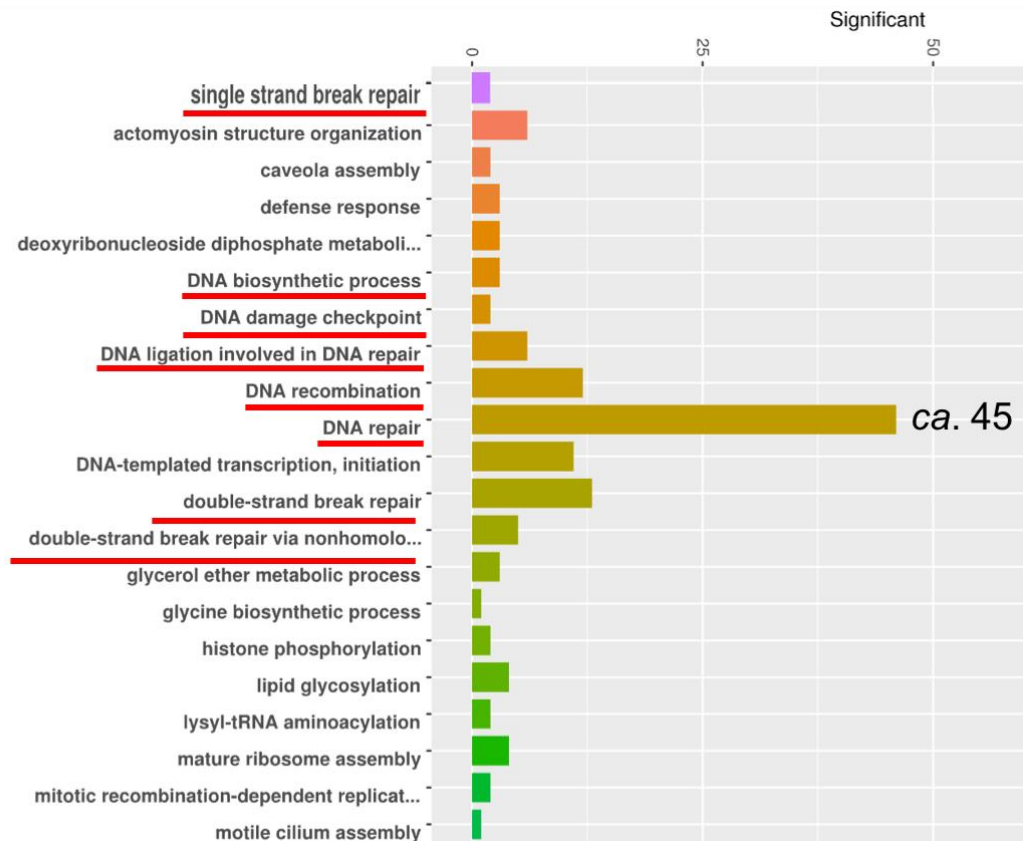


ROTIFER-B

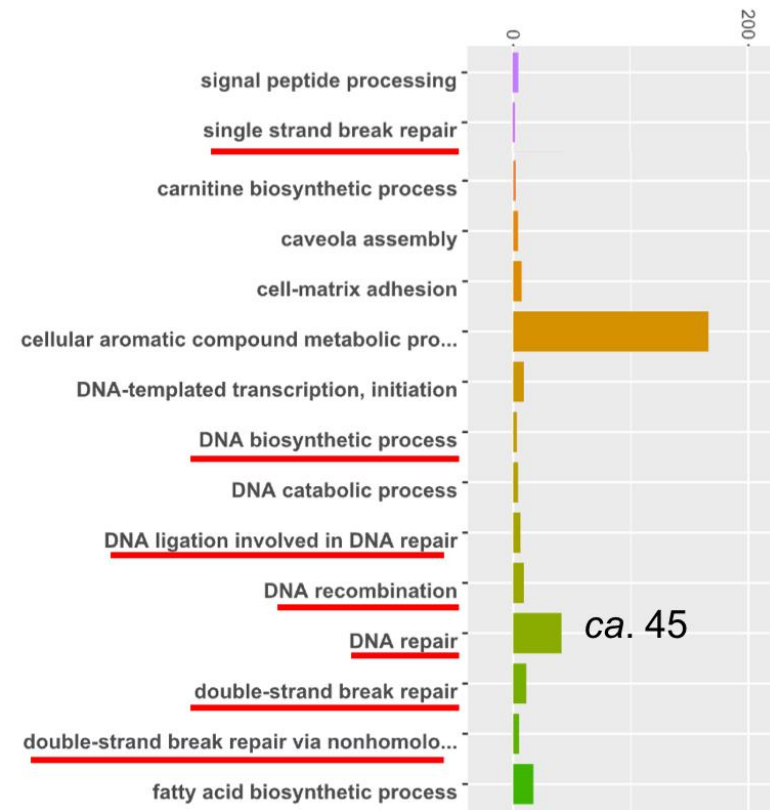
Rob-1: preliminary results

DNA repair following exposure to X-rays

500 Gy X-rays, **hydrated *A. vaga***
Timepoint: 2.5h after radiation



500 Gy X-rays, **desiccated *A. vaga***
Timepoint: 2.5h after rehydration



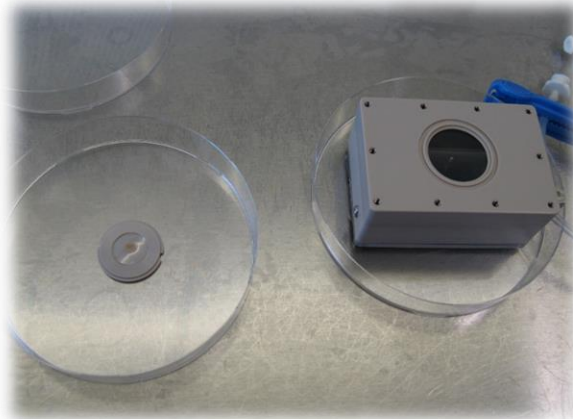
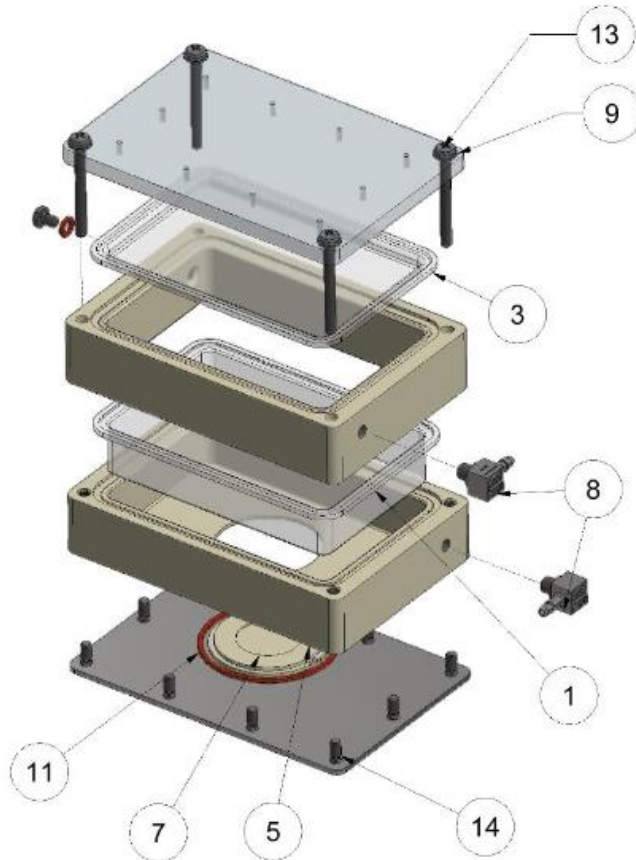


ROTIFER-B

Rob-2: DNA repair in microgravity?

DNA repair on ISS following exposure of desiccated
A. vaga to X-rays?

- ✓ Autonomous rehydration
- ✓ Long term autonomous cultures
- ✓ Restart new populations from eggs and fixed adults.



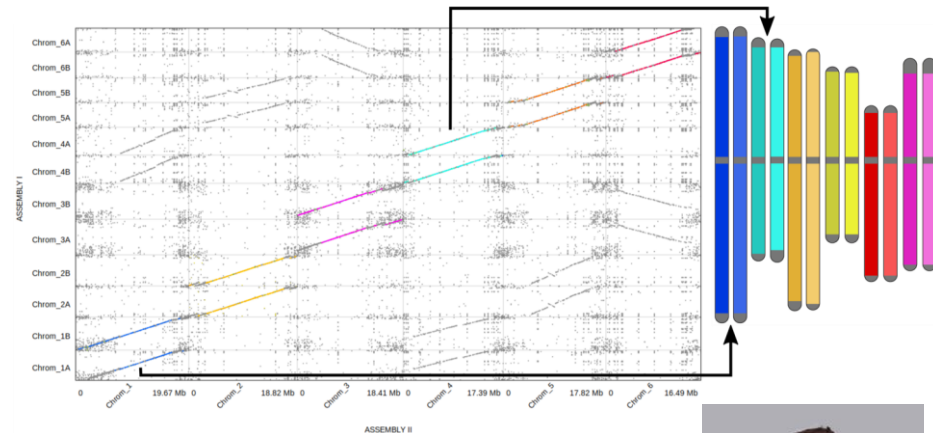
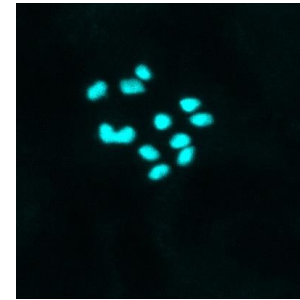
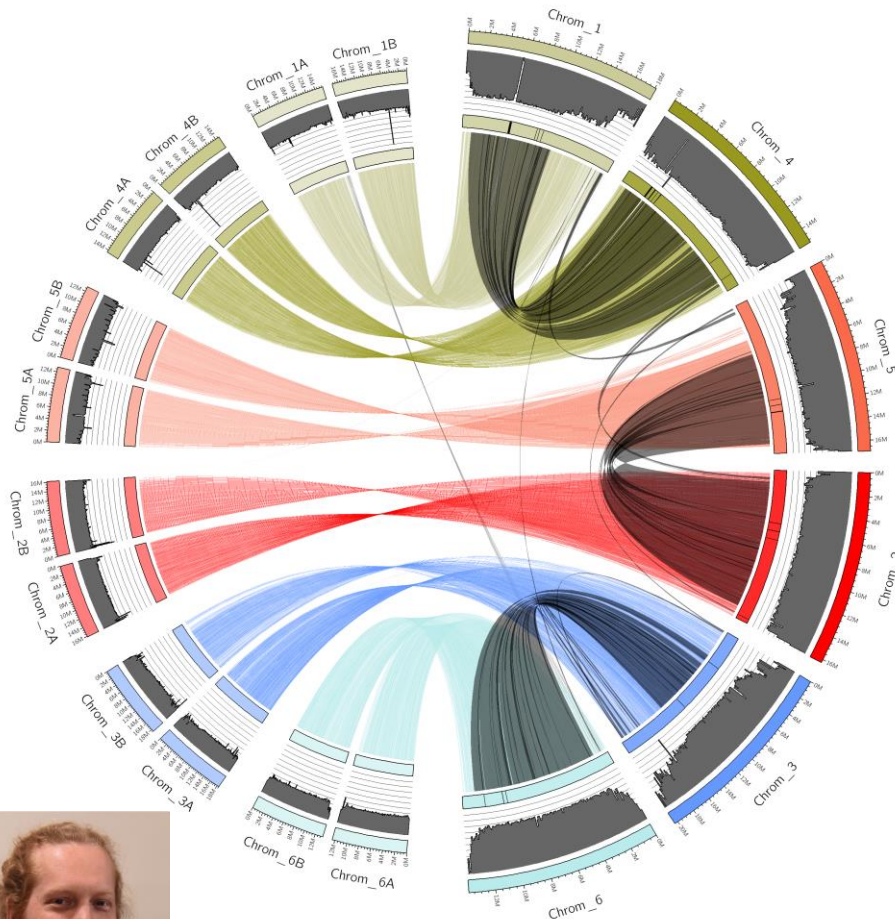
SVT hardware



ROTIFER-B

Rob-2: DNA repair in microgravity?

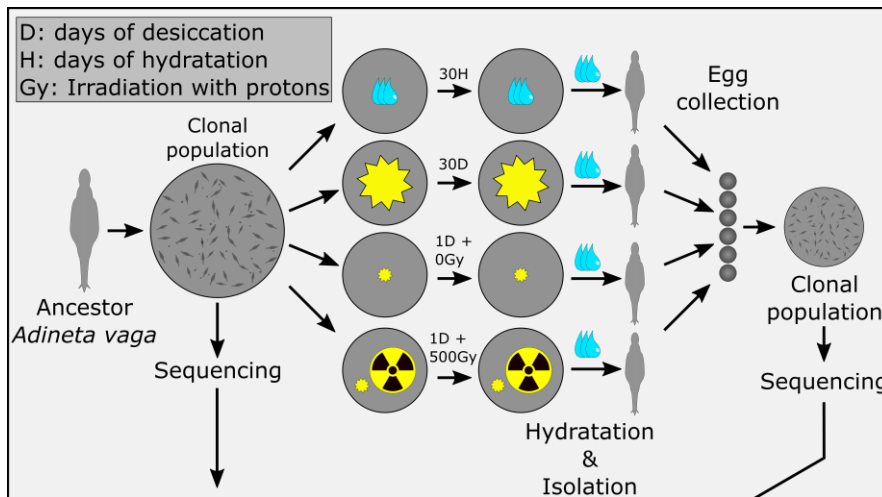
Chromosome-scale genome assembly of *Adineta vaga*



Postdoc
Paul Simion

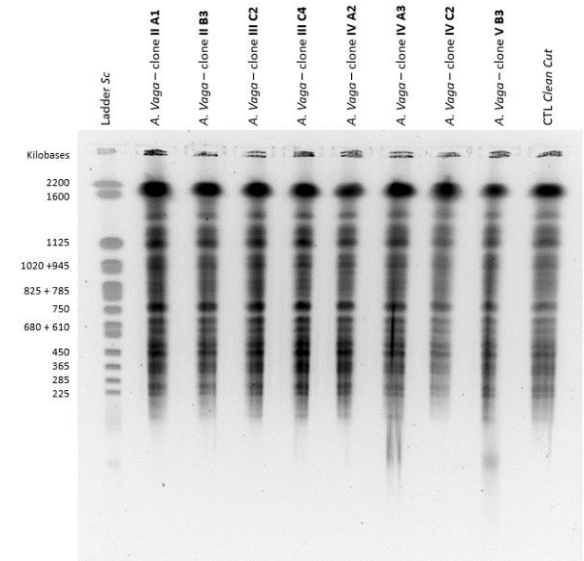
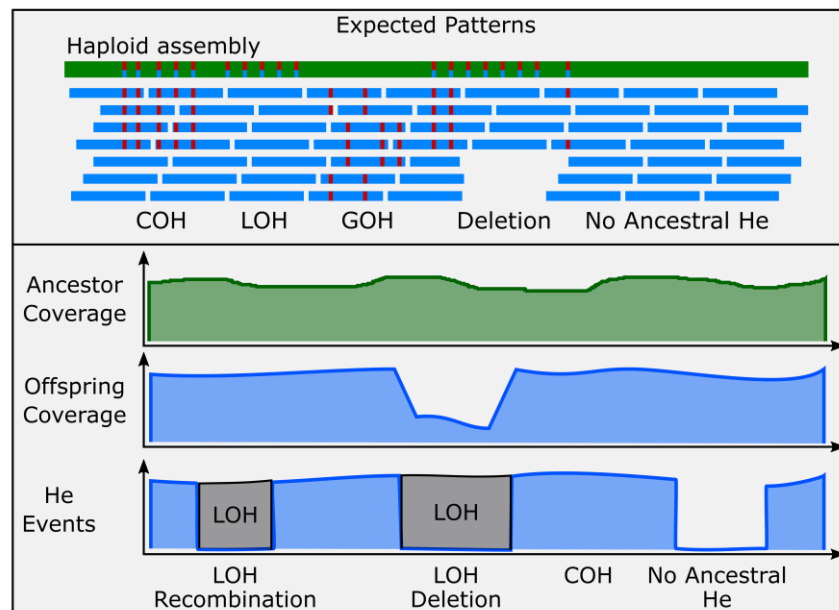
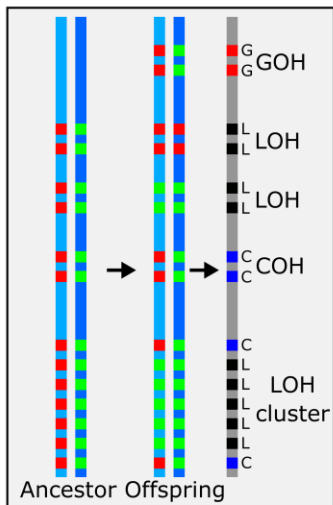
PhD student
Antoine Houtain

Rob-2: DNA repair in microgravity?



Haploid Genome Assembly

Mapping and Coverage
Variant Calling

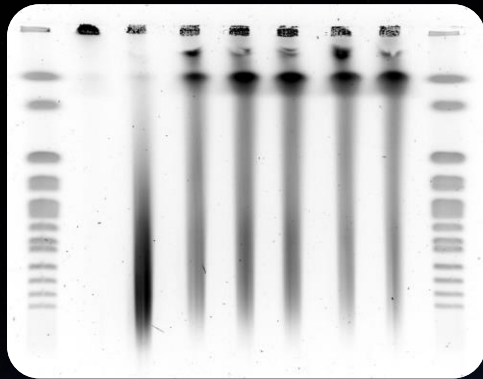


PhD student
Antoine Houtain

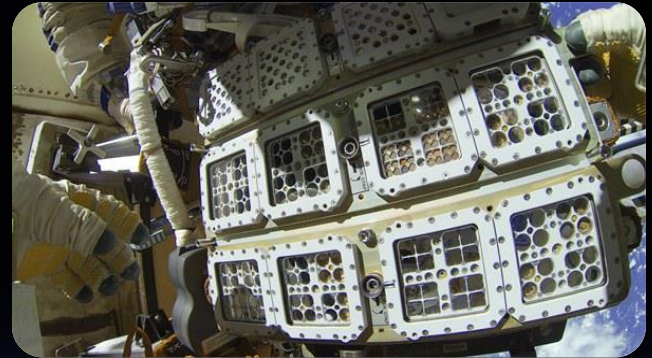




Rob2 (**November 2020**)
DNA repair in Space?



RoA (**2024**)
Astrobiology



Rotifers In SpaceE

a new eukaryotic extremophile model organism to study the impact of radiation and micro-gravity on biological processes



www.rotifer-in-space.com

Acknowledgements



Véronique Baumlé
(Unamur)



Lucie Bruneau
(Unamur)



Rohan Arora
(Unamur)



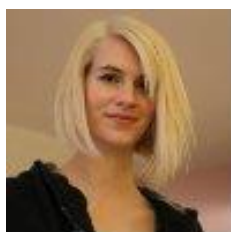
Cecile Bopp
(Unamur)



Bernard Hallet
(UCL)



Pr. Stéphane
Lucas
(Unamur)



Pr. Anne-
Catherine Heuskin
(Unamur)



Randy Vermeesen
(SCK-CEN)



Rene Demets
(ESA)



Nicol Caplin
(ESA)



Jutta Krauss
(ESA)



Bjorn Baselet
(SCK-CEN)



Marjan Moreels
(SCK-CEN)



Sarah Baatout
(SCK-CEN)

URBE/LEGE/RISE team, LARN team and
SIAM platform, SCK-CEN team, BIOTESC,
ESA, Prodex/BELSPO, Vocatio, ...

Acknowledgments

I also acknowledge the bdelloid rotifers, to be such a fascinating clade of microscopic females already discovered by van Leeuwenhoek



Thank you for your attention!