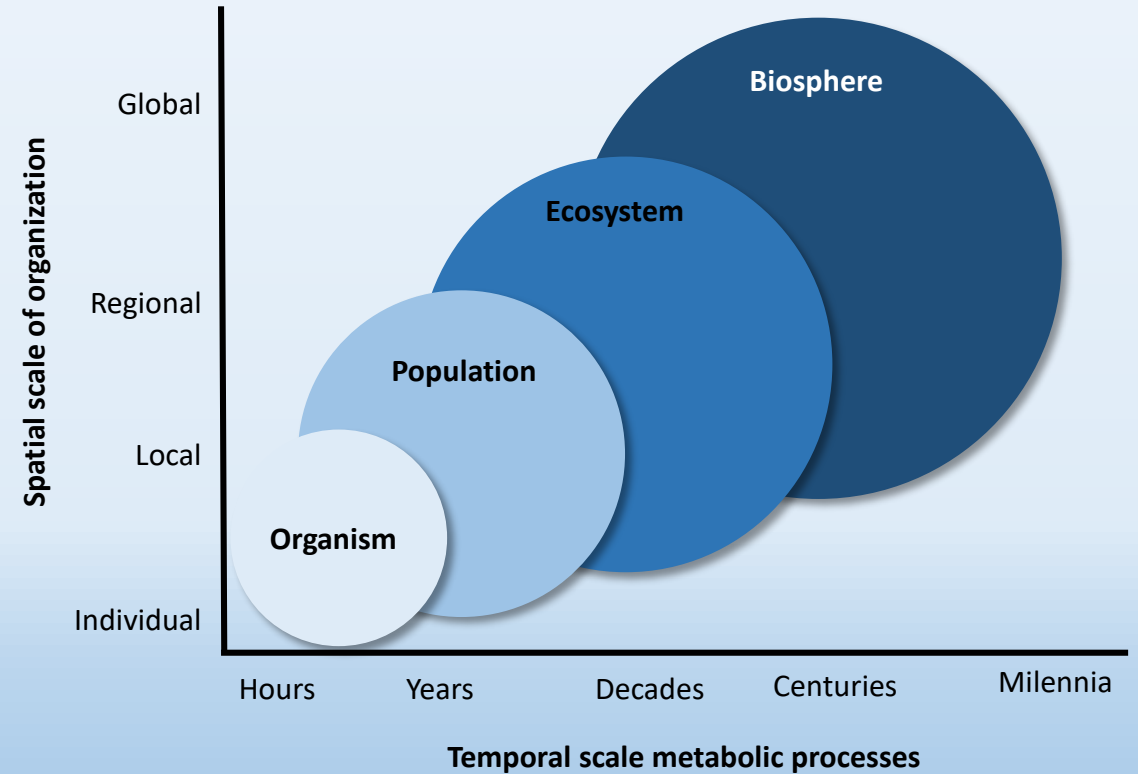


# Scaling in biological systems: application in terrestrial ecology and formation of artificial ecological systems



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Department of Biology  
Subdepartment of Quantitative Ecology

# Scales of ecological organization





# Ecotoxicology

- Pesticides
- New materials – nanoparticles
- Abiotic parameters – climate change








Ecotoxicology and Environmental Safety

Volume 148, February 2018, Pages 480-489



Influence of soil temperature and moisture on biochemical biomarkers in earthworm and microbial activity after exposure to propiconazole and chlorantraniliprole

Davorka K. Hackenberger , Goran Palijan , Željka Lončarić , Olga Jovanović Glavaš ,  
Branimir K. Hackenberger 

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<https://doi.org/10.1016/j.ecoenv.2017.10.072>

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Chemosphere

Volume 224, June 2019, Pages 572-579



Effects of single and combined exposure to nano and bulk zinc-oxide and propiconazole on *Enchytraeus albidus*

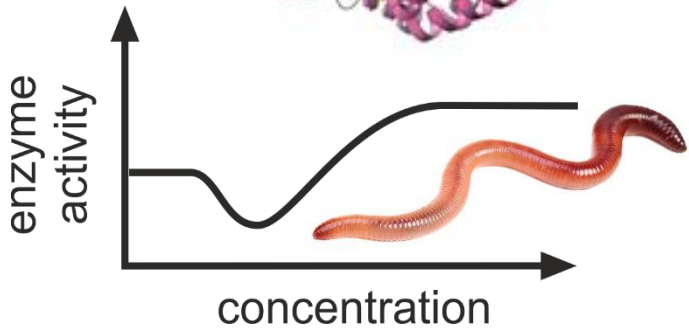
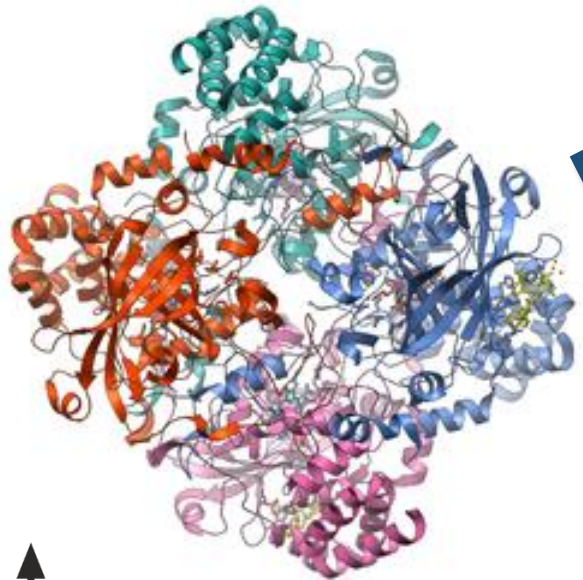
Davorka K. Hackenberger, Nikolina Stjepanović, Željka Lončarić, Branimir K. Hackenberger 

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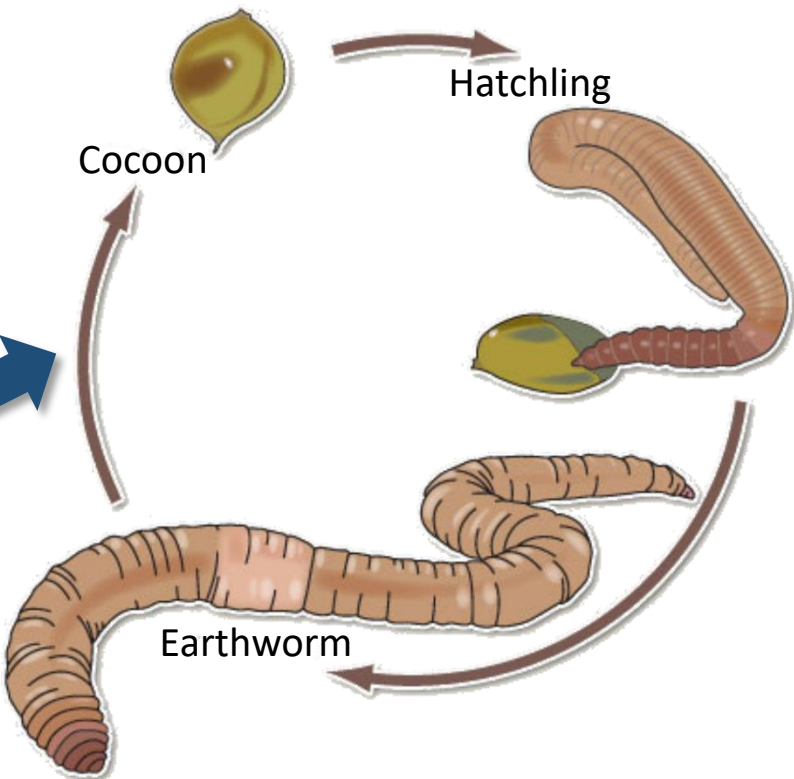
<https://doi.org/10.1016/j.chemosphere.2019.02.189>

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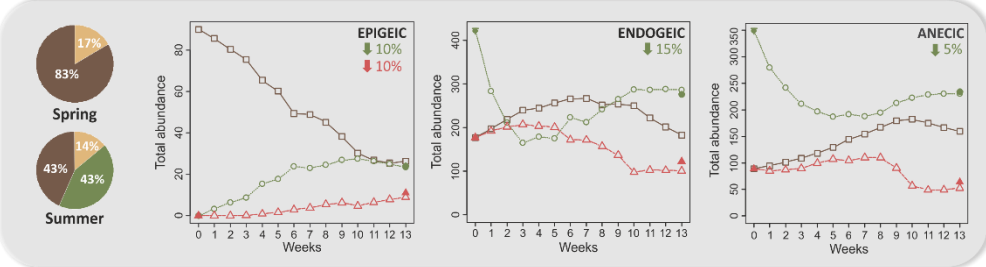
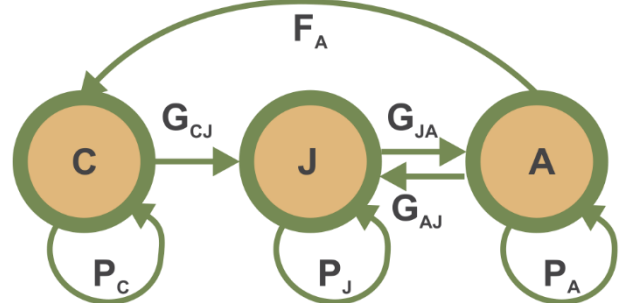
**MOLECULAR BIOMARKERS**



**REPRODUCTION SUCCESS MORTALITY**



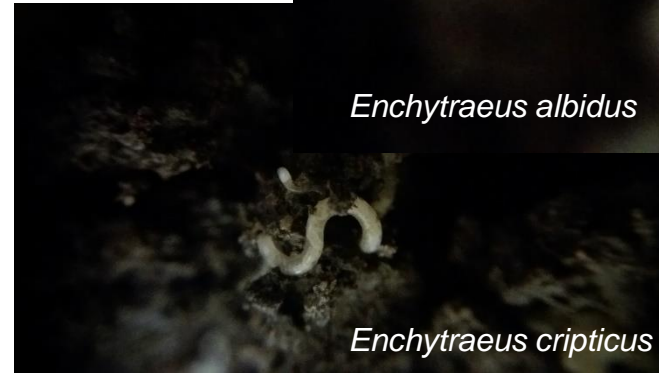
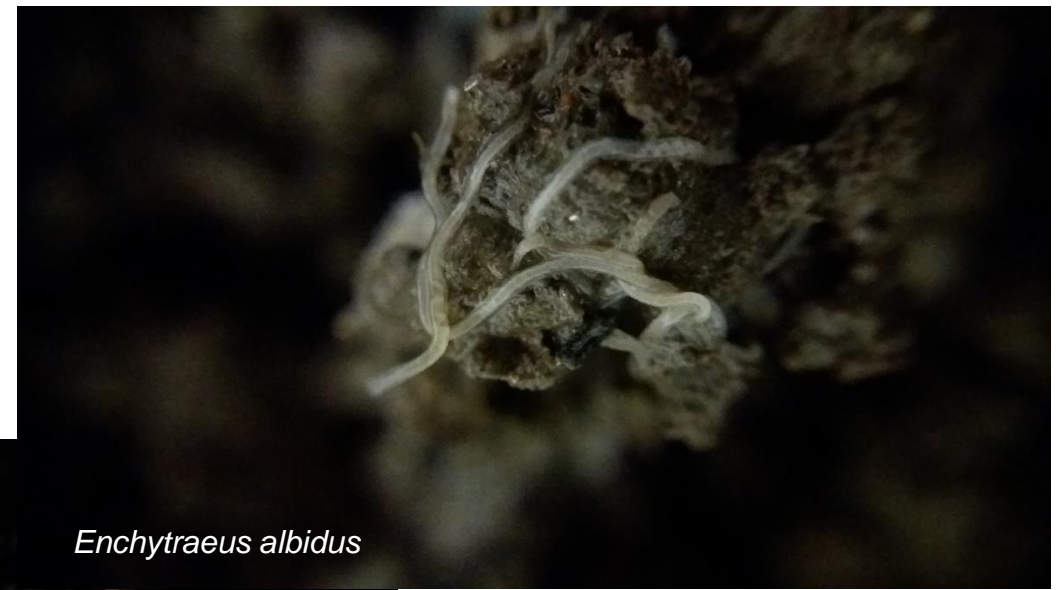
**POPULATION MODELS IN SILICO EXPERIMENTS**





# Experimental organisms

## Earthworms



## Enchytraeids

## Collembola



## *Folsomia candida*





# Ecotoxicology

- Sensor systems



ELSEVIER

Aquatic Toxicology

Volume 206, January 2019, Pages 154-163



Real-time CO<sub>2</sub> uptake/emission measurements as a tool for early indication of toxicity in Lemna-tests

Vesna Peršić✉, Tamara Đerđ✉, Martina Varga✉, Branimir K. Hackenberger✉✉

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<https://doi.org/10.1016/j.aquatox.2018.11.013>

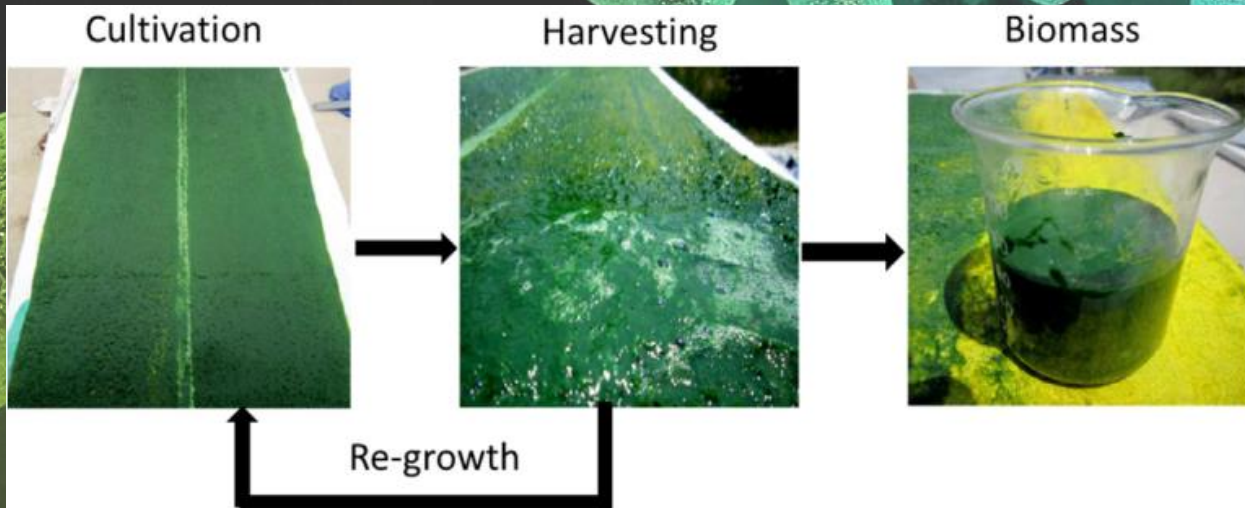
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# Microbiology

- MELISSA (Micro-Ecological Life-Support System Alternative)
- PGPB (Plant Growth Promoting Bacteria)
- Bacterial biofilms in simulated extraterrestrial soil





# Plant physiology



- Ex. 1. How does photosynthetic apparatus response to sudden drop/increase in temperature in real time?
- Ex. 2. Inhibition of photosynthetic reactions, both photochemical and biochemical ones, by many xenobiotics.
- Ex. 3. How plants cope with physiological drought (water stress)?



# Plant physiology

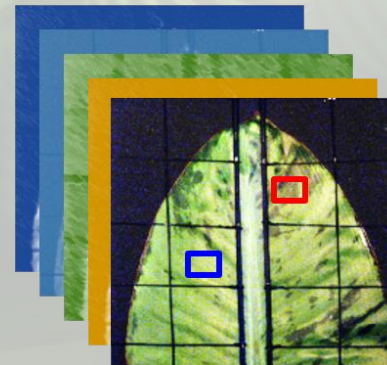
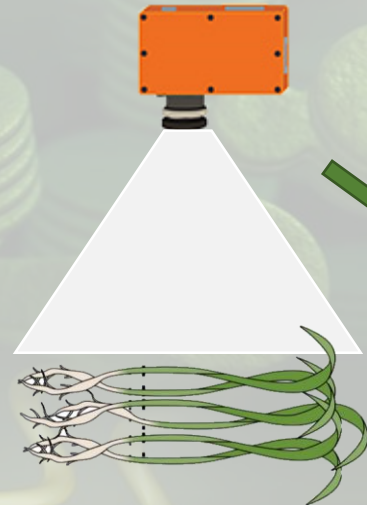
- Hyperspectral imaging
- Biochemical, physiological, molecular analysis



Ex. 1., 3.



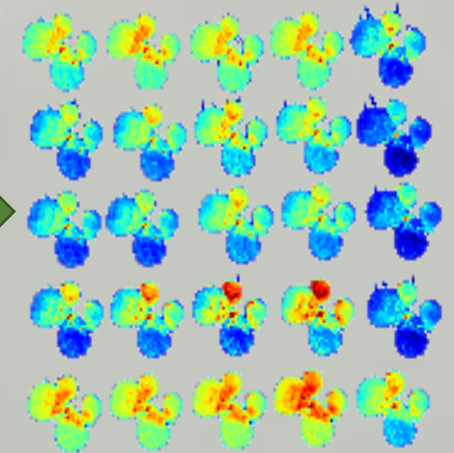
Ex. 2.



HSI Cube



Fluorescence



HSI Matrix



# Computational methods

- *In silico* experiments
  - Climate change scenarios
- Big data analytics



Theoretical Population Biology

Volume 83, February 2013, Pages 82-94



Stage and age structured *Aedes vexans* and *Culex pipiens* (Diptera: Culicidae) climate-dependent matrix population model

Željka Lončarić<sup>a</sup>, Branimir K. Hackenberger<sup>b</sup>  

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<https://doi.org/10.1016/j.tpb.2012.08.002>

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