

Varnost nanomaterialov: povezava med njihovimi lastnostmi in učinki na okolje

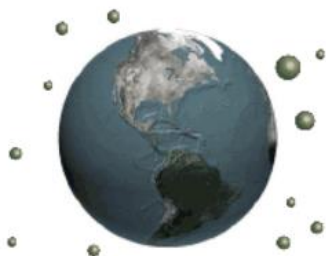
Anita Jemec, Damjana Drobne

Skupina za Nanobiologijo in Nanotoksikologijo,
Biotehniška fakulteta, Oddelek za biologijo.

We are looking for insights into bio-nano interactions at various levels

The Bionanoteam strives to holistically assess specific interactions of biological systems with nanoparticles on different levels of biological organization. Our main topics of research are:

ENVIRONMENTAL NANOTOXICOLOGY



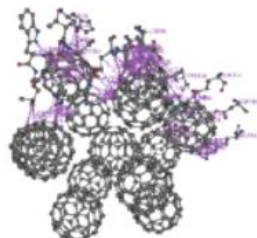
ACETYLCHOLINESTERASE RESEARCH



HUMAN NANOTOXICOLOGY



BIOSENSORS & NANODEVICES



Principal Investigator



Prof. Dr. Damjana Drobne

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[email](#) | [bibliography](#)

Bionanoteam is a research group at the Biotechnical Faculty, University of Ljubljana.

Founded in 2008 by Prof. Damjana Drobne, Bionanoteam currently consists of 4 experienced researchers, 4 PhD candidates, and a number of graduate and undergraduate students. Damjana is a Professor of Zoology and Professor of Toxicology from University of Ljubljana. With over twenty years of research experience, she is the founder and principal investigator of Bionanoteam.

Kje smo?



UNILJ



Biotehniška fakulteta



Oddelek za biologijo

SKUPINA ZA NANOBIOLOGIJO IN NANOTOKSIKOLOGIJO

študije *in vivo* in *in vitro* delovanja nanomaterialov na biološke sisteme



KOPENSKI IZOPODNI RAKI

- spremljanje dinamike prehranjevanja, preživetje
- študije bioakumulacije in biodistribucije nanomaterialov
- študije na izoliranem prebavnem organu



VODNE BOLHE

- akutni testi toksičnosti
- kopičenje NM na površini živali



MIGETALKARJI

- spremljanje viabilnosti modelnega organizma



ČEBELE

- spremljanje prehranskih parametrov in preživetja
- študije nevrotoksičnosti NM



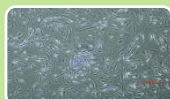
MORSKI JEŽKI

- vpliv NM na jajčne celice, spermije in spremembe zarodka
- študije okoljskega plašča NM



SOLINSKI RAKI

- akutni testi toksičnosti



CELIČNE KULTURE

- spremembe integritete celične membrane, aktivnosti, proliferacijo celic, celično smrt, genotoksičnost...
- fosfolipidoza



- ERITROCITI

- spremenjena morfologija
- adsorpcija NM na površino eritrocitov
- mikrovezikulacija



ENCIMI

- inhibicija delovanja encima zaradi prisotnosti NM
- adsorpcija encima na NM

Bionanoteam v EU FP7 in H2020 projektih:



- **EU FP7 NanoValid** (2011-2015) RIA
- **EU FP7 NanoMILE** (2013-2017) RIA
- **H2020 NanoFASE** (2015-2019) RIA
- **H2020 Pandora** (2015-2018) MSCA-ITN-2015; Marie-Sklodowska-Curie Actions

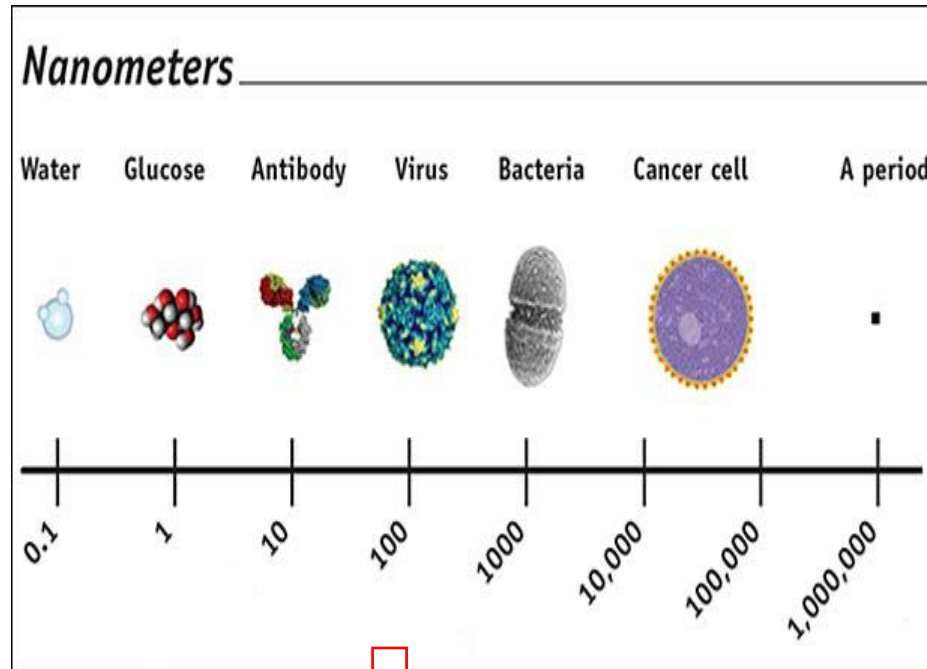
and a partner in

- **NanoSafety cluster**; hazard group

a partner in two national Centers of Excellence(CO):

- **CO NAMASTE**
- **CO Nanocenter**

Nanomateriali



Nanomateriali

NANO

Latinsko: nanus

Grško: nanos



Definicija nanomaterialov



Definition of a nanomaterial

The EU adopted a definition of a nanomaterial in 2011 ([Recommendation on the definition of a nanomaterial](#) (2011/696/EU)). Its provisions include a requirement for review "*in the light of experience and of scientific and technological developments. The review should particularly focus on whether the number size distribution threshold of 50 %*

*A natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for **50 % or more of the particles** in the number size distribution, one or more external dimensions is in the **size range 1 nm - 100 nm**.*

*In **specific cases** and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50 % may be replaced by a threshold between 1 and 50 %.*

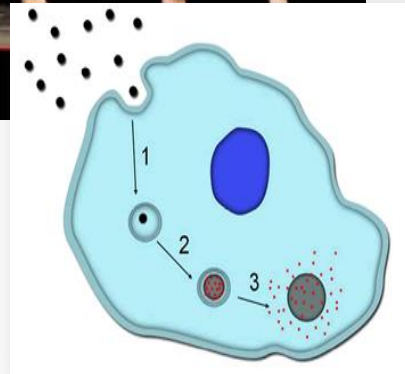
By derogation from the above, fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials.

http://ec.europa.eu/environment/chemicals/nanotech/faq/definition_en.htm

Naravni izvor



Inženirsko proizvedeni



Consumer Products Inventory



The Project on Emerging Nanotechnologies

[CPI HOME](#) / [PRODUCTS](#)

All Products

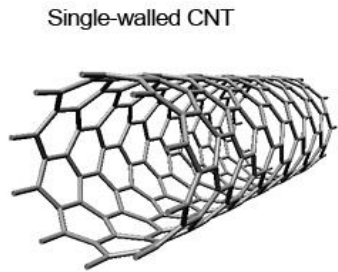
Products 1-25 of 1827

[STANJE 20-11-2016: 1827 NANO PRODUKTOV](#)

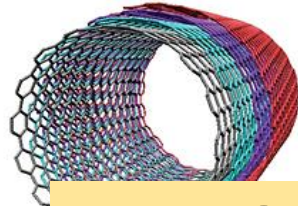
<http://www.nanotechproject.org/cpi/browse/nanomaterials/titanium-dioxide/>

Primeri nanomaterialov

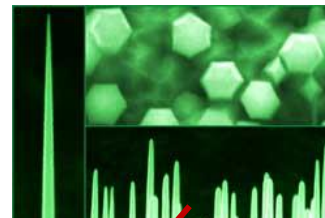
*nano*CEVKE



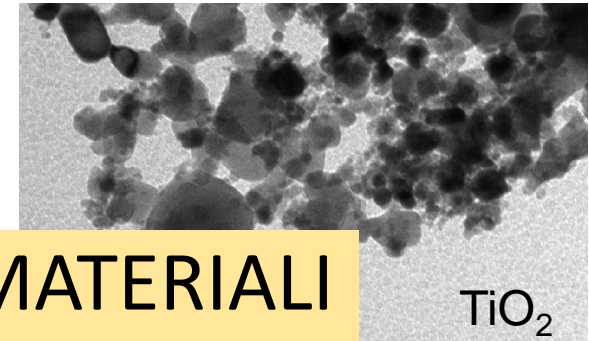
Multi-walled CNT



nano IGLICE

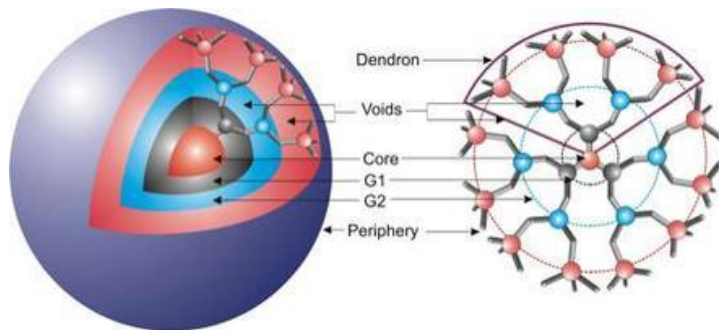


*nano*DELICI

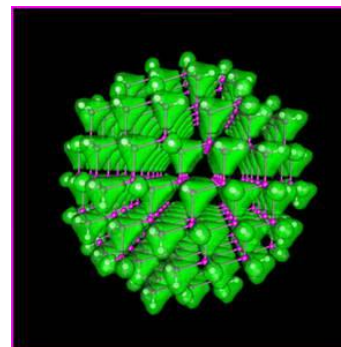


NANODELICI = NANOMATERIALI

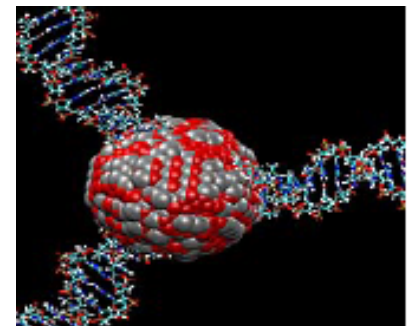
SFERIČNI DENDRIMERI



KVANTNE PIKE
Quantum dots



*nano*BIOKOMPOZITI
TiO₂+ DNA



LASTNOSTI

as they are

- ✓ Kemijska sestava
- ✓ Površinska kemija
- ✓ Kristalna struktura
- ✓ oblika
- ✓ velikost



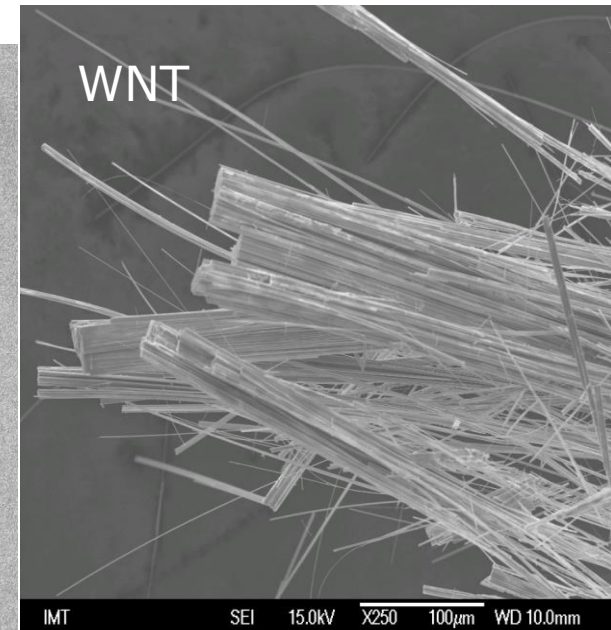
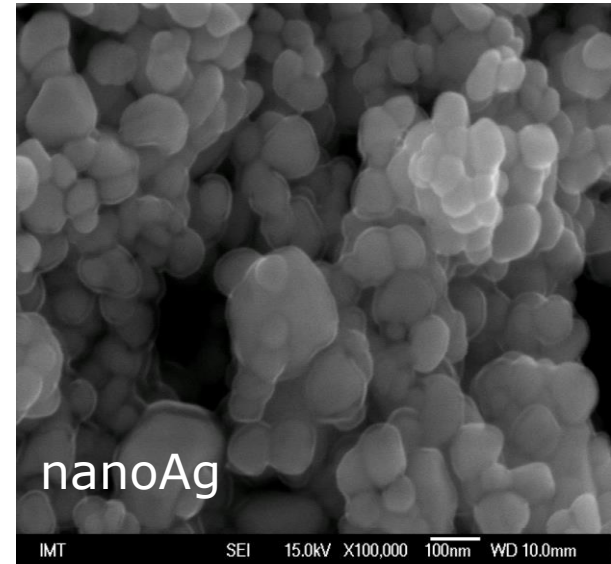
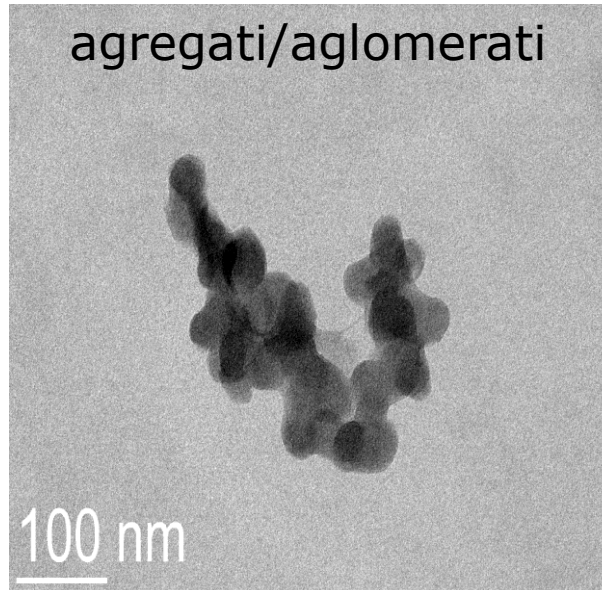
as they behave

- ✓ corona
- ✓ raztapljanje
- ✓ agregacija
- ✓ staranje

as they interact

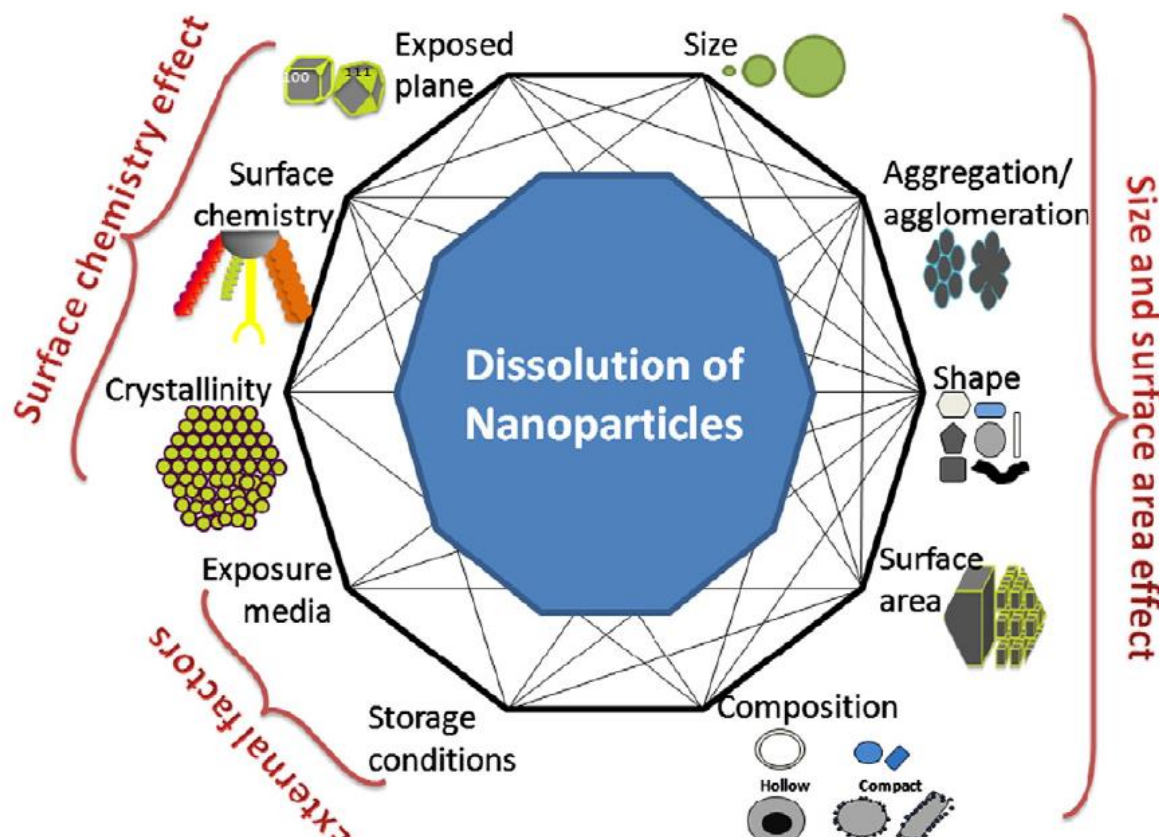
- ✓ hidrofobnost
- ✓ adsorbpcija

agregati/aglomerati

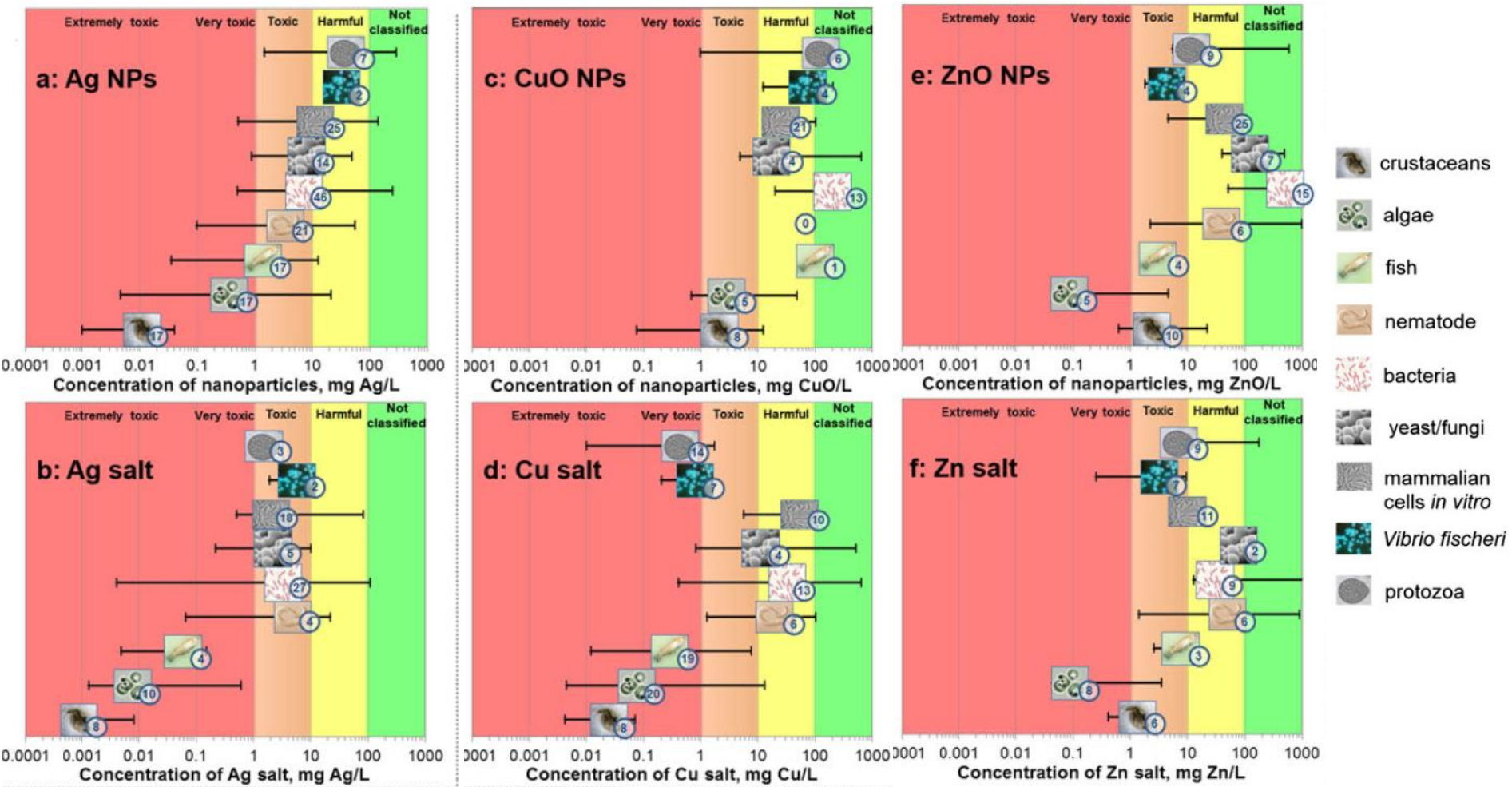


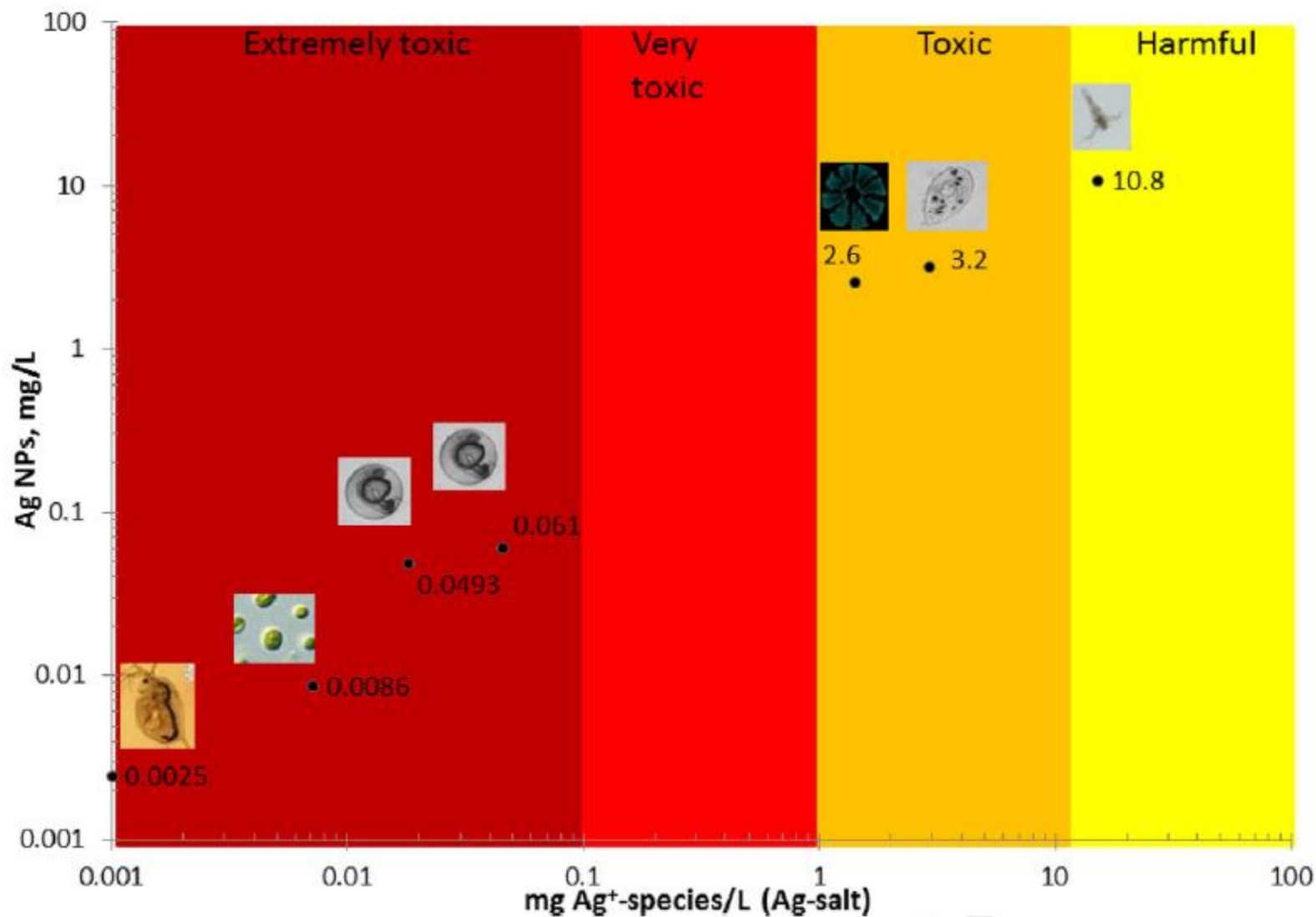
Od LASTNOSTI do UČJNKOV_ znanje v 2017

KEMIJSKA SESTAVA: RAZTAPLJANJE



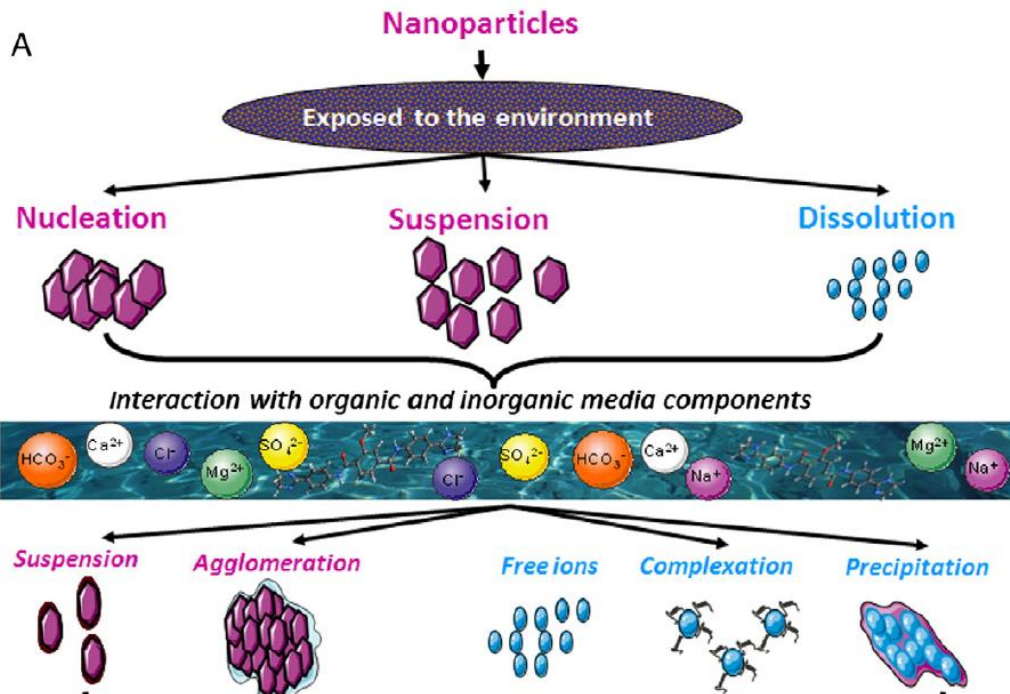
TOKSIČNOST NEKATERIH MATERIALOV JE ODVISNA OD RAZTAPLJANJA



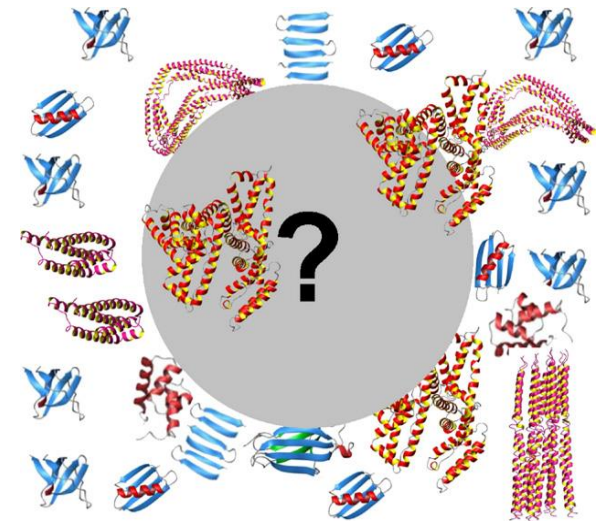


NANOMATERIALI IMAJO INTERAKCIJO Z MEDIJEM

DISSOLUTION/AGGREGATION/INTERACTION



PROTEIN-NANOPARTICLE COMPLEX „PROTEIN CORONA“

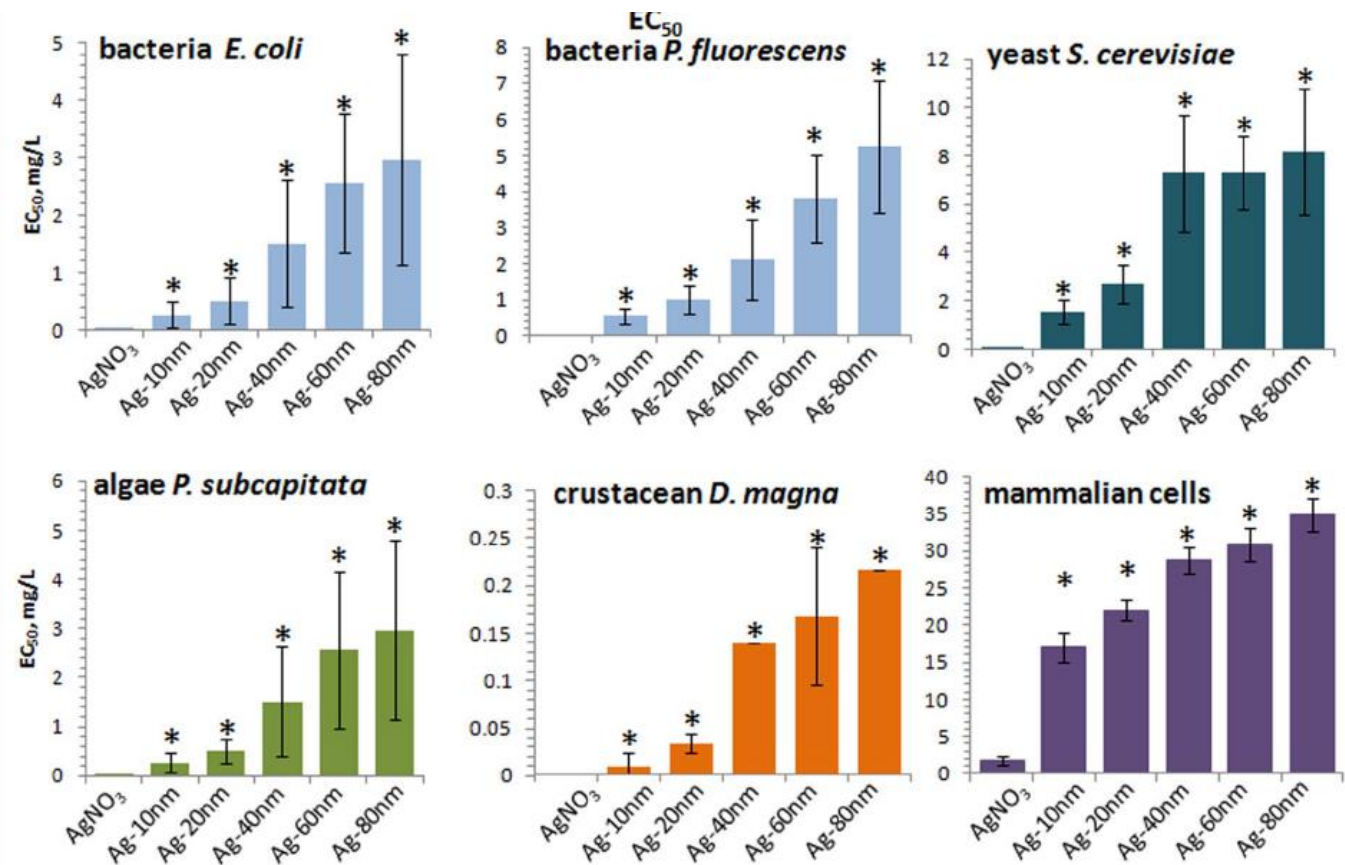


Je UČINEK ODVISEN OD VELIKOSTI?

Size-Dependent Toxicity of Silver Nanoparticles to Bacteria, Yeast, Algae, Crustaceans and Mammalian Cells *In Vitro*

Angela Ivask^{1*}, Imbi Kurvet¹, Kaja Kasemets¹, Irina Blinova¹, Villem Aruoja¹, Sandra Suppi¹, Heiki Vija¹,

PLoS ONE 9(7): e102108.



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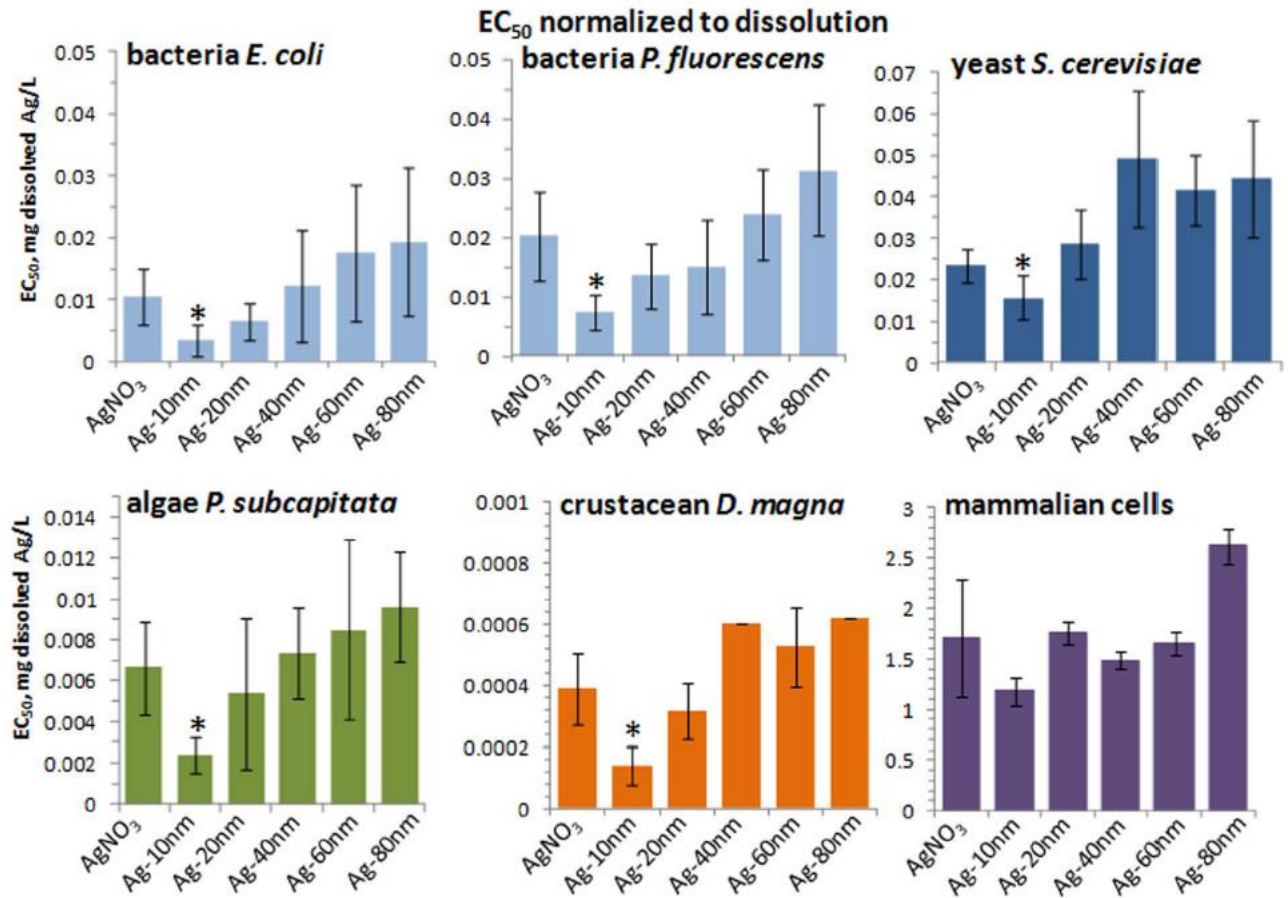


Table 4. Tox

GRUPIRANJE NANOMATERIALOV GLEDE NA LASTNOSTI

Tests models	Time, medium, endpoint	NANOMATERIALS							SOLUBLE METAL SALTS			
		SiO ₂	TiO ₂	Au	MWCNT	Ag	CuO	ZnO	AgNO ₃	CuSO ₄	ZnSO ₄	
BACTERIA:		EC ₅₀ , MBC or LOEC (mg metal/l or mg MWCNTs/l)										
Prokaryotes, single cell	<i>Escherichia coli</i>	4 h EC ₅₀ , LB, growth inhibition	>100	>100	>10	n.d.	3,1	>100	67	1,3	>100	52,3
	<i>Staphylococcus aureus</i>	4 h EC ₅₀ , LB, growth inhibition	>100	>100	>10	n.d.	5,2	>100	16	2,2	>100	15,5
	<i>Bacillus subtilis</i>	4 h EC ₅₀ , LB, growth inhibition	>100	>100	>10	n.d.	4,5	>100	14	3,0	>100	16,0
	<i>Pseudomonas putida</i>	4 h EC ₅₀ , LB, growth inhibition	>100	>100	>10	n.d.	3,8	>100	69	2,0	>100	49,5
	<i>Pseudomonas aeruginosa</i>	4 h EC ₅₀ , LB, growth inhibition	>100	>100	>10	n.d.	3,2	>100	>100	2,1	>100	>100
	<i>Vibrio fischeri</i>	0.5 h EC ₅₀ , 2% NaCl, bioluminescence inhibition	>100	>100	4,8*	n.d.	2,9	3,4	8,3	1,4	0,3	7,7
Eukaryotes, single cell	YEAST: <i>Saccharomyces cerevisiae</i>	24 h MBC, deionized water, viability	n.d.	>100	>10	>100	1	>100	20	1	4	>100
	ALGA: <i>Raphidocelis subcapitata</i>	72 h EC ₅₀ , OECD201 medium, growth inhibition	83,6	6,8	n.d.	n.d.	0.0086**	0,7	0,14	0.0071**	0,011	0.042***
Human cell cultures in vitro	PROTOZOAN: <i>Tetrahymena thermophila</i>	24 h EC ₅₀ , deionized water, viability	>100	>100	>30	>100	3,9	>100	3,9	2,9	n.d.	n.d.
	human mesenchymal stem cells	24 h EC ₅₀ , complete medium, membrane integrity (PI)	>100	>100	>30	100	6,4	2,2	1,9	n.d.	2,73	1,7
	human mesenchymal stem cells	24 h EC ₅₀ , complete medium, mitochondrial activity (MTT)	>100	>100	>30	n.d.	4,6	>100	16,3	n.d.	>100	48
	murine fibroblasts	24 h, 50% complete medium, mitochondrial activity (MTT)	>100	>100	>6	>100	3****	0,7	9,1	2	2,9	8,7

SALTS

ZnSO₄

52,3

15,5

16,0

49,5

>100

7,7

>100

0.042***

n.d.

1,7

48

8,7

5,3

n.d.

1,55

>100

n.d.

0,042

subcapitata

harmful

harmful

harmful

harmful

harmful

harmful

harmful

harmful

harmful

harmful

harmful

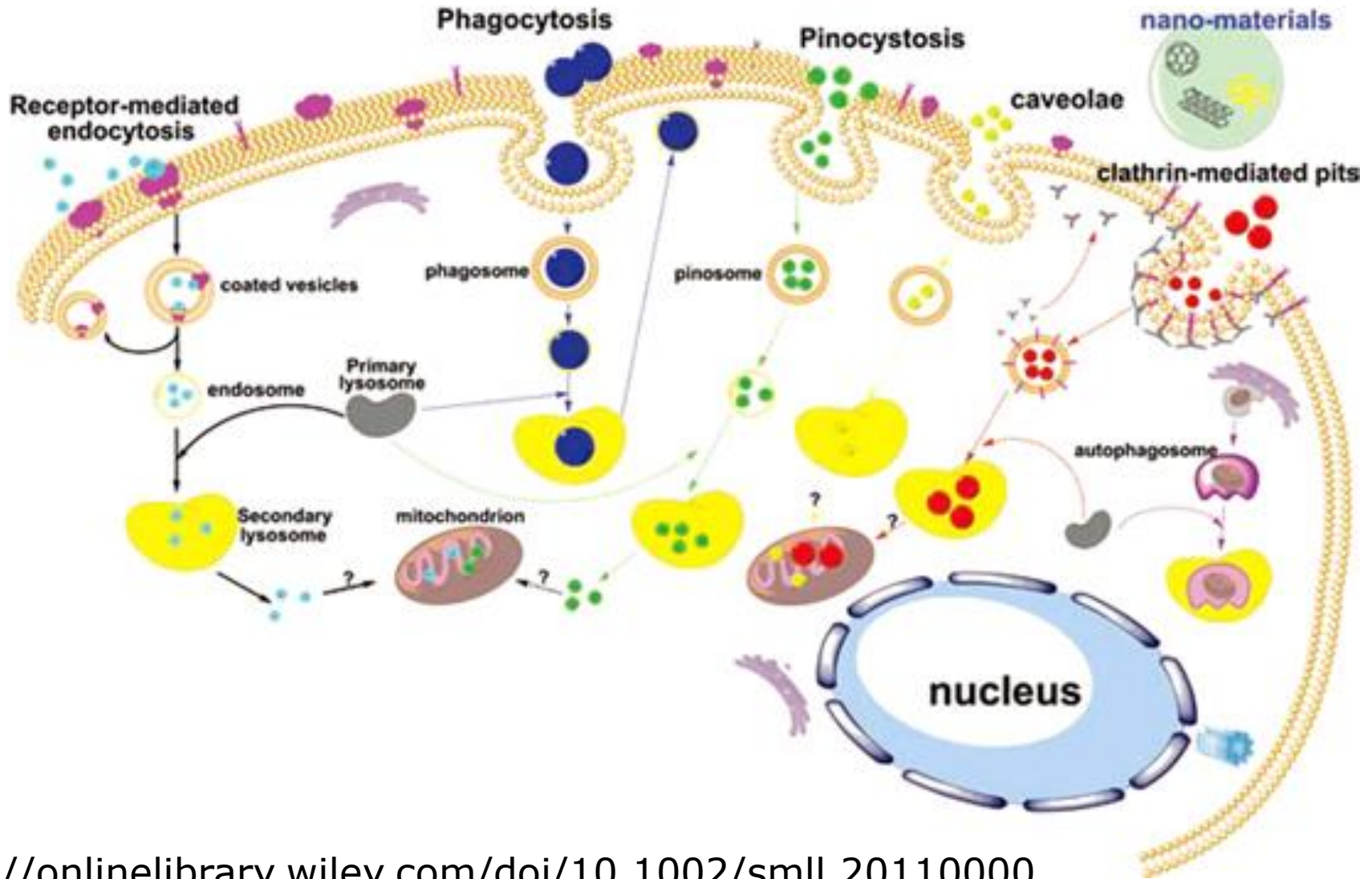
harmful

harmful

harmful

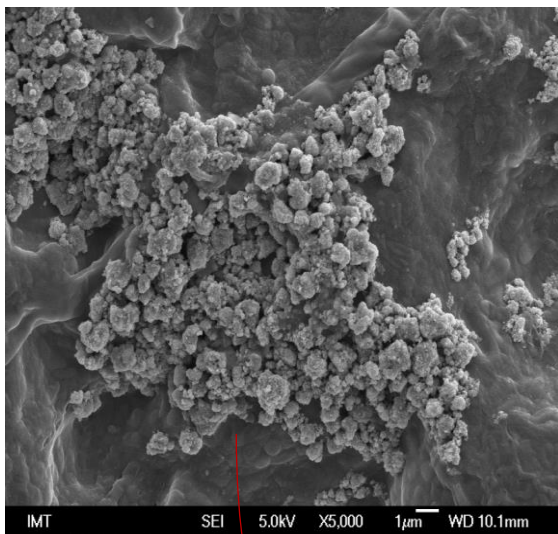
harmful

VSTOP NANODELCEV V CELICO ?

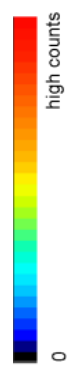
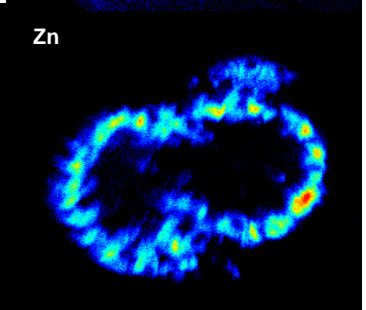
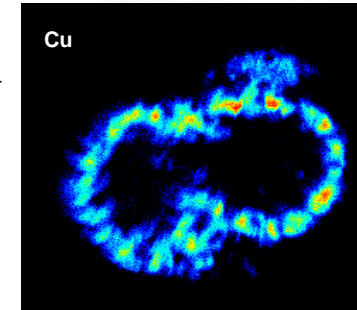
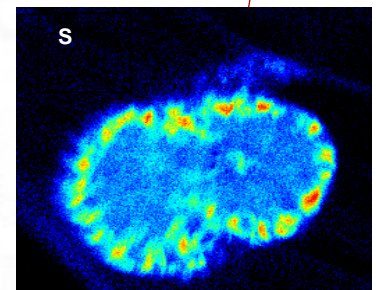
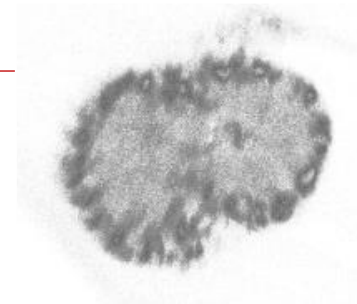
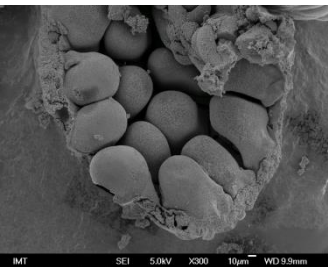
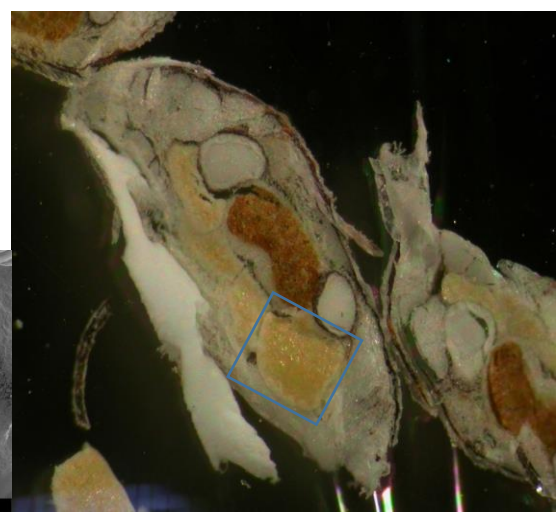
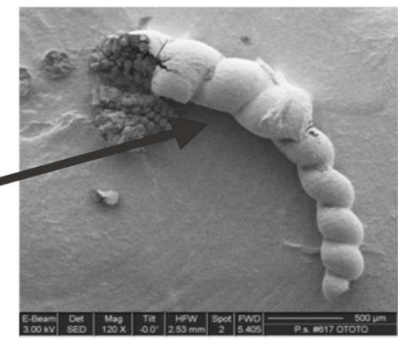
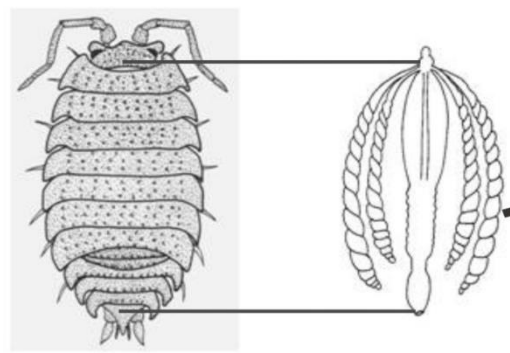


NP na listih

Porcellio scaber



+



PIXE elementna analiza

Dođumentirani učinki na organizme

Stabilnost membrane celic prebavnih žlez –

fluorescentna mikroskopija

Hranjenje modelnih živali z nanomateriali

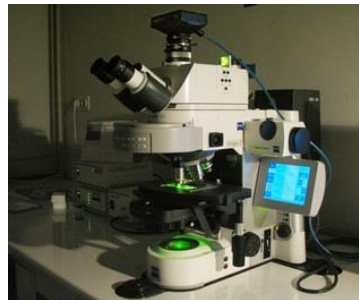


Izolacija prebavnih žlez

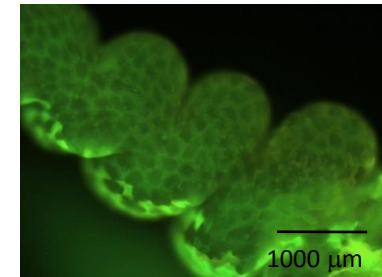


Barvanje z mešanico barvil AO/EB

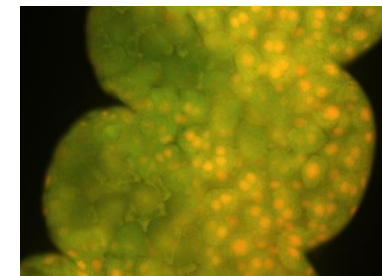
Fluorescentna mikroskopija



Mikrografije pobarvanih prebavnih žlez of *P. scaber* (Valant et al., 2009)

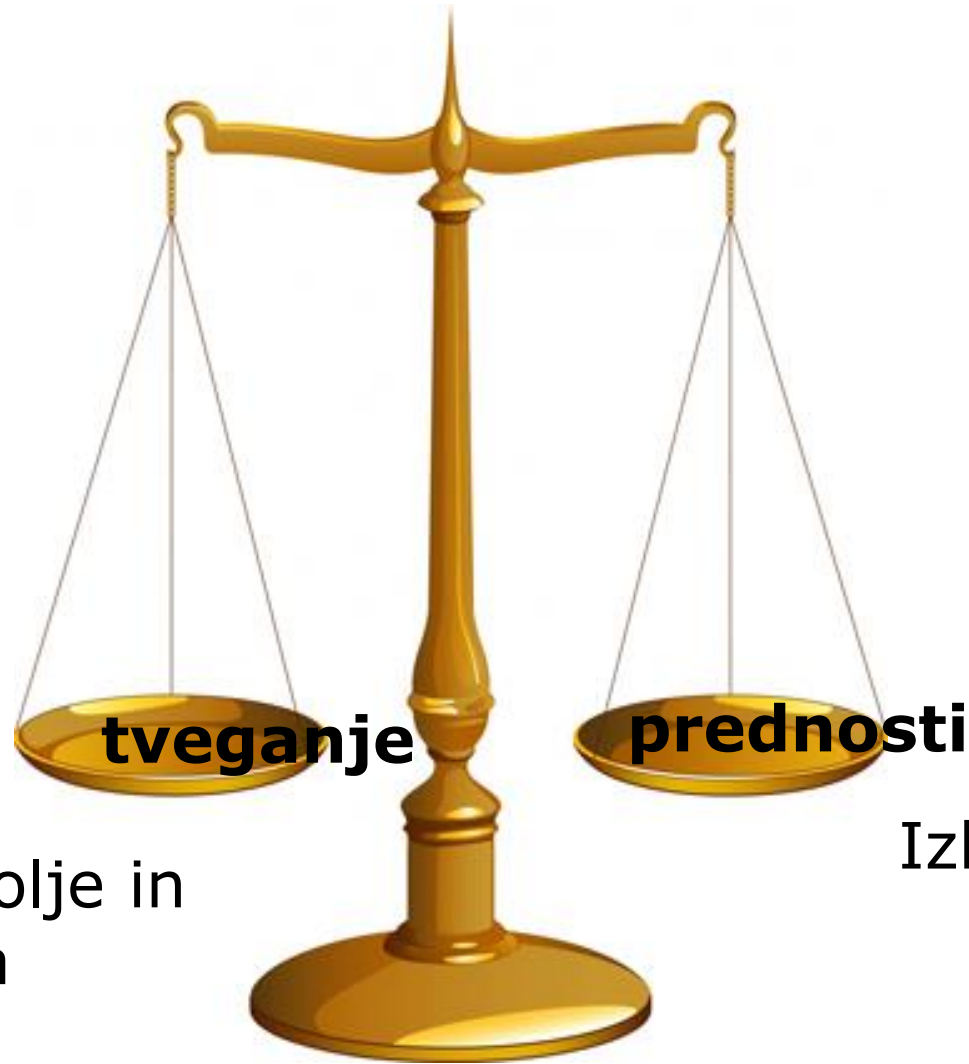


(A) Negativna kontrola, jedra niso obarvana



(B) Pozitivna kontrola, jedra svetijo oranžno (EB)

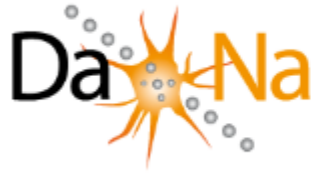
Kdaj so nanodelci varni, kdaj niso



Učinki na okolje in
človeka

Izboljšave za
naše
življenje

Priporočamo v branje

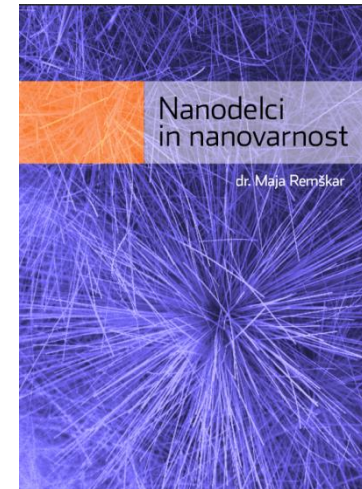


Acquisition, evaluation and public-oriented presentation of society-relevant data and findings relating to nanomaterials (DaNa)

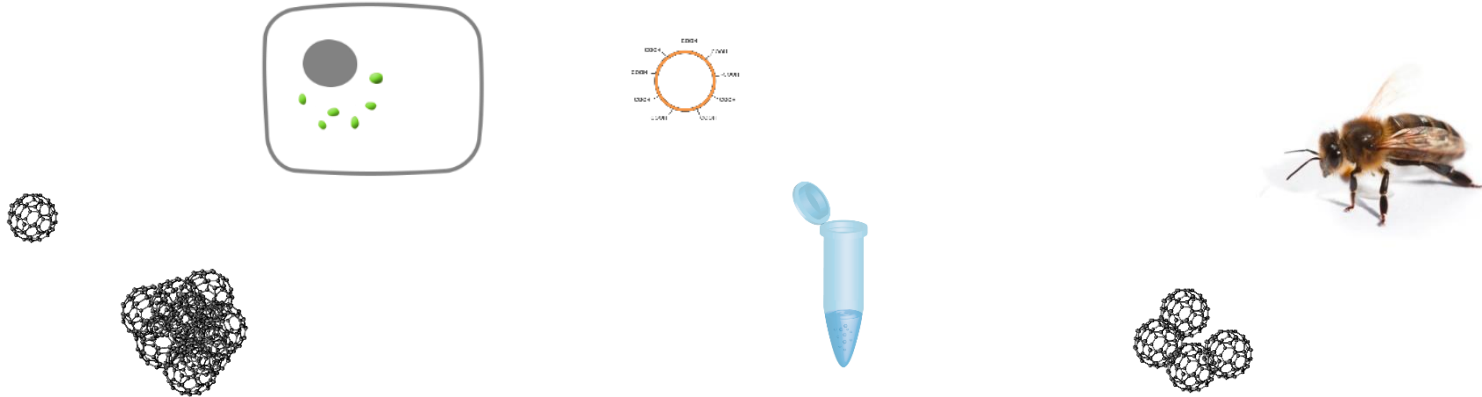
<http://nanopartikel.info/en/projects/completed-projects/dana>



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http://www.kemijskovaren.si/files/nano_knjiga.pdf



Hvala za pozornost.

