

Antibacterial Activity of Selenium Nanoparticles (NPs)

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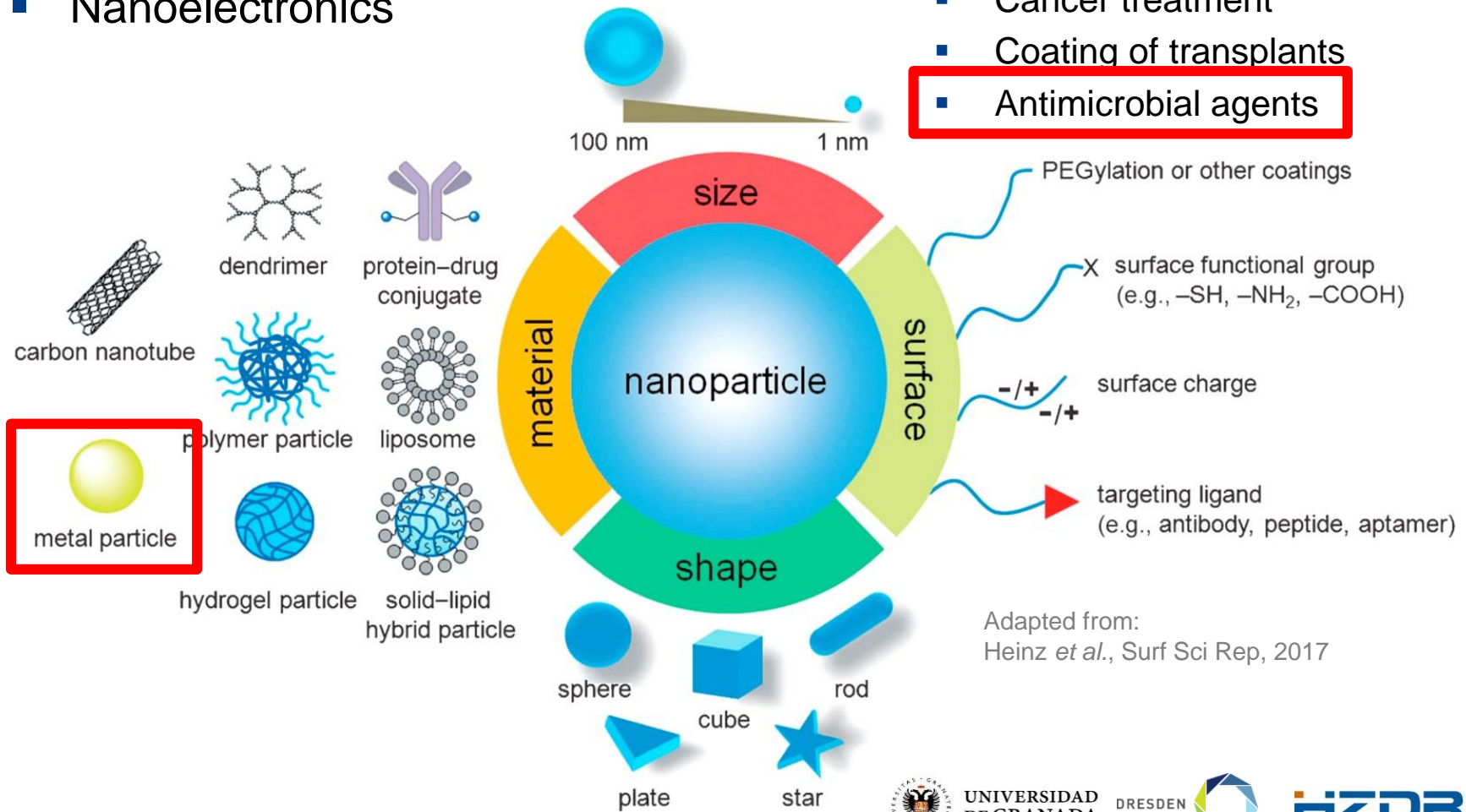
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NPs are attractive tools for different applications.

- Nanomaterials
- Nanoelectronics

- Nanomedicine
 - Drug delivery
 - Cancer treatment
 - Coating of transplants
 - **Antimicrobial agents**



Adapted from:
Heinz *et al.*, Surf Sci Rep, 2017



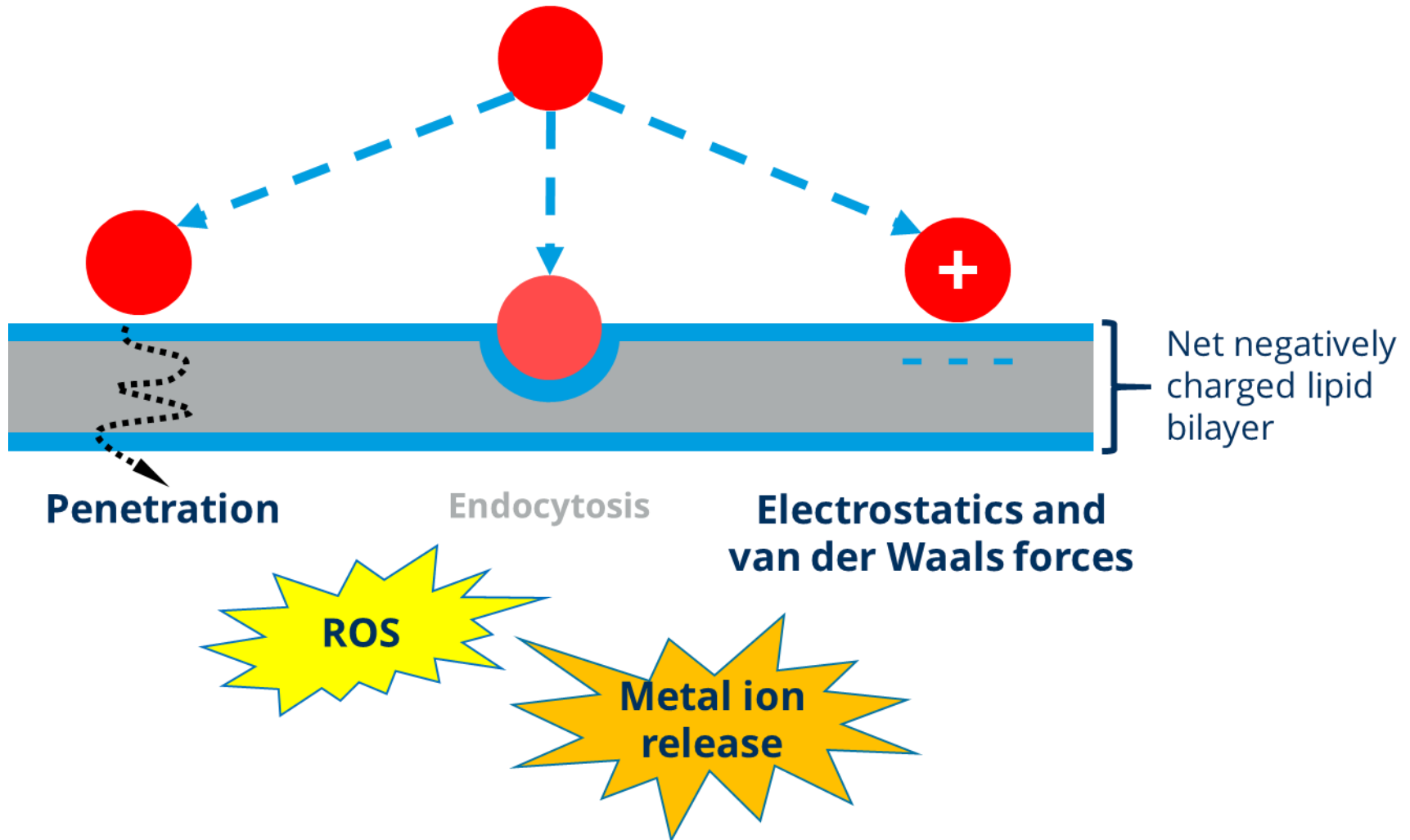
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How is the interaction between metal NPs and cells proposed?

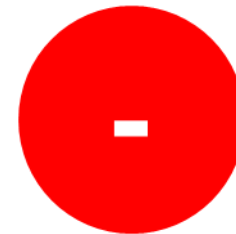


Selenium might be an alternative to silver.

- Selenium is cheaper.
- Selenium shows a low toxicity to the human body.
- Selenium NPs exhibit antimicrobial activity.¹

How do selenium NPs **INTERACT** with bacterial cells?

Does the **ZETA POTENTIAL** affect their **TOXICITY**?



¹Nguyen *et al.*, Food Control, 2017

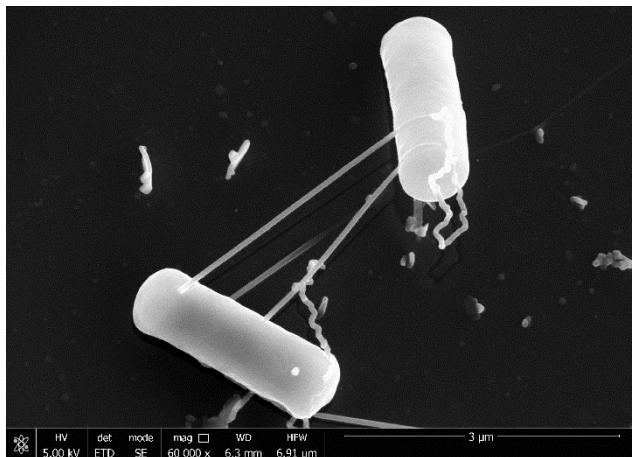
Selenium NPs and model bacterial strains

NP-coating	Zeta Potential (mV)	Diameter (nm)
Chitosan (+)	+1.3 ± 0.4	85 ± 27
Undefined (-)	- 3.9 ± 0.7	86 ± 21
BSA (- - -)	- 14.7 ± 1.1	73 ± 29

Gram-positive

vs.

Gram-negative



Lysinibacillus sphaericus



vs. *Stenotrophomonas bentonitica*



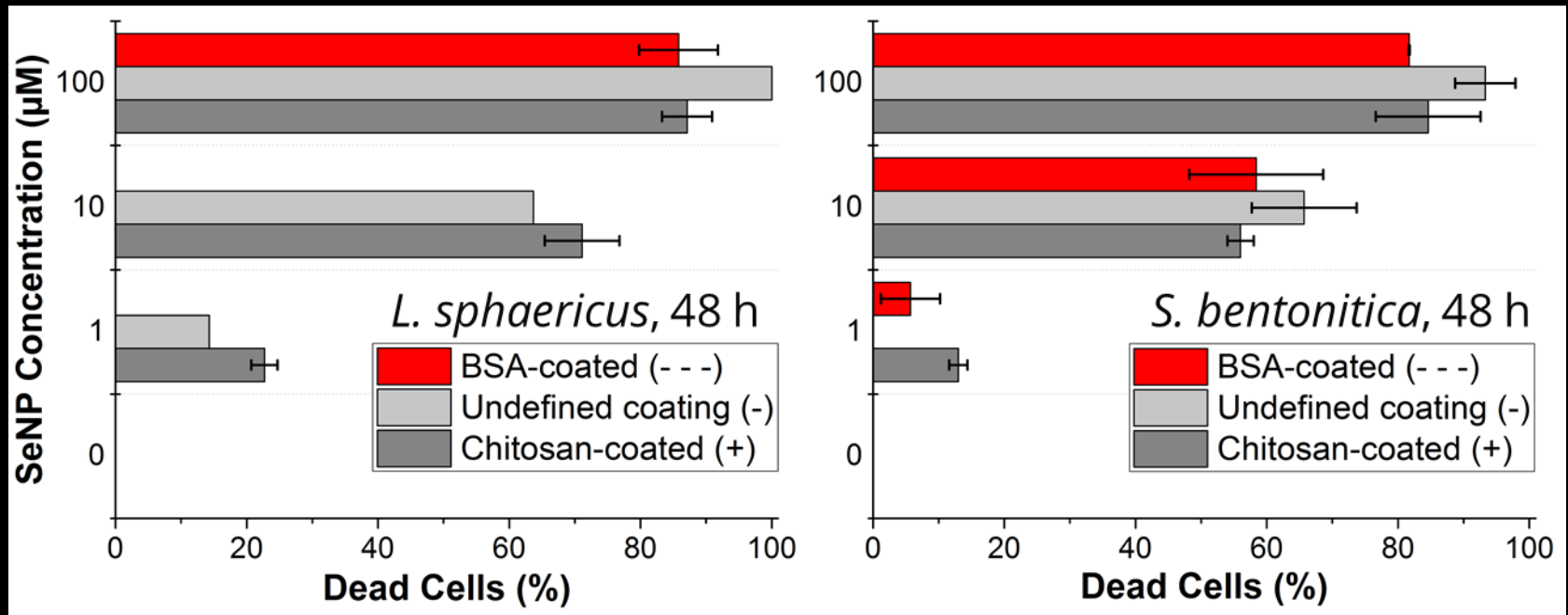
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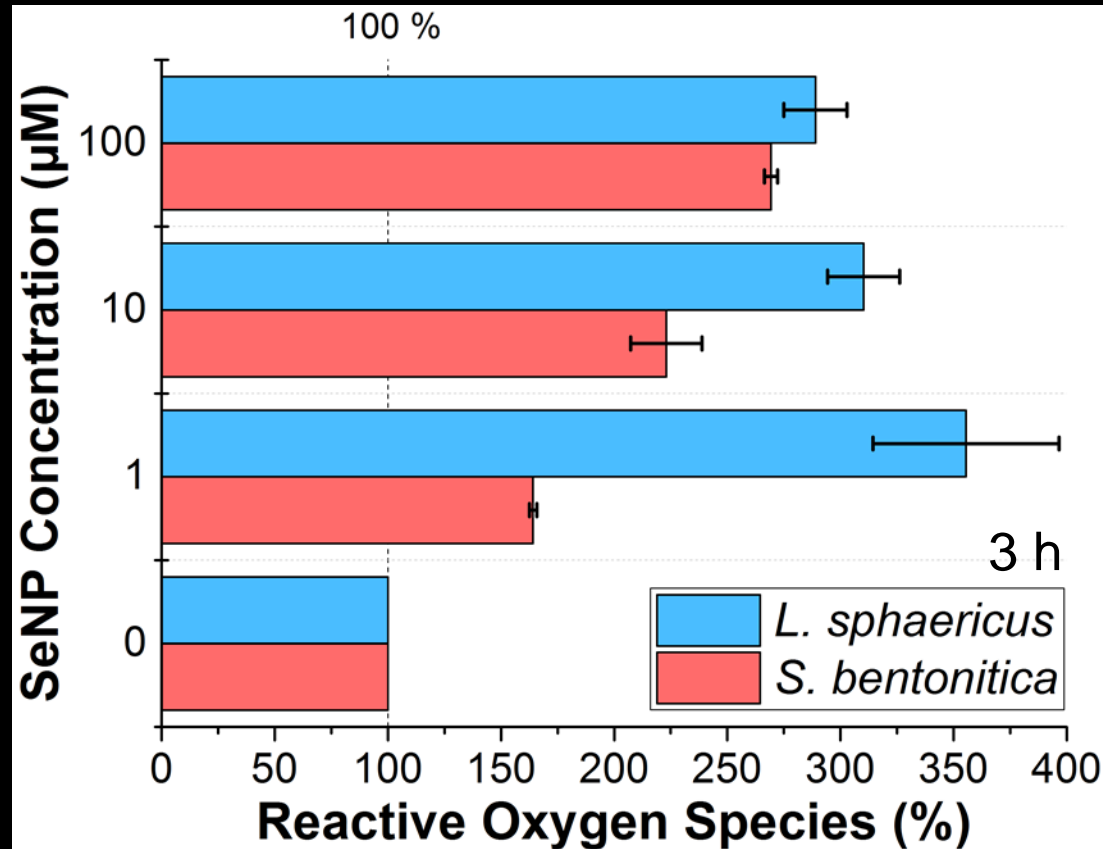
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NP toxicity depends on CONCENTRATION, ZETA POTENTIAL and CELL WALL COMPOSITION.



- Cell viability measured by propidium iodide and FDA staining.
- Slightly charged NPs show higher toxicity than highly negatively charged.
- Grampositive bacteria seem to be more resitant to negatively charged NPs.

Intracellular reactive oxygen species level is increased.



Undefined coating

- DC-FDA was used to measure the intracellular ROS level.
- Selenium NPs might generate ROS which damage enzymes, DNA and lipids.



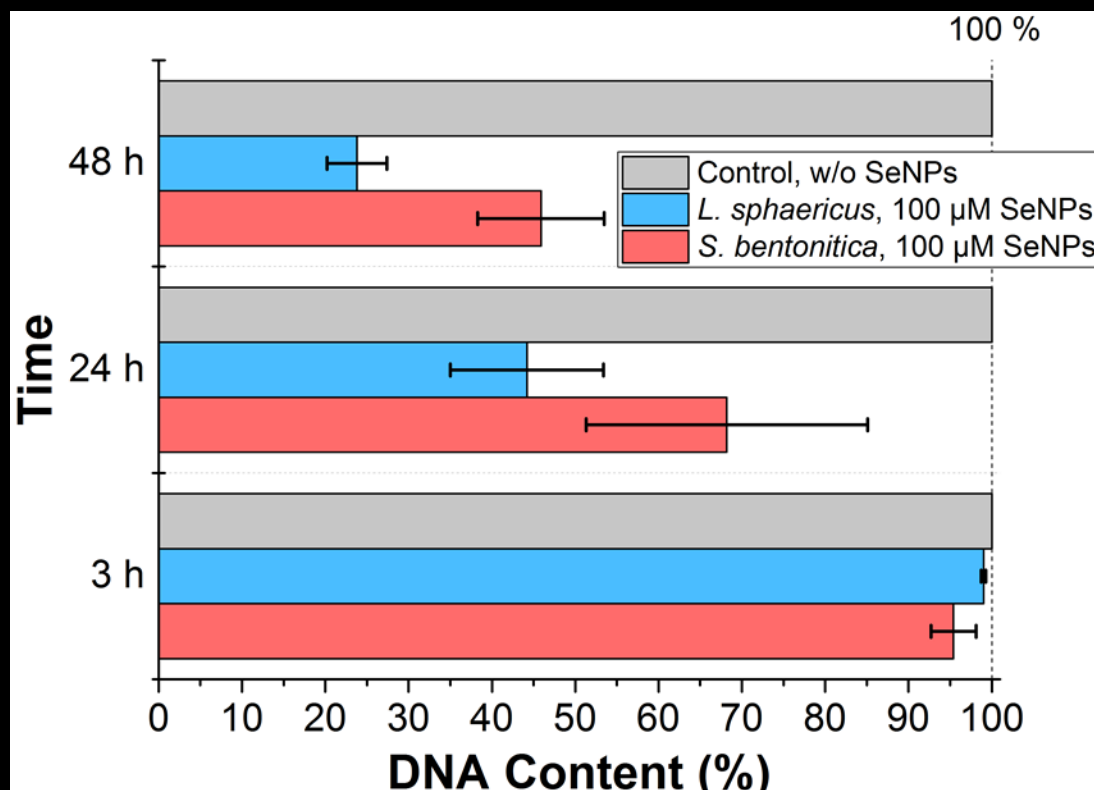
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Selenium NPs decrease intracellular DNA content.



Undefined coating

- Acridine Orange is used to quantify intracellular DNA content.
- Selenium NPs might release ROS and metal ions which interact with DNA and DNA repair enzymes¹.

¹Letavayová *et al.*, Toxicology, 2006



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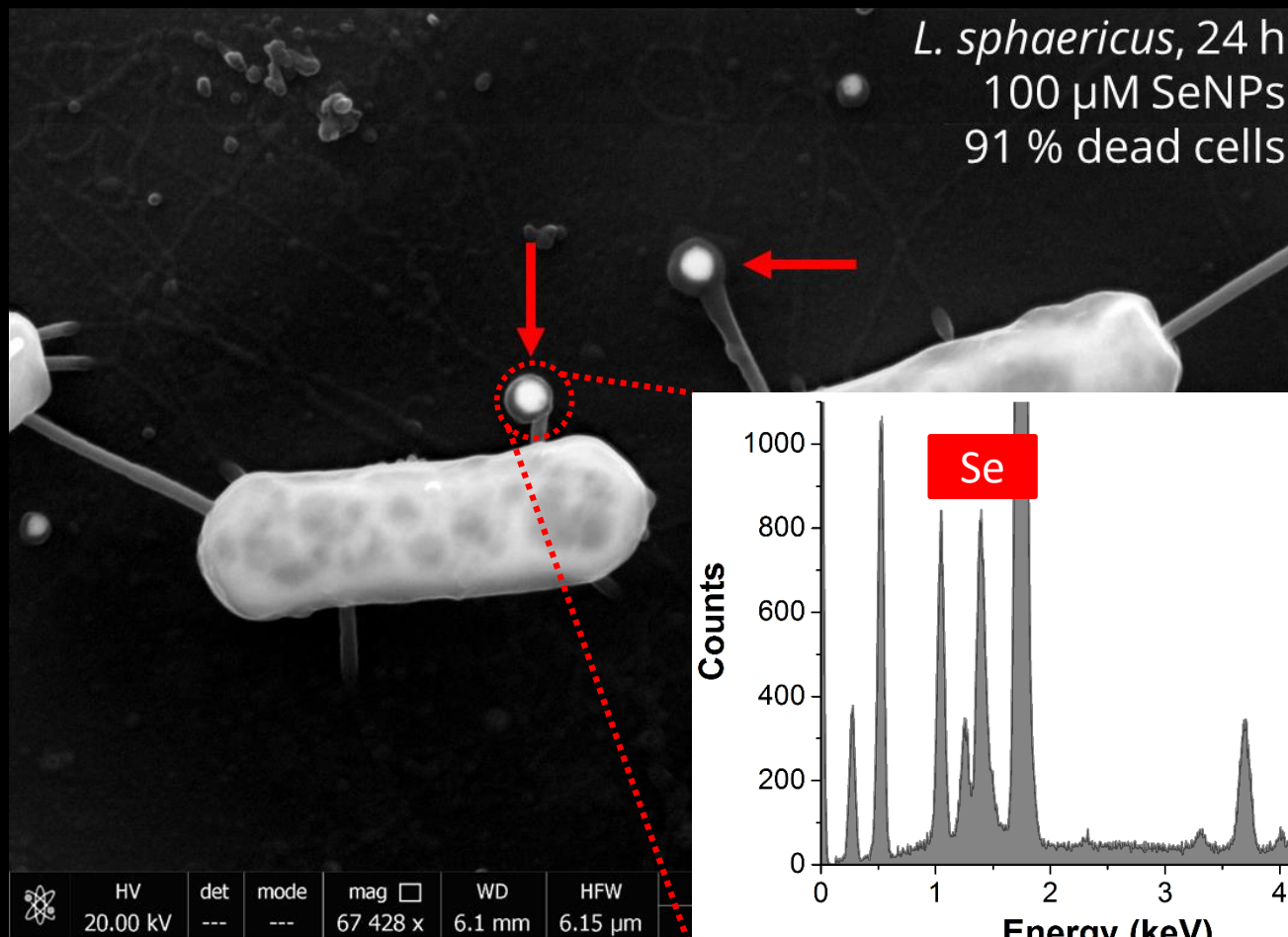


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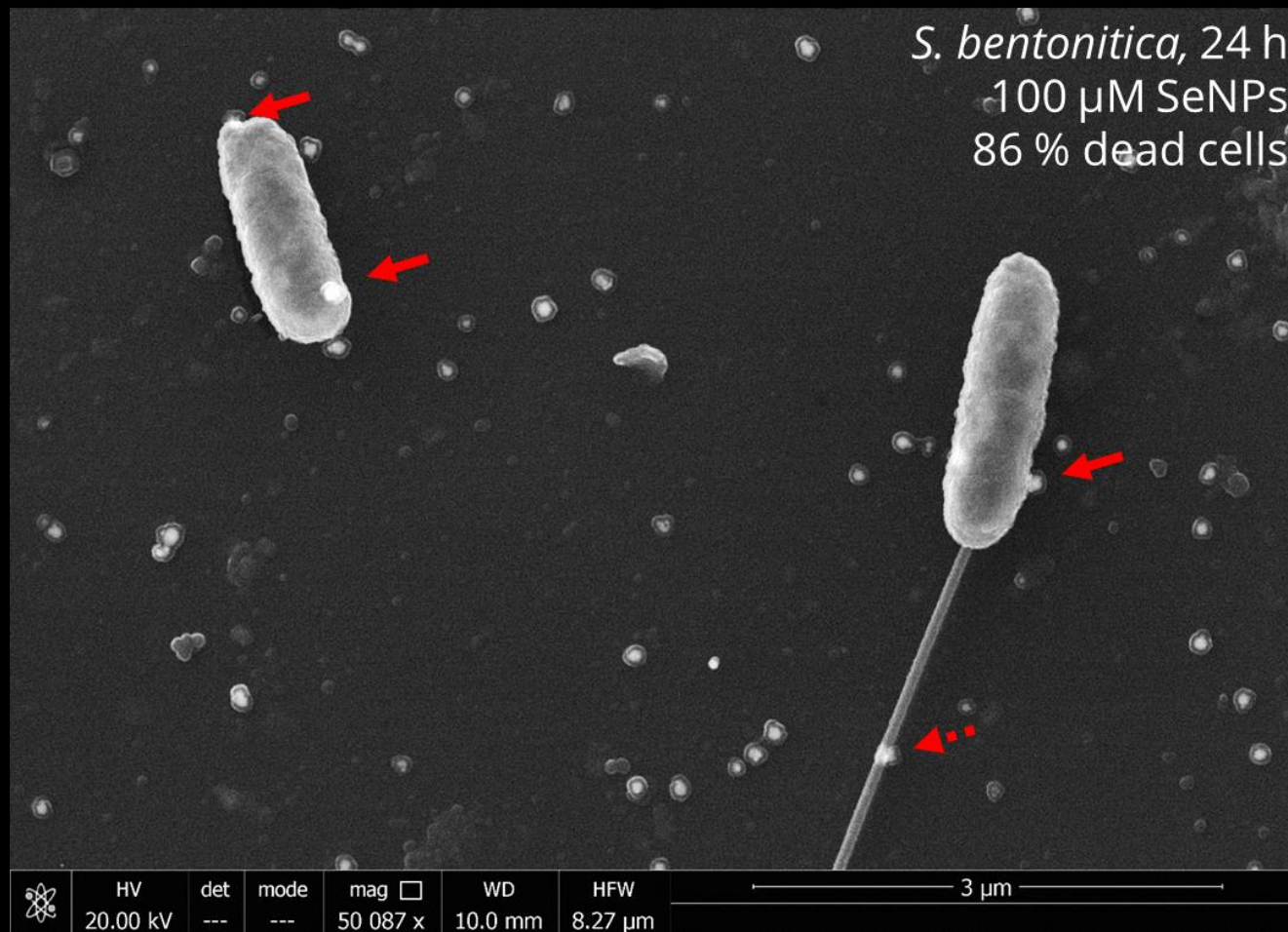
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ESEM confirms an extracellular interaction of selenium NPs with *L. sphaericus*.



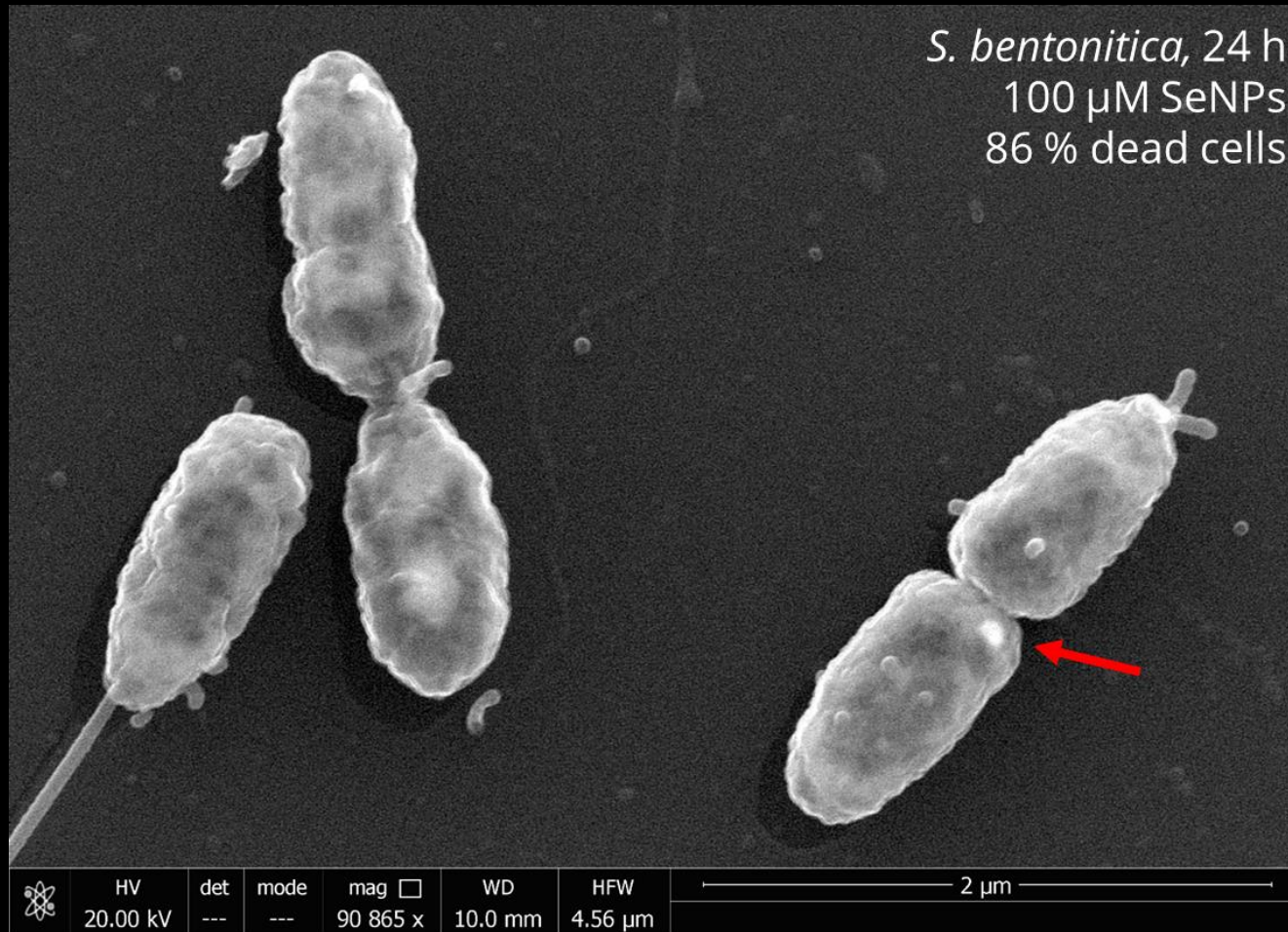
Undefined coating

For *S. bentonitica*, the selenium NPs interact extracellularly with the cell wall and proteins ...



Undefined coating

... and accumulate intracellularly.



Undefined coating



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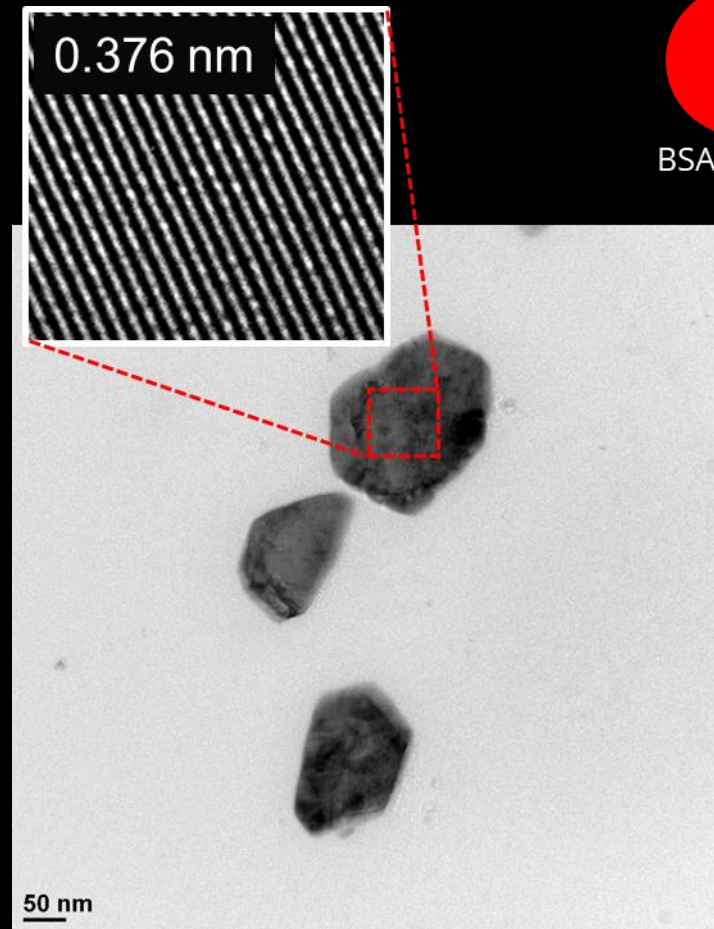
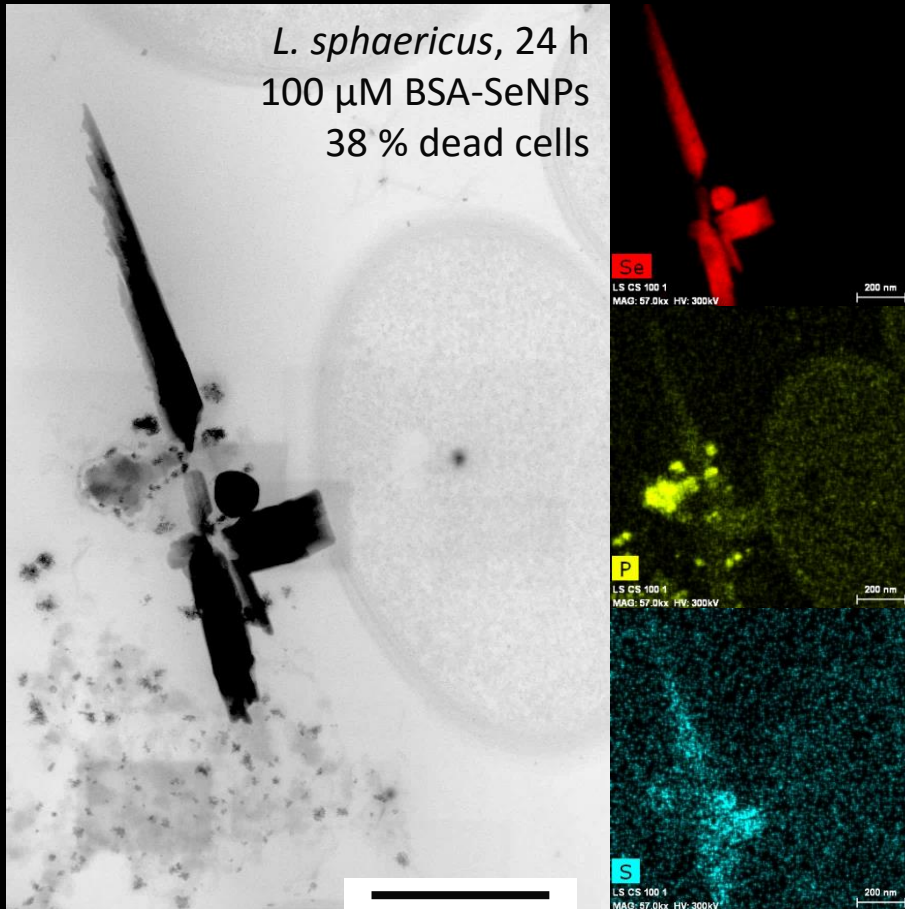
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L. sphaericus is able to transform selenium NPs to trigonal nanostructures.



BSA-coated



Trigonal selenium planes Se(100),
Se(011) and Se(101) were observed.



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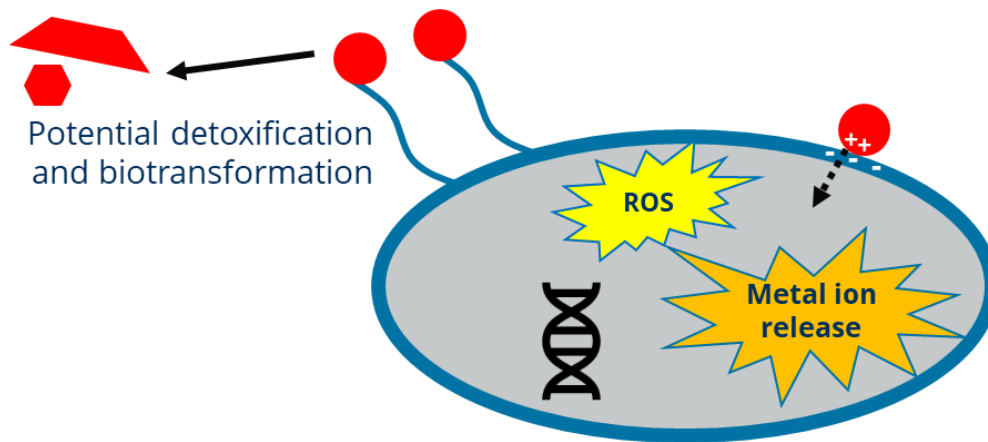
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Take home messages

- Selenium NPs possess antibacterial activity and represent an alternative to AgNPs.
- Antibacterial activity is dependent on concentration, zeta potential and cell wall composition.
- The generation of reactive oxygen species seems to be a key trigger.
- A subsequent decrease in DNA content was observed.
- NPs were biotransformed extracellularly to less toxic, trigonal nanostructures.



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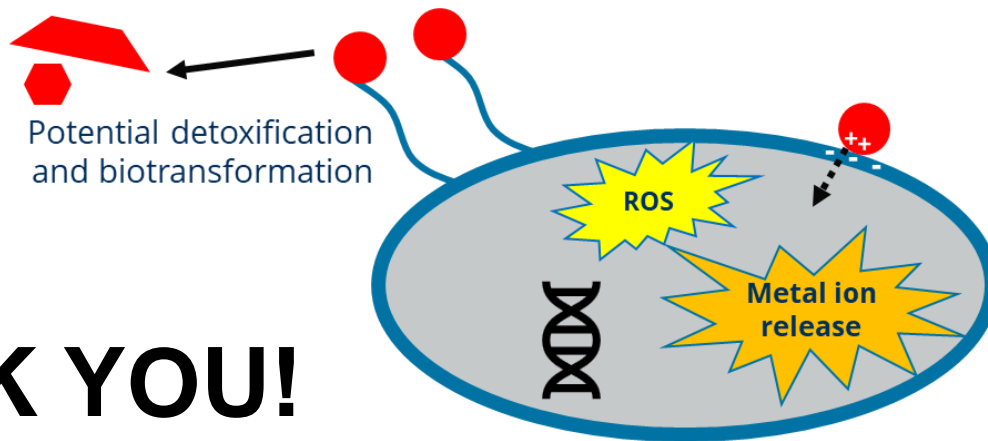


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THANK YOU!



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